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Evaluation of novel insecticidal molecules against thrips and whitefly in blackgram

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Abstract
Field experiments were conducted over three consecutive *Rabi* seasons (2019-20, 2020-21, and 2021-22) at Agricultural Research Station, Utukur, Kadapa, Andhra Pradesh. The trial was laid out in a randomized block design (RBD) with eight treatments, three replications using black gram variety LBG 752. Observations on whitefly and thrips populations were recorded on trifoliate leaves per plant before treatment and at 3, 7, and 10 days after each spray. Among the tested insecticides, spinetoram @ 0.6 ml l^{-1}, spiromesifen @ 1 ml l^{-1}, and diafenthiuron @ 1.25 g l^{-1} consistently demonstrated superior control of both pest populations across multiple sampling intervals following foliar sprays. These treatments significantly reduced thrips and whitefly densities, consequently lowering the incidence of bud necrosis and yellow mosaic virus (YMV), respectively.

Keywords: Blackgram, thrips, whiteflies, evaluation and novel insecticides

Introduction

Mung bean (*Vigna radiata* (L.) Wilczek) is the third most important pulse crop in India after chickpea and pigeon pea. Black gram, commonly known as urd bean, has been cultivated in India for over 4,500 years (Fuller and Harvey, 2006) [2]. It serves as a vital source of dietary protein and plays a crucial role in crop rotation and soil fertility enhancement. Black gram is primarily grown for its high protein content. However, its productivity at both national and state levels remains low due to abiotic and biotic stresses such as drought, weeds, insect pests, and diseases. About 70 per cent of the world's Black gram production comes from India. India is the world's largest producer as well as consumer of Black gram. It produces about 21.5 lakh tonnes of Urad annually from about 4 million hectares of area, with an average productivity of 546 Kg per hect are in 2020-21.

Over 200 insect pests belonging to 48 families and seven species of mites (order Acarina) have been reported to cause significant damage to black gram at different growth stages under varying agro-climatic conditions (Naik *et al.*, 2019) [1]. The major insect pests include sap feeders like aphids (*Aphis craccivora* Koch), jassids (*Empoasca kerri* Pruthi), whiteflies (*Bemisia tabaci* Gennadius), and thrips (genera *Megalurothrips* and *Caliothrips indicus* Bagnall). Other pests include plant bugs (*Riptortus pedestris* Fabricius, *Nezara viridula* L., *Plautia fimbriata* Fabricius), pod bugs (*Clavigralla gibbosa* Spinola), spotted pod borer (*Maruca vitrata* Geyer), and field bean pod borer (*Adisura atkinsoni* Moore). Among these, sap feeders such as whiteflies, jassids, green leafhoppers (*Nephotettix* spp.), and flower thrips cause severe damage to the crop (Chandra and Rajak, 2004) [3].

Avoidable losses due to this pest complex in different urd bean varieties range from 15.62% to 30.96%, averaging 24.03%. Whitefly, a major vector of mungbean yellow mosaic virus (MYMV), can alone cause up to 30-70% damage (Duraimurugan and Tyagi, 2014) [4]. While various indigenous, botanical, and conventional insecticides have been tested, there is limited research on the efficacy of novel chemical insecticides under the agro-climatic conditions of Western Uttar Pradesh. Scientific and judicious use of novel insecticides remains one of the most effective strategies for pest management. Therefore, a field trial involving seven insecticides was conducted to evaluate their efficacy against thrips and whiteflies in black gram.

Materials and Methods

Field experiments were conducted over three consecutive *Rabi* seasons (2019-20, 2020-21, and 2021-22) at Agricultural Research Station, Utukur, Kadapa, Andhra Pradesh, Acharya N.G. Ranga Agricultural University. The trial was laid out in a randomized block design (RBD) with eight treatments, three replications using black gram variety LBG 752. Observations for whitefly and thrips populations were recorded on trifoliate leaves per plant before treatment and at 3, 7, and 10 days after each spray. Data were subjected to square root transformation for statistical analysis.

