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Efficacy of combination insecticides against pod fly on pigeonpea

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ABSTRACT

Pod fly (M. obtusa) in pigeonpea is difficult to manage due to its internal larval feeding habit which significantly reduces the effectiveness of conventional insecticides. Continuous use of single-molecule insecticides has caused resistance, pest resurgence and environmental risks. Early detection is challenging as visible symptoms appear late and limited farmer awareness about the efficacy and cost–benefit of combination insecticides restricts their field adoption. A field investigation was conducted during 2024–2025 at the Entomology Section, College of Agriculture, Nagpur, to evaluate the efficacy and cost-effectiveness of combination insecticides against pod fly (Melanagromyza obtusa) on pigeonpea. Nine treatments, including an untreated control were tested. Chlorantraniliprole 9.3% + Lambda-cyhalothrin 4.6% ZC @ 200 ml/500 L proved most effective in reducing pod damage and grain loss caused by M. obtusa. This was followed by Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC and Novaluron 5.25% + Indoxacarb 4.5% SC which also significantly suppressed infestation. All the combination insecticide treatments were statistically superior to the untreated control in minimizing pod fly damage. The highest grain yield (14.03 q/ha) was recorded in the Chlorantraniliprole + Lambda-cyhalothrin treatment contributing to better crop performance. However, Thiamethoxam + Lambda-cyhalothrin emerged as the most economical option recording the highest ICBR of 1:9.09 with a net return of Rs. 47,751/ha. These results highlight the potential of selective combination insecticides in achieving both effective pest suppression and higher economic returns in pigeonpea cultivation under field conditions. The study aims to identify insecticide combinations that provide broad-spectrum control, longer residual activity and superior cost–benefit ratios compared to conventional single-molecule treatments. Through field evaluation and integration of efficacy with Incremental Cost-Benefit Ratio (ICBR) analysis the research offers a balanced assessment of both biological effectiveness and economic sustainability. The findings are expected to guide the development of eco-efficient and practical pest management strategies for pigeonpea cultivation.

Keywords: *Efficacy, Combination, Chlorantraniliprole + Lambda-cyhalothrin, Thiamethoxam + Lambda-cyhalothrin, Pigeonpea, Pod fly.*

INTRODUCTION

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is one of the most vital leguminous crops cultivated in India. It belongs to the genus *Cajanus* within the Fabaceae family. As a major food legume it thrives in semi-arid tropical and subtropical farming systems across diverse agro-ecological zones. India stands as both the top producer and the largest consumer of pulses globally accounting for approximately 33% of the global area and contributing about 25% to the total world pulse output. Key pulse crops cultivated in the country include chickpea, pigeonpea, mungbean, urdbean, lentil and field pea. [1]

The pod fly, *Melanagromyza obtusa* (Malloch) is a significant pest of pigeonpea in South and Southeast Asia. Its infestation begins from the pod filling stage and continues until maturity. Females lay eggs on the inner pod wall, embedding them under the epidermis of green pods. After hatching, larvae feed internally on developing seeds, rendering them unsuitable for consumption or planting [10]. Being an internal feeder, the pod fly causes damage that often remains undetected until the larvae mature and create exit holes through a thin membrane a process termed 'windowing'. This concealed feeding behavior contributes to substantial hidden yield losses as damage is frequently noticed only at harvest [17]. Pod fly infestation has emerged as a serious issue due to its impact on both yield and grain quality. Therefore, timely and efficient pest management is essential including the identification of effective insecticidal treatments that also address concerns of pesticide residues and environmental safety. Adopting such sustainable strategies is critical to maintaining the productivity and quality of pigeonpea crops.

