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Efficacy of combination insecticides against pod borer complex on pigeonpea at harvest

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Abstract
A field study was conducted during 2024-2025 at the Entomology Section, College of Agriculture, Nagpur (Maharashtra) to evaluate the efficacy of combination insecticides against the pod borer complex on pigeonpea at harvest. The experiment aimed to assess the effectiveness of different insecticidal treatments against pod fly and lepidopteran pod borers and their influence on pod damage, grain damage, yield and economics. Nine combination insecticides were tested along with an untreated control