Table 1: Details of the insecticides used for experiment

Treatments	Details of the Insecticides
T_1	Seed treatment with imidacioprid 600FS @ 5 ml/kg seed +No spraying of insecticide
T_2	T_1+ Spraying of diafenthiuron 50% WP @ 1.25 g/l at 25 & 45 DAS
T_3	T_1+Spraying of spiromesifen 240SC @ 1 ml/l at 25 & 45 DAS
T_4	T_1+ Spraying of spinosad 45% SC @ 0.3 ml/l at 25 & 45 DAS
T_5	T_1 + Spraying of spinetoram12% SC @ 0.6 ml/l at 25 & 45 DAS
T_6	T_1+Spraying of cyantraniliprole10% @ 1 ml/l at 25 & 45 DAS
T_7	T_1+Spraying of fipronil 5% SC @ 2 ml/l at 25 & 45 DAS
T_8	Untreated check

Results and Discussion

Efficacy of novel insecticides against thrips in black gram

The efficacy of various insecticidal treatments on the mean thrips population per three leaves was evaluated following two foliar sprays first at 25 days after sowing (DAS) and second at 45 DAS. Observations were recorded at before spray (B/S), 3 days after spray (3 DAS), 7 days after spray (7 DAS), and 10 days after spray (10 DAS).

First Spray (25 DAS)

Before the first spray, thrips populations were statistically similar across all treatments, ranging from 5.74 to 6.20 thrips per three leaves. A significant reduction in thrips population was recorded three days after spraying in all treated plots compared with the untreated check. Among the treatments, T_5 (T_1 + spinetoram @ 0.6 ml/l) recorded the lowest thrips population at 3 DAS (2.27), 7 DAS (1.07), and 10 DAS (0.51), with a mean of 1.31 thrips per three leaves, followed closely by T_4 (T_1 + spinosad @ 0.3 ml/l) with a mean population of 0.14. Moderate control was observed with T_2 (T_1 + diafenthiuron @ 1.25 g/l) and T_3 (T_1 + spiromesifen @ 1 ml/l), recording mean populations of 2.64 and 3.24, respectively.The untreated check (T_8) maintained a high thrips population throughout the observation period (mean 5.73 thrips per three leaves) (Table 1).

Second Spray (45 DAS)

A similar trend was observed following the second spray. Before spraying, thrips counts ranged from 2.59 to 6.46 across treatments. By 10 DAS, the lowest thrips population was again recorded in T_5 (T_1 + spinetoram @ 0.6 ml/l) with 0.30 thrips per three leaves, followed by T_4 (T_1 + spinosad @ 0.3 ml/l) with 0.65 thrips per three leaves. Their mean thrips populations were 0.70 and 1.15, respectively, indicating superior and sustained efficacy. Moderate efficacy was exhibited by T_2 (T_1 + diafenthiuron) and T_6 (T_1 + cyantraniliprole), with mean populations of 1.80 and 1.51, respectively. The highest thrips population persisted in the untreated check (T_8) with a mean of 6.08, followed by T_1 (seed treatment with imidacloprid) showing limited suppression (mean 5.61) (Table 2).

Bud Necrosis Incidence

A clear correlation between thrips infestation and bud necrosis incidence was observed. The lowest bud necrosis incidence was recorded in T_5 (T_1 + spinetoram) with 0.89%, followed by T_4 (T_1 + spinosad) with 1.47%, indicating effective management of both thrips and associated bud necrosis. The highest incidence occurred in the untreated check (17.57%), followed by T_1 (14.14%).