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MATERIALS AND METHODS

A field experiment was conducted in Randomized Block Design during kharif season at the Entomology section, College of Agriculture, Nagpur with eight different treatments consisting Profenofos 40% + Cypermethrin 4% EC, Pyriproxyfen 5% + Fenpropathrin 15% EC, Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC, Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6% ZC, Cypermethrin 10% + Indoxacarb 10% SC, Novaluron 5.25% + Indoxacarb 4.5% SC, Acephate 50% + Imidacloprid 1.8% SP, Beta-cyfluthrin 8.49% + Imidacloprid 19.81% ZC along with untreated control were evaluated against pigeonpea pod fly (*Melanagromyza obtusa*). Each treatment was replicated thrice. The variety PKV TARA was sown in plots of 4.5 m × 4.8 m maintaining a spacing of 90 cm × 20 cm.

To evaluate the impact of insecticidal treatments on pod fly infestations and yield in pigeonpea, Pod fly (*Melanagromyza obtusa*) damage was evaluated by examining fifty randomly selected green pods at 7 and 14 days after the first and second insecticide applications. Treatment efficacy was assessed by comparing pod damage against untreated control. Grain yield from each net plot was recorded post-harvest and extrapolated to a per hectare basis for comparison. Finally, the economic viability of treatments was assessed using the Incremental Cost Benefit Ratio (ICBR), calculated by dividing the net profit (extra yield value minus cost of protection) by the cost of plant protection.
The data on per cent pod damage will be calculated by adopting the following formula.

$$\text{Per cent pod damage} = \frac{\text{Number of damaged pods}}{\text{Total number of pods}} \times 100$$

RESULTS AND DISCUSSION

1. Effect of combination insecticides for the management of pigeonpea pod fly.

First spray:

One day before application of the treatment

Prior to the application of treatments, there were no significant differences observed in pod fly incidence across treatments.

Seven days after application of the treatment

At seven days after first spraying, all insecticidal treatments demonstrated significant efficacy in reducing pod damage compared to the untreated control. Among them the lowest pod damage caused by *M. obtusa* i.e 6.67 per cent was observed in T4 (Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6% ZC) and was followed by T3 (Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC) with 8.00 per cent, T6 (Novaluron 5.25% + Indoxacarb 4.5% SC) with 8.67 per cent, T1 (Profenofos 40% + Cypermethrin 4% EC) with 9.33 per cent and were at par with each other and significantly superior over rest of the treatments.
The next treatment in order of efficacy was T5 (Cypermethrin 10% + Indoxacarb 10% SC) recorded 10.00 per cent pod damage and was followed by T8 (Beta-cyfluthrin 8.49% + Imidacloprid 19.81% ZC) with 10.67 per cent, T7 (Acephate 50% + Imidacloprid 1.8% SP) with 11.00 per cent and T2 (Pyriproxyfen 5% + Fenpropathrin 15% EC) with 12.00 per cent and were at par with each other. Whereas highest per cent pod damage by *M. obtusa* i.e 13.67 per cent was recorded in T9 (Untreated control). (Table 1).

Fourteen days after application of the treatment

A similar efficacy trend was observed at fourteen days after treatment application. The lowest pod damage caused by *M. obtusa* i.e 7.33 per cent was observed in T4 (Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6% ZC) and was followed by T3 (Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC) with 8.67 per cent, T6 (Novaluron 5.25% + Indoxacarb 4.5% SC) with 9.33 per cent, T1 (Profenofos 40% + Cypermethrin 4% EC) with 10.67 per cent and were at par with each other and significantly superior over rest of the treatments.
The next treatment in order of efficacy was T5 (Cypermethrin 10% + Indoxacarb 10% SC) and T8 (Beta-cyfluthrin 8.49% + Imidacloprid 19.81% ZC) were equally effective with 11.33 per cent and was at par with T7 (Acephate 50% + Imidacloprid 1.8% SP) with 12.00 per cent and T2 (Pyriproxyfen 5% + Fenpropathrin 15% EC) with 12.67 per cent and were at par with each other. Significantly, maximum per cent pod damage was observe in treatment T9 (Untreated control) recorded 15.33 per cent. (Table 1).

