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Efficacy of combination insecticides against tur plume moth on pigeonpea (*Cajanus cajan* L. Millisp.)

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Abstract

A field study was conducted during 2024-2025 at Entomology Section, College of Agriculture, Nagpur (Maharashtra) to evaluate the efficacy and cost-effectiveness of nine combination insecticides against the Tur plume moth (*Exelastis atomosa*). Among the evaluated insecticides, Chlorantraniliprole 9.3% + Lambda-cyhalothrin 4.6% ZC was the most effective treatment with lowest larval population of plume moth along with recording highest grain yield (14.03 q/ha). ICBR data revealed superiority of Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC with the highest ICBR of 1:9.09 with net returns of ₹47,751/ha.

Keywords: Efficacy, chlorantraniliprole + lambda-cyhalothrin, thiamethoxam + lambda-cyhalothrin, tur, plume moth

Introduction

India is the world's largest producer of pulses cultivating crops like chickpea, red gram, urd bean, and field pea across varied agroclimatic zones. Among these, pigeonpea (*Cajanus cajan* (L.) Millsp.) is a crucial legume grown widely for its protein-rich seeds (approx. 22%) and its contribution to soil fertility through nitrogen fixation. Despite its importance the productivity of pigeonpea remains low primarily due to biotic stresses, especially insect pests^[2].

Over 300 insect species have been recorded on pigeonpea with the pod borer complex causing the most severe yield losses, particularly during the reproductive stage. Among these, *Exelastis atomosa* (plume moth) is a key pest, damaging flowers and pods from early flowering to pod maturity often resulting in significant economic losses (Ahmad and Rai, 2005)^[11]. Yield losses due to pod borers have been estimated at 40.6% (Subharani and Singh, 2007)^[16].

Despite efforts in breeding and biological control, chemical control remains the primary method of pest management due to its rapid action and ease of application (Durairaj, 1999). However, indiscriminate use of insecticides has led to resistance development in pests like *E. atomosa* (Rao *et al.*, 2000)^[11], necessitating the evaluation of new combination insecticides for sustainable pest control (Pappu *et al.*, 2010)^[8].

Several combination insecticides such as Chlorantraniliprole + Lambda-cyhalothrin, Thiamethoxam + Lambda-cyhalothrin and Novaluron + Indoxacarb have shown promising efficacy against the pod borer complex (Wadaskar *et al.*, 2013). However, specific data on the control of *Exelastis atomosa* remains limited highlighting the need for targeted studies.

Therefore, the present investigation aims to evaluate the efficacy of selected combination insecticides against tur plume moth (*Exelastis atomosa*) on pigeonpea.

Materials and Methods

A field experiment was conducted in Randomized Block Design during *kharif* season at the Entomology section, College of Agriculture, Nagpur with 9 treatments including an untreated check. 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.

The efficacy of various insecticidal treatments against tur plume moth and yield in pigeonpea was assessed.

The larval abundance of *E. atomosa* was recorded on five inflorescences (20 cm each) per plant on randomly selected five tagged plants. In all three applications were made and the larval abundance was recorded at 7 and 14 days after the insecticide application. Treatment efficacy was compared in terms of reduction in larval populations over untreated control. Grain yield from each net plot was extrapolated to 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 with the cost of plant protection. The statistical analysis was done to test the level of significance and to compare the efficacy of the treatments.

Results and Discussion

1. Effect of combination insecticides on larval population of *Exelastis atomosa* after spraying.

A. Pretreatment larval abundance of *E. atomosa* on pigeonpea

The data on abundance of *E. atomosa* larvae per 5 plants presented in table 1 revealed non-significant variations in pre-treatment populations. The larval population was in the range of 1.27 to 1.93 larvae per 5 plants.

B. First spray

1. Seven days after application of the treatment

Seven days after application of the treatment the lowest larval population of *E. atomosa* i.e 0.73 larvae/plant 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) recorded 0.80 larvae/plant, T₆ (Novaluron 5.25% + Indoxacarb 4.5% SC) with 0.87 Larvae/plant, T₁ (Profenofos 40% + Cypermethrin 4% EC) with 0.93 larvae/plant 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) with 1.13 larvae/plant and was followed by T₈ (Beta-cyfluthrin 8.49% + Imidacloprid 19.81% ZC) observed 1.20 larvae/plant, T₇ (Acephate 50% + Imidacloprid 1.8% SP) with 1.27 larvae/plant and T₂ (Pyriproxyfen 5% + Fenpropathrin 15% EC) with 1.33 larvae/plant and were at par with each other. Whereas highest population of *E. atomosa* i.e. 1.80 larvae/plant was recorded in T₉ (untreated control).