The results indicate that all insecticidal treatments were effective in reducing thrips populations compared to the untreated control, with T_5 and T_4 consistently recording the lowest populations throughout the observation period. The superior performance of these treatments may be attributed to the specific modes of action of the active ingredients, which likely affected both adult thrips and immature stages, thereby reducing reproduction and population buildup. The gradual decline in thrips population from three to ten days after the second spray suggests that these treatments not only provided an initial knockdown effect but also exhibited residual activity, sustaining suppression over time. The results of the present findings are in line with the Wakil *et al.* (2023) [5] reported that the lowest level of thrips damage in onion was recorded in plots treated with spinetoram, particularly at 7 days after the second spray application. This indicates that spinetoram not only provides rapid suppression of the pest population but also maintains its residual activity for a considerable period after application. Similarly, Tan *et al.* (2022) [6] observed a significant increase in the efficacy of spinetoram when it was applied at the recommended dose of 0.67 ml/L in cowpea, demonstrating its potential as a reliable insecticidal option across different legume crops.

Further, Mrittunjai *et al.* (2018) [7] reported that the application of spinetoram at 61 g a.i./ha was equally effective as spinosad applied at 140 g a.i./ha in managing flower thrips in pepper. This finding highlights the higher potency of spinetoram, as it achieved comparable control at a relatively lower active ingredient dosage, suggesting advantages in terms of reduced chemical load and possibly lowers environmental impact. These observations are consistent with earlier work in blackgram, where fipronil and diafenthiuron achieved approximately 62 % and ~51.2 % reduction in thrips damage, respectively, but did not approach the suppression achieved by the spinetoram treatments (Patel *et al.*, 2021) [8].

Efficacy of novel insecticides against whiteflies in black gram

The mean whitefly population per three leaves was significantly influenced by the insecticidal treatments after both the first and second foliar sprays (Table 2).

First spray (25 DAS)

Before spraying, the whitefly populations did not differ significantly among treatments and ranged from 9.15 to 9.75 adults per three leaves. A marked reduction was recorded in all treated plots within 3 days after spraying (DAS), with the lowest population in T_3 (T_1 + spiromesifen @ 1 ml l⁻¹) (3.31 whiteflies) followed by T_2 (T_1 + diafenthiuron @ 1.25 g l⁻¹) (4.16) and T_5 (T_1 + spinetoram @ 0.6 ml l⁻¹) (4.38). By 7 DAS, the population declined sharply across treatments, reaching 1.84 in T_3 (spiromesifen) and 2.65 in T_2 (diafenthiuron), compared with 9.55 in the untreated control. At 10 DAS, T_3 (spiromesifen) again recorded the lowest population (0.91 whiteflies per three leaves), followed by T_2 (1.73) and T_5 (1.95), whereas the untreated check (T_8) maintained 9.49. The mean whitefly population after the first spray was lowest in T_3 (2.02) and T_2 (2.83), indicating high residual efficacy of these insecticides (Table 1).

Second spray (45 DAS)

Prior to the second spray, the whitefly population ranged from 4.69 to 10.79 per three leaves. Three days after spraying, a substantial reduction was observed in all treated plots. The lowest population at 3 DAS was recorded in T_3 (spiromesifen) (1.59) followed closely by T_2 (2.57) and T_5 (4.41), while the untreated check had 10.51 whiteflies. At 7 DAS, T_3 (spiromesifen) continued to record the lowest whitefly density (0.82), followed by T_2 (1.39) and T_5 (1.72), compared with 10.24 in the untreated check. By 10 DAS, the lowest population persisted in T_3 (0.79), indicating prolonged residual activity, while T_5 (2.00) and T_2 (1.37) also maintained effective suppression. Across all observation intervals, T_3 (spiromesifen) recorded the lowest mean population (0.93 whiteflies per three leaves) after the second spray, followed by T_2 (1.62) and T_5 (2.00), demonstrating superior efficacy of these treatments (Table 2).

Incidence of yellow mosaic virus (YMV)

A strong association was observed between whitefly population and YMV incidence. The minimum YMV incidence was recorded in T_3 (spiromesifen) (0.48%), followed by T_2 (0.88%) and T_5 (1.47%), while the maximum incidence was observed in the untreated control (11.56%). Similar observations were made by Rao *et al.* (2022) [9], who reported that whitefly population dynamics significantly influence YMV spread in leguminous crops.