Second spray

Seven days after application of the treatment

Seven days after the second spray, Chlorantraniliprole 9.3% + Lambda-cyhalothrin 4.6% ZC (T4) was observed to be the most effective treatment, recording the lowest pod damage at 9.00 per cent and was followed by T3 (Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC) with 9.33 per cent, T6 (Novaluron 5.25% + Indoxacarb 4.5% SC) with 10.67 per cent, T1 (Profenofos 40% + Cypermethrin 4% EC) with 11.33 per cent and were at par with each other and significantly superior over rest of the treatments.
The next treatment in order of efficacy was T5 (Cypermethrin 10% + Indoxacarb 10% SC) and T8 (Beta-cyfluthrin 8.49% + Imidacloprid 19.81% ZC) were equally effective with 12.67 per cent and was followed by T7 (Acephate 50% + Imidacloprid 1.8% SP) and T2 (Pyriproxyfen 5% + Fenpropathrin 15% EC) both recorded 12.67 per cent and were at par with each other. Whereas highest per cent pod damage by *M. obtusa* i.e 18.67 per cent was recorded in T9 (Untreated control). (Table 1).

Fourteen days after application of the treatment

Fourteen days after second spraying, all insecticidal treatments were significantly effective in reducing pod damage caused by *Melanagromyza obtusa* compared to the untreated control (T9). The minimum pod damage caused by *M. obtusa* i.e 9.33 per cent was observed in T4 (Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6% ZC) and was followed by T3 (Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC) with 10.67 per cent, T6 (Novaluron 5.25% + Indoxacarb 4.5% SC) with 11.33 per cent, T1 (Profenofos 40% + Cypermethrin 4% EC) with 12.00 per cent and were at par with each other and significantly superior over rest of the treatments.
The next treatment in order of efficacy was T5 (Cypermethrin 10% + Indoxacarb 10% SC) recorded 13.33 per cent pod damage and was followed by T8 (Beta-cyfluthrin 8.49% + Imidacloprid 19.81% ZC) with 14.67 per cent, T7 (Acephate 50% + Imidacloprid 1.8% SP) and T2 (Pyriproxyfen 5% + Fenpropathrin 15% EC) both were equally effective recorded 15.33 per cent pod damage and were at par with each other. Significantly, maximum per cent pod damage was observe in treatment T9 (Untreated control) recorded 23.00 per cent. (Table 1).

Mean per cent pod damage by pod fly

The overall mean percent pod damage recorded after the application of insecticidal treatments revealed that the lowest pod damage caused by *M. obtusa* i.e 8.08 per cent was observed in T4 (Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6% ZC) and was followed by T3 (Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC) with 9.16 per cent, T6 (Novaluron 5.25% + Indoxacarb 4.5% SC) with 10.00 per cent, T1 (Profenofos 40% + Cypermethrin 4% EC) with 10.83 per cent and were at par with each other and significantly superior over rest of the treatments.
The next treatment in order of efficacy was T5 (Cypermethrin 10% + Indoxacarb 10% SC) recorded 11.83 per cent pod damage and was followed by T8 (Beta-cyfluthrin 8.49% + Imidacloprid 19.81% ZC) with 12.33 per cent, T7

(Acephate 50% + Imidacloprid 1.8% SP) and T2 (Pyriproxyfen 5% + Fenpropathrin 15% EC) both were equally effective recorded 13.33 per cent pod damage and were at par with each other. Whereas highest per cent pod damage by *M. obtusa* i.e 17.67 per cent was recorded in T9 (Untreated control). (Table 1).