2. Fourteen days after application of the treatment

Similar suppression trend continued even at 14 days after application of the treatments with superiority of Chlorantraniliprole 9.3% + Lambda-cyhalothrin 4.6% ZC (T₄) with lowest larval population of *E. atomosa* i.e 0.47 larvae/plant 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 0.60 larvae/plant, T₆ (Novaluron 5.25% + Indoxacarb 4.5% SC) with 0.67 larvae/plant, T₁ (Profenofos 40% + Cypermethrin 4% EC) with 0.80 larvae/plant and were at par with each other and significantly superior over remaining treatments.

The next treatment in order of efficacy was T₅ (Cypermethrin 10% + Indoxacarb 10% SC) with 0.93 larvae/plant and was followed by T₈ (Beta-cyfluthrin 8.49% + Imidacloprid 19.81% ZC) observed 1.00 larvae/plant, T₇ (Acephate 50% + Imidacloprid 1.8% SP) with 1.07 larvae/plant and T₂ (Pyriproxyfen 5% + Fenpropathrin 15% EC) with 1.13 larvae/plant and were at par with each other. Significantly, maximum larval population was observed in treatment T₉

(untreated control) recorded 1.93 larvae/plant. (Table 1).

C. Second spray

1. Seven days after application of the treatment

The lowest larval population of *E. atomosa* i.e 0.40 larvae/plant 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) and T₆ (Novaluron 5.25% + Indoxacarb 4.5% SC) were equally effective recorded 0.53 larvae/plant, T₁ (Profenofos 40% + Cypermethrin 4% EC) with 0.67 larvae/plant 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 recorded 0.73 larvae/plant and was followed by T₂ (Pyriproxyfen 5% + Fenpropathrin 15% EC) with 0.87 larvae/plant, T₇ (Acephate 50% + Imidacloprid 1.8% SP) with 1.00 larvae/plant and were at par with each other. Whereas highest population of *E. atomosa* i.e 2.13 larvae/plant was recorded in T₉ untreated control.

2. Fourteen days after application of the treatment

The lowest larval population of *E. atomosa* i.e 0.27 larvae/plant 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) and T₆ (Novaluron 5.25% + Indoxacarb 4.5% SC) were equally effective recorded 0.40 larvae/plant, T₁ (Profenofos 40% + Cypermethrin 4% EC) with 0.47 larvae/plant and were at par with each other and significantly superior over remaining treatments.

The next treatment in order of efficacy was T₅ (Cypermethrin 10% + Indoxacarb 10% SC) recorded 0.60 larvae/plant and was followed by T₈ (Beta-cyfluthrin 8.49% + Imidacloprid 19.81% ZC) with 0.67 larvae/plant, T₂ (Pyriproxyfen 5% + Fenpropathrin 15% EC) with 0.73 larvae/plant and T₇ (Acephate 50% + Imidacloprid 1.8% SP) with 0.87 larvae/plant and were at par with each other. Significantly maximum larval population was observed in treatment T₉ (untreated control) recorded 2.53 Larvae/plant. (Table 1).

D. Third spray

1. Seven days after application of the treatment

The lowest larval population of *E. atomosa* i.e 0.13 larvae/plant 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) and T₆ (Novaluron 5.25% + Indoxacarb 4.5% SC) were equally effective recorded 0.27 larvae/plant, T₁ (Profenofos 40% + Cypermethrin 4% EC) recorded 0.33 larvae/plant and were at par with each other and significantly superior over remaining treatments.

The next treatment in order of efficacy was T₅ (Cypermethrin 10% + Indoxacarb 10% SC) recorded 0.40 larvae/plant and was followed by T₈ (Beta-cyfluthrin 8.49% + Imidacloprid 19.81% ZC) with 0.47 larvae/plant, T₂ (Pyriproxyfen 5% + Fenpropathrin 15% EC) with 0.60 larvae/plant and T₇ (Acephate 50% + Imidacloprid 1.8% SP) with 0.67 larvae/plant and were at par with each other. Whereas highest population of *E. atomosa* i.e 2.47 larvae/plant was recorded in T₉ untreated control.