Yield and economics

Yield was significantly higher in all treated plots compared with the untreated check. The maximum pod yield (1458 kg ha⁻¹) was recorded in T_5 (T_1 + spinetoram @ 0.6 ml l⁻¹), followed by T_6 (T_1 + cyantraniliprole @ 1 ml l⁻¹) (1419 kg ha⁻¹) and T_2 (T_1 + diafenthiuron) (1332 kg ha⁻¹). The lowest yield (799 kg ha⁻¹) was obtained in the untreated control. The benefit-cost (B:C) ratio was highest in T_5 (1 : 2.69) followed by T_2 (1 : 2.54) and T_6 (1 : 2.45) . These findings are comparable to those of Kaur and Singh (2023) [10], who noted that spinetoram-treated blackgram plots recorded the highest economic returns due to reduced pest incidence and improved pod yield.

The present investigation clearly revealed that all insecticidal treatments significantly reduced the whitefly (*Bemisia tabaci*) population compared with the untreated check. Among them, spiromesifen @ 1 ml l⁻¹, diafenthiuron @ 1.25 g l⁻¹, and spinetoram @ 0.6 ml l⁻¹ exhibited superior performance after both sprays. The rapid knockdown and residual control achieved by these treatments suggest that they possess strong translaminar or systemic activity, consistent with the findings of Naveen *et al.* (2020) [11], who observed that spiromesifen at 96 g a.i. ha⁻¹ provided > 80 % reduction in *B. tabaci* populations in cotton and tomato.

Spiromesifen, a tetronic acid derivative, acts as a lipid biosynthesis inhibitor, affecting immature and adult stages of whiteflies (Dericci *et al.*, 2024) [12]. Its ability to control both adults and nymphs may explain the sustained population decline up to 10 days after spraying in the present study. Likewise, diafenthiuron, a thiourea-based insecticide, has been reported to exhibit excellent persistence and contact activity against whiteflies and other sucking pests (Kumar *et al.*, 2021) [13]. The superior efficacy of spinetoram also aligns with reports by Kaur and Singh (2023) [10], who found that spinetoram significantly reduced whitefly incidence in groundnut and improved pod yield, owing to its dual neurotoxic action as a spinosyn compound.

The positive correlation between whitefly density and yellow mosaic virus (YMV) incidence recorded in this study confirms the role of *B. tabaci* as the sole vector of the virus. The lowest YMV incidence observed in spiromesifen-and diafenthiuron-treated plots agrees with Rao *et al.* (2022) [9], who established that effective suppression of vector populations minimizes virus transmission in legumes.

Economic analysis further demonstrated that spinetoram-treated plots produced the highest yield (1458 kg ha⁻¹) and B:C ratio (1: 2.69), followed by diafenthiuron and cyantraniliprole. This finding corroborates previous work by Patel *et al.* (2021) [8], who reported that integrating new-generation insecticides enhanced pod yield and profitability in blackgram. Such improvements are attributed to reduced pest pressure during critical vegetative and flowering stages, leading to better canopy development and pod filling.

Overall, the results emphasize that rotating insecticides with different modes of action—particularly spinosyns, lipid biosynthesis inhibitors, and thioureas can maintain efficacy while reducing the risk of resistance development, as also suggested by Gebre *et al.* (2022) [14] in onion thrips management.

Experimental view at Agricultural Research Station, Utukur, Kadapa

Thrips in blackgram

Whiteflies in blackgram

Table 2: Pooled data of efficacy of novel insecticides against thrips in black gram