The results of the present studies are comparable with the results of [12] reported that fipronil 4 + thiamethoxam 4 SC @ 40 + 40 g a.i./ha, thiamethoxam 25 WG @ 50 g a.i./ha and fipronil 40 + imidacloprid 40 WG @ 160 + 160 g a.i./ha provided better control of pod fly infesting pigeonpea. Higher grain yield and benefit cost ratio was also obtained from these treatments as compared to other insecticides and untreated control. [4] reported that novaluron + fipronil @ 80 g a.i./ha and fipronil @ 50 g a.i./ha were the best with 72.5% reduction of pod fly population for each treatment. [15] revealed that thiamethoxam 25 WG @ 75 g a.i./ha recorded lowest pod damage (17.33%). [8] concluded that pod fly management with Lambda- cyhalothrin 2.5 EC, 5 ml/L treated plots was found most effective than other treatments in reducing the pod fly infestation.

Table 1: Effect of combination insecticides for the management of pigeonpea pod fly during 2024-25.
*(*Figure in parentheses are the corresponding square root transformed values, DBS= Days before spray, DAS= Days after spray).*

Tr. No.	Treatment	Percent pod damage by *M. obtusa*					Mean
		1st spray			2nd spray		
		1 DBS	7 DAS	14 DAS	7 DAS	14 DAS	
T_1	Profenofos 40% +Cypermethrin 4% EC	5.33 (2.30)	9.33 (3.05)	10.67 (3.26)	11.33 (3.34)	12.00 (3.46)	10.83
T_2	Pyriproxyfen 5% + Fenpropathrin 15% EC	4.67 (2.15)	12.00 (3.43)	12.67 (3.56)	13.33 (3.65)	15.33 (3.91	13.33
T_3	Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC	6.00 (2.43)	8.00 (2.81)	8.67 (2.94)	9.33 (3.05)	10.67 (3.25)	9.16
T_4	Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6% ZC	5.33 (2.30)	6.67 (2.58)	7.33 (2.70)	9.00 (2.98)	9.33 (3.05)	8.08
T_5	Cypermethrin 10% + Indoxacarb 10% SC	4.67 (2.15)	10.00 (3.15)	11.33 (3.36)	12.67 (3.54)	13.33 (3.65)	11.83
T_6	Novaluron 5.25% + Indoxacarb 4.5% SC	8.00 (2.79)	8.67 (2.91)	9.33 (3.05)	10.67 (3.24)	11.33 (3.34)	10.00
T_7	Acephate 50% + Imidacloprid 1.8% SP	7.33 (2.69)	11.00 (3.30)	12.00 (3.46)	13.33 (3.64)	15.33 (3.90)	12.92
T_8	Beta-cyfluthrin 8.49% + Imidacloprid 19.81% ZC	6.67 (2.54)	10.67 (3.26)	11.33 (3.30)	12.67 (3.56)	14.67 (3.82)	12.33
T_9	Untreated control	6.67 (2.16)	13.67 (3.70)	15.33 (3.91)	18.67 (4.32)	23.00 (4.80)	17.67
	F Test	NS	Sig	Sig	Sig	Sig	Sig
	SEm±	0.52	0.21	0.19	0.17	0.18	1.15
	CD	-	0.62	0.58	0.52	0.54	3.44
	CV %	-	11.52	10.26	8.68	8.43	10.09

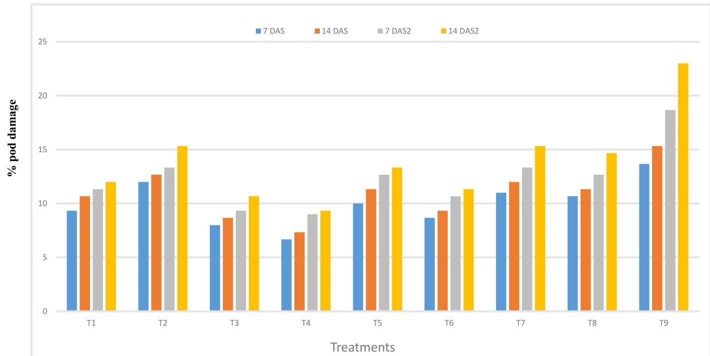

Fig 1. Effect of combination insecticides for the management of pigeonpea pod fly during 2024-25