2. Fourteen days after application of the treatment

The lowest larval population of *E. atomosa* i.e 0.07 larvae/plant 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) recorded 0.13

larvae/plant, T₆ (Novaluron 5.25% + Indoxacarb 4.5% SC) with 0.20 larvae/plant, T₁ (Profenofos 40% + Cypermethrin 4% EC) with 0.27 larvae/plant 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 0.27 larvae/plant and was followed by T₈ (Beta-cyfluthrin 8.49% + Imidacloprid 19.81% ZC) with 0.33 larvae/plant, T₇ (Acephate 50% + Imidacloprid 1.8% SP) with 0.40 larvae/plant and T₂ (Pyriproxyfen 5% + Fenpropathrin 15% EC) with 0.47 larvae/plant and were at par with each other. Significantly maximum larval population was observed in treatment T₉ (untreated control) recorded 2.27 larvae/plant (Table 1).

E. Mean larval abundance of *E. atomosa*

The average larval density of *E. atomosa* following insecticidal sprays revealed that all treatment combinations were significantly more effective than the untreated control. The lowest larval population of *E. atomosa* i.e 0.35 larvae/plant 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 0.46 larvae/plant, T₆ (Novaluron 5.25% + Indoxacarb 4.5% SC) with 0.49 larvae/plant, T₁ (Profenofos 40% + Cypermethrin 4% EC) with 0.57 larvae/plant and were at par with each other and significantly superior over remaining treatments.

The next treatment in order of efficacy was T₅ (Cypermethrin 10% + Indoxacarb 10% SC) recorded 0.67 larvae/plant and was followed by T₈ (Beta-cyfluthrin 8.49% + Imidacloprid 19.81% ZC) with 0.73 larvae/plant, T₂ (Pyriproxyfen 5% + Fenpropathrin 15% EC) with 0.86 larvae/plant and T₇ (Acephate 50% + Imidacloprid 1.8% SP) with 0.88 larvae/plant and were at par with each other. Whereas highest population of *E. atomosa* i.e 2.18 larvae/plant was recorded in T₉ untreated control. (Table 1)

The present findings are in agreement with Regupathy and Sathyaseelan (2011) [12], They mentioned Ampligo 150 ZC Chlorantraniliprole 100 g/L (10% w/v) + Lambda cyhalothrin 50 g/L (5% w/v) a new insecticide of the anthranilic diamide + pyrethroid class had showed considerable levels of toxicity to many lepidopteron targets globally. The present findings in respect of chlorantraniliprole 18.5% SC are in agreement with

those of Sreekanth *et al.* (2014) [14] obtained effective control of pod borers through application of chlorantraniliprole 18.5% in pigeon pea. The findings of these works are confirmative with present findings. Similarly, with According Tohinshi *et al.* (2010). The next best treatment in order of effectiveness was Indoxacarb 14.5% SE. These results corroborate the findings of Meena *et al.* (2018) [7] which is similar with Patange and Chiranjeevi (2013) [9] and Dinesh *et al.* (2017) [4] who reported that indoxacarb 14.5% SC provided good control against pod borer complex of pigeon pea.



A. Larvae of *E. atomosa*



B. Damage pods by *E. atomosa*

Fig 1: Larval phase and pod damage by tur plume moth (*E. atomosa*)