Treatments	Mean thrips population (per 3 leaves)										% inc. of Bud necrosis
	First spray at 25DAS					Second spray at 45DAS					
	B/S	3DAS	7DAS	10DAS	Mean	B/S	3DAS	7DAS	10DAS	Mean	
T_8: Seed treatment with imidacloprid 600 FS @ 5 ml/kg seed	6.03	5.49	5.28	5.26	5.3	5.94	5.65	5.47	5.73	5.61	14.14
	(2.46)	(2.34)	(2.3)	(2.29)	(2.3)	(2.44)	(2.38)	(2.34)	(2.39)	(2.37)	(22.07)
T_2: T_1+ diafenthiuron @ 1.25 g/l	5.74	3.73	2.5	1.7	2.64	3.96	2.39	1.76	1.26	1.8	4.92
	(2.4)	(1.93)	(1.58)	(1.3)	(1.61)	(1.99)	(1.55)	(1.32)	(1.12)	(1.33)	(12.81)
T_3: T_1+ spiromesifen @ 1 ml/l	5.93	4.33	2.93	2.1	3.24	4.57	2.8	2.15	1.66	2.2	6.1
	(2.43)	(2.08)	(1.71)	(1.44)	(1.79)	(2.14)	(1.67)	(1.47)	(1.29)	(1.48)	(14.29)
T_4: T_1+spinosad @ 0.3 ml/l	5.94	2.97	1.6	0.85	0.14	3.49	1.82	0.96	0.65	1.15	1.47
	(2.44)	(1.72)	(1.25)	(0.92)	(1.3)	(1.87)	(1.35)	(0.98)	(0.81)	(1.05)	(6.95)
T_5:T_1+ spinetoram @ 0.6 ml/l	6.02	2.27	1.07	0.51	1.31	2.59	1.18	0.61	0.3	0.7	0.89
	(2.45)	(1.51)	(1.03)	(0.71)	(1.11)	(1.61)	(1.08)	(0.78)	-0.55)	(0.8)	(5.42)
T_6:T_1+ Cyantraniliprole @ 1 ml	6.04	3.36	2.09	1.27	2.22	3.72	2.12	1.42	0.95	1.51	2.18
	(2.46)	(1.83)	(1.44)	(1.13)	(1.46)	(1.93)	(1.45)	(1.19)	(0.97)	(1.21)	(8.48)
T_7:T_1+ fipronil @ 2 ml/l	5.85	4.67	3.28	2.72	3.5	4.98	3.33	2.53	2.15	2.67	8.9
	(2.42)	(2.16)	(1.81)	(1.65)	(1.86)	(2.23)	(1.83)	(1.59)	(1.47)	(1.63)	(17.34)
T_8: Untreated check	6.2	5.89	5.59	5.77	5.73	6.46	6.27	5.97	6	6.08	17.57
	(2.49)	(2.43)	(2.36)	(2.4)	(2.39)	(2.54)	(2.5)	(2.49)	(2.45)	(2.47)	(24.78)
SEm+	0.03	0.05	0.08	0.05	0.09	0.02	0.03	0.03	0.04	0.06	0.3
CD @ 0.05	0.1	0.15	0.24	0.15	0.26	0.07	0.1	0.08	0.12	0.2	0.92
CV	2.29	4.54	8.66	6.31	9.13	2.05	3.38	3.32	5.59	7.98	4.21

Table 3: Pooled data of efficacy of novel insecticides against whitefly in black gram