Grain Yield

The highest grain yield of 14.03 q/ha was recorded in treatment with Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6% ZC, which was statistically at par with Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC with yield level of 12.91 q/ha and Novaluron 5.25% + Indoxacarb 4.5% SC (11.22 q/ha). These superior treatments were followed by Profenofos 40% + Cypermethrin 4% EC with 10.94 q/ha, Cypermethrin 10% + Indoxacarb 10% SC with 10.38 q/ha, Beta-cyfluthrin 8.49% + Imidacloprid 19.81% ZC with 9.54 q/ha, Acephate 50% + Imidacloprid 1.8% SP with 9.26 q/ha and Pyriproxyfen 5% + Fenpropathrin 15% EC with 8.42 q/ha. The lowest grain yield was observed in the untreated control which recorded only 5.89 q/ha. (Table 2).

Incremental cost benefit ratio (ICBR)

The data revealed that the application of Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC proved to be the most cost-effective treatment, achieving the highest Incremental Cost-Benefit Ratio (ICBR) of 1:9.09. It was followed by Profenofos 40% + Cypermethrin 4% EC, which recorded an ICBR of 1:8.97 and Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6% ZC with an ICBR of 1:7.65. The treatments Cypermethrin 10% + Indoxacarb 10% SC and Acephate 50% + Imidacloprid 1.8% SP recorded ICBRs of 1:6.30 and 1:5.96 respectively. Pyriproxyfen 5% + Fenpropathrin 15% EC showed an ICBR of 1:5.07. Meanwhile, Beta-cyfluthrin 8.49% + Imidacloprid 19.81% ZC and Novaluron 5.25% + Indoxacarb 4.5% SC registered lower cost-benefit ratios of 1:4.82 and 1:2.47, respectively. (Table 3).

The present findings are supported by the results of [8] conducted a study at the Student's Instructional Farm, A.N.D.U.A.&T., Kumarganj, Ayodhya (U.P.). In his evaluation of different treatments for pod fly management, Lambda-cyhalothrin 2.5 EC at 5 ml/L proved to be the most effective, resulting in the highest grain yield of 29.5 q/ha, followed by Indoxacarb at 2 ml/L, which yielded 28.75 q/ha.

The highest cost-benefit ratio was also observed with Lambda-cyhalothrin (1:22.32), closely followed by Indoxacarb (1:20.45), indicating the superior economic performance of these treatments.

The results were in accordance with [12] reported that fipronil 4+ thiamethoxam 4 SC @ 40+40 g a.i./ha, thiamethoxam 25 WG @ 50 g a.i./ha and fipronil 40+ imidacloprid 40 WG @ 160+160 g a.i./ha provided better control of pod fly infesting pigeonpea. Higher grain yield and benefit cost ratio was also obtained from these treatments as compared to other insecticides and untreated control.

Table 2: Effect of combination insecticides on grain yield of pigeonpea

Tr. No.	Treatments	Yield qt / ha
T_1	Profenofos 40% + cypermethrin 4% EC	10.94
T_2	Pyriproxyfen 5% + Fenpropathrin 15% EC	8.42
T_3	Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC	12.91
T_4	Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6% ZC	14.03
T_5	Cypermethrin 10% + Indoxacarb 10% SC	10.38
T_6	Novaluron 5.25% + Indoxacarb 4.5% SC	11.22
T_7	Acephate 50% + Imidacloprid 1.8% SP	9.26
T_8	Beta-cyfluthrin 8.49% + Imidacloprid 19.81% ZC	9.54
T_9	Untreated control	5.89
	F Test	Sig
	SEm±	0.96
	CD	2.88
	CV %	16.19

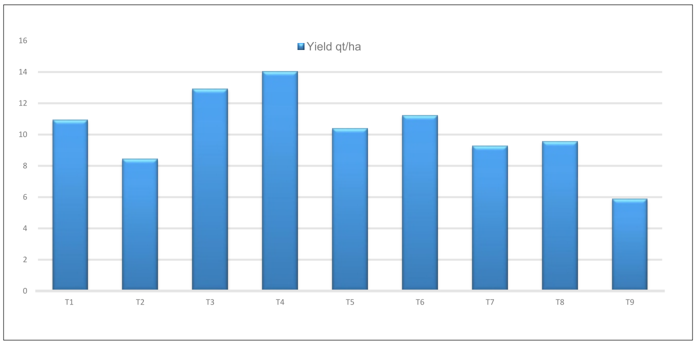

Fig 2. Effect of combination insecticides on grain yield of pigeonpea.