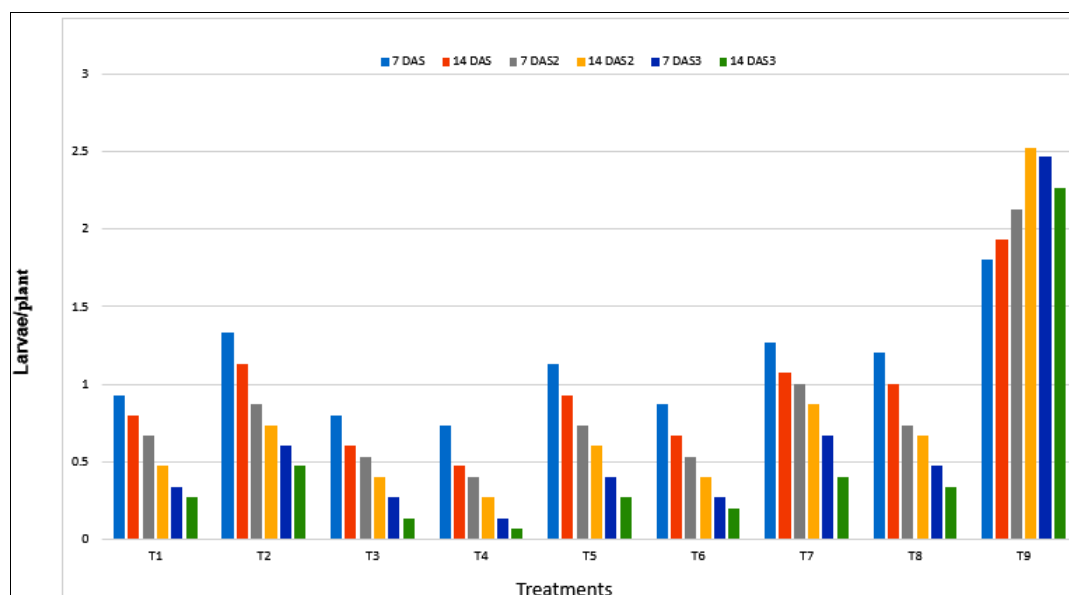


Fig 2: Effect of combination insecticides on larval population of *Exelastis atomosa* after spraying

Table 1: Effect of combination insecticides against tur plume moth, *Exelastis atomosa* on pigeonpea during 2024-25.

Tr. No.	Treatment	Average no. of <i>E. atomosa</i> larvae/plant							Mean
		1 st spray			2 nd spray		3 rd spray		
		1 DBS	7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS	
T ₁	Profenofos 40% +Cypermethrin 4% EC	1.47 (1.21)	0.93 (0.96)	0.80 (0.89)	0.67 (0.79)	0.47 (0.67)	0.33 (0.56)	0.27 (0.41)	0.57
T ₂	Pyriproxyfen 5% + Fenpropathrin 15% EC	1.53 (1.24)	1.33 (1.15)	1.13 (1.06)	0.87 (0.92)	0.73 (0.84)	0.60 (0.77)	0.47 (0.68)	0.86
T ₃	Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC	1.67 (1.29)	0.80 (0.87)	0.60 (0.77)	0.53 (0.71)	0.40 (0.62)	0.27 (0.51)	0.13 (0.30)	0.46
T ₄	Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6% ZC	1.93 (1.39)	0.73 (0.85)	0.47 (0.66)	0.40 (0.62)	0.27 (0.51)	0.13 (0.30)	0.07 (0.15)	0.35
T ₅	Cypermethrin 10% + Indoxacarb 10% SC	1.27 (1.11)	1.13 (1.06)	0.93 (0.96)	0.73 (0.84)	0.60 (0.77)	0.40 (0.62)	0.27 (0.51)	0.67
T ₆	Novaluron 5.25% + Indoxacarb 4.5% SC	1.53 (1.23)	0.87 (0.92)	0.67 (0.81)	0.53 (0.69)	0.40 (0.63)	0.27 (0.51)	0.20 (0.44)	0.49
T ₇	Acephate 50% + Imidacloprid 1.8% SP	1.60 (1.26)	1.27 (1.12)	1.07 (1.03)	1.00 (0.96)	0.87 (0.91)	0.67 (0.80)	0.40 (0.62)	0.88
T ₈	Beta-cyfluthrin 8.49% + Imidacloprid 19.81% ZC	1.73 (1.24)	1.20 (1.09)	1.00 (1.00)	0.73 (0.83)	0.67 (0.81)	0.47 (0.68)	0.33 (0.57)	0.73
T ₉	Untreated control	1.60 (1.20)	1.80 (1.34)	1.93 (1.39)	2.13 (1.46)	2.53 (1.59)	2.47 (1.57)	2.27 (1.51)	2.18
	F Test	NS	Sig	Sig	Sig	Sig	Sig	Sig	Sig
	S.Em±	0.16	0.07	0.06	0.07	0.08	0.08	0.10	0.07
	CD at 5%	-	0.22	0.20	0.22	0.23	0.25	0.30	0.24
	CV (%)	-	12.24	11.64	14.46	15.80	14.26	15.85	14.04

(*Figure in parentheses are the corresponding square root transformed values, DAS= Days after spraying).