Treatments	Mean whiteflies population (per 3 leaves)										% inc. of YMV	Yield (kg/ha)	B:C ratio
	First spray at 25DAS					Second spray at 45DAS							
	B/S	3DAS	7DAS	10DAS	Mean	B/S	3DAS	7DAS	10DAS	Mean			
T_1: ST with imidacloprid 600FS @ 5 ml/kg seed	9.24	8.64	8.85	8.6	8.69	10.29	10.04	8.93	9.1	9.87	9.67	885	1:1.80
	(3.04)	(2.94)	(2.97)	(2.93)	(2.95)	(3.21)	(3.17)	(2.98)	(3.01)	(3.14)	(18.12)		
T_2: T_1+ diafenthiuron @ 1.25 g/l	9.38	4.16	2.65	1.73	2.83	4.69	2.57	1.39	1.37	1.62	0.88	1332	1:2.54
	(3.06)	(2.04)	(1.62)	(1.31)	(1.65)	(2.16)	(1.6)	(1.18)	(1.16)	(1.24)	(5.38)		
T_3: T_1+ spiromesifen @ 1 ml/l	9.15	3.31	1.84	0.91	2.02	3.79	1.59	0.82	0.79	0.93	0.48	1243	1:2.45
	(3.02)	(1.82)	(1.36)	(0.95)	(1.38)	(1.95)	(1.26)	(0.91)	(0.88)	(0.92)	(3.94)		
T_4: T_1+spinosad @ 0.3 ml/l	9.22	5.68	4.58	3.71	4.66	6.76	4.79	3.56	2.7	3.72	5.07	1261	1:2.40
	(3.04)	(2.38)	(2.14)	(1.92)	(2.15)	(2.6)	(2.19)	(1.88)	(1.64)	(1.92)	(12.98)		
T_5:T_1+ spinetoram @ 0.6 ml/l	9.18	4.38	2.93	1.95	3.09	5.43	4.41	1.72	1.62	2	1.47	1458	1:2.69
	(3.03)	(2.09)	(1.71)	(1.39)	(1.73)	(2.33)	(2.07)	(1.31)	(1.26)	(1.38)	(6.95)		
T_6:T_1+ cyantraniliprole @ 1 ml/l	9.35	5.3	4.05	2.91	4.33	6.24	3.96	2.62	2.29	2.76	2.78	1419	1:2.54
	(3.06)	(2.3)	(2.01)	(1.7)	(2.07)	(2.5)	(1.99)	(1.62)	(1.51)	(1.64)	(9.6)		
T_7:T_1+ fipronil @ 2 ml/l	9.26	6.39	4.57	4.58	5.42	7.93	5.55	4.45	3.52	4.53	6.13	1070	1:2.10
	(3.04)	(2.53)	(2.13)	(2.14)	(2.32)	(2.82)	(2.35)	(2.11)	(1.87)	(2.12)	(14.27)		
T_8: Untreated check	9.75	9.62	9.55	9.3	9.49	10.79	10.51	10.24	9.39	10.28	11.56	799	1:1.70
	(3.12)	(3.1)	(3.09)	(3.05)	(3.08)	(3.28)	(3.24)	(3.2)	(3.06)	(3.21)	(19.88)		
SEm±	0.05	0.04	0.07	0.06	0.1	0.03	0.11	0.05	0.05	0.08	0.46	11.97	
CD @ 0.05	0.16	0.12	0.21	0.18	0.29	0.09	0.32	0.16	0.16	0.25	1.4	36.31	
CV	2.96	2.93	6.08	5.9	8.26	2.11	8.83	5.41	6.51	8.56	7.85	1.67	

Summary and Conclusion

The study evaluated the efficacy of various insecticidal treatments combined with imidacloprid seed treatment against two major pests of black gram: thrips (*Thrips spp.*) and whiteflies (*Bemisia tabaci*). Among the tested insecticides, spinetoram @ 0.6 ml l^{-1}, spiromesifen @ 1 ml l^{-1}, and diafenthiuron @ 1.25 g l^{-1} consistently demonstrated superior control of both pest populations across multiple sampling intervals following foliar sprays. These treatments significantly reduced thrips and whitefly densities, consequently lowering the incidence of bud necrosis and yellow mosaic virus (YMV), respectively.

Economic analysis indicated that spinetoram not only suppressed pest populations effectively but also produced the highest pod yield and benefit-cost ratio, highlighting its potential for practical blackgram pest management. The integration of seed treatment with imidacloprid and foliar sprays of selective insecticides with differing modes of action—such as spinosyns, lipid biosynthesis inhibitors, and thioureas—emerged as an effective strategy to manage both thrips and whiteflies while minimizing resistance risk.

In conclusion, the combined use of imidacloprid seed treatment followed by foliar applications of spinetoram or spiromesifen or diafenthiuron offers a robust and economically viable integrated pest management (IPM) approach for controlling thrips and whiteflies in blackgram. Adoption of these treatments will help reduce viral disease incidence, enhance yield, and promote sustainable pest management in blackgram cropping systems.

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