Table 3: Incremental cost benefit ratio of different insecticidal combination treatments on pigeonpea

Treatments	Quantity of insecticide required (g or ml/ha)	Cost of insecticides (Rs/ha)	Cost of treatments (For 3 spray) Rs/ha	Labour cost + Sprayer charges (3 spray) (Rs/ha)	Total cost of plant protection (A)	Yield (q/ha)	Yield increased over control (q/ha)	Value of increased yield (Rs/ha) (B)	Net gain over control (C) (Rs) (B-A)	ICBR C/A	Rank
Profenofos 40% + Cypermethrin 4% EC	600 ml	328	984	2838	3822	10.94	5.05	38127	34305	1: 8.97	II
Pyriproxyfen 5% + Fenpropathrin 15% EC	150 ml	102	305	2838	3143	8.42	2.53	19101	15958	1:5.07	VI
Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC	450 ml	804	2412	2838	5250	12.91	7.02	53001	47751	1:9.09	I
Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6% ZC	600 ml	1420	4260	2838	7098	14.03	8.14	61457	54359	1:7.65	III
Cypermethrin 10% + Indoxacarb 10% SC	1200 ml	600	1800	2838	4638	10.38	4.49	33899	29261	1:6.30	IV
Novaluron 5.25% + Indoxacarb 4.5% SC	2550 ml	2915	8746	2838	11584	11.22	5.33	40241	28657	1:2.47	VIII
Acephate 50% + Imidacloprid 1.8% SP	750 g	272	816	2838	3654	9.26	3.37	25443	21789	1:5.96	V
Beta-cyfluthrin 8.49% + Imidacloprid 19.81% ZC	450 ml	630	1890	2838	4728	9.54	3.65	27557	22829	1:4.82	VII
Untreated control	-	-	-	-	-	5.89	-	-	-	-	-

CONCLUSION

The study emphasizes the effectiveness of combination insecticides in managing the pod fly (*Melanagromyza obtusa*) infestation in pigeonpea. Treatments like Chlorantraniliprole + Lambda-cyhalothrin, Thiamethoxam + Lambda-cyhalothrin and Novaluron + Indoxacarb significantly reduced pod damage caused by *Melanagromyza obtusa*, resulting in higher yields and improved economic returns. Among these, Chlorantraniliprole + Lambda-cyhalothrin was most effective in minimizing pod fly damage and enhancing yield while Thiamethoxam + Lambda-cyhalothrin recorded the highest cost-benefit ratio. All treatments significantly outperformed the untreated control confirming that timely application of these combinations during the pod formation stage is a profitable strategy for managing pod fly.

FUTURE SCOPE OF STUDY

1. Resistance Management: Continuous monitoring of *Melanagromyza obtusa* populations should be done to detect early signs of insecticide resistance and rotation of insecticides with different modes of action should be implemented to delay resistance development.

2. Integration with IPM: The most effective insecticide combinations (e.g., Chlorantraniliprole + Lambda-cyhalothrin) should be incorporated into Integrated Pest Management (IPM) modules along with biological and cultural control practices for sustainable pod fly management.

3. Residue and Environmental Safety Studies: Further research is needed to assess the residual toxicity, environmental persistence and effects on non-target organisms to ensure safe and eco-friendly use of these combination insecticides.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest and the research work was conducted for academic and scientific purposes without any financial or personal influence.

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