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 reported by Swami and Ameta (2017) ^[17] that the spray of Chlorantraniliprole 9.6% + Lambda cyhalothrin

4.6% at 300 mL/ha during *kharif* 2011 and 2012, respectively, resulted in the maximum pigeon pea seed yields of 9.50 and 10.78 quintal per ha. This result is in conformity with the findings of Dadas *et al.* (2019) ^[3], application of chlorantraniliprole 18.5% SC 50% flowering and podding stage of 15 days interval resulted in higher yield of pigeon pea (8.79 qt/ha). Similarly, Sreekanth *et al.* (2014) ^[14] also observed effective control of pod borer with highest yield of 886.1 kg/ha when chlorantraniliprole 18.5% SC 50% was applied thrice, commencing from 50% flowering stage. Also, higher yield of pigeonpea by using chlorantraniliprole 18.5% SC (686.1 kg/ha) was reported by Khorasiya *et al.* (2004) ^[5].

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
	S.Em±	0.96
	CD	2.88
	CV%	16.19

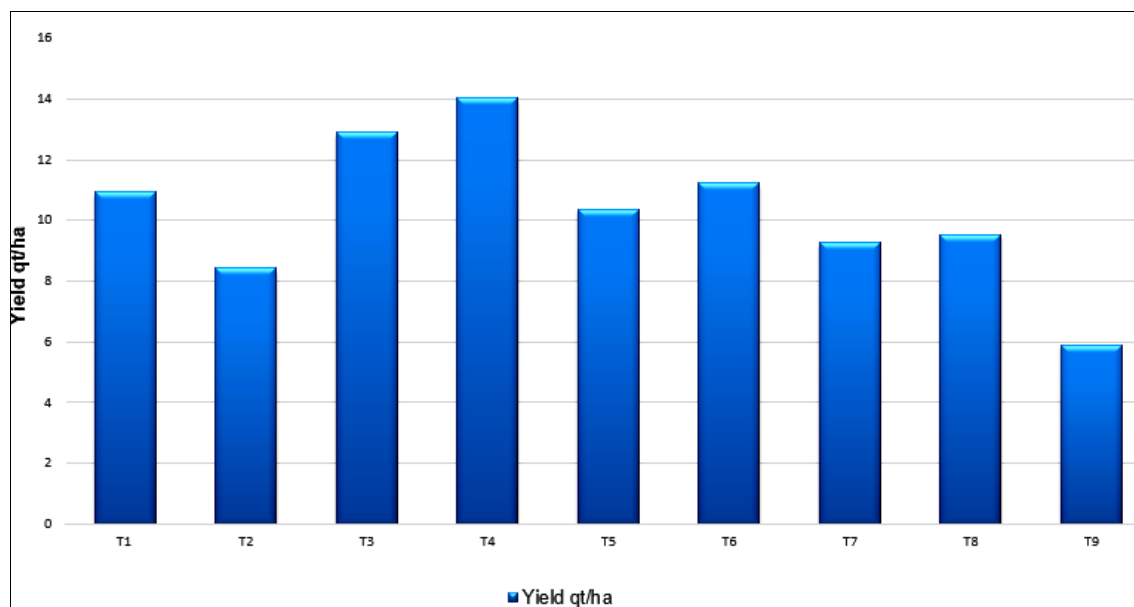


Fig 3: Effect of combination insecticides on grain yield of pigeonpea

Table 3: Incremental cost benefit ratio of combination insecticides 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 (water spray)	-	-	-	-	-	5.89	-	-	-	-	-

Conclusion

The study emphasizes the effectiveness of combination insecticides in managing the Tur plume moth (*Exelastis atomosa*) in pigeonpea. Treatments like Chlorantraniliprole + Lambda cyhalothrin, Thiamethoxam + Lambda cyhalothrin, and Novaluron + Indoxacarb significantly reduced the larval population of tur plume moth, leading to higher yields and better economic returns. Among these, Chlorantraniliprole + Lambda cyhalothrin was most effective in pest control and yield improvement, while Thiamethoxam + Lambda cyhalothrin showed the highest cost-benefit ratio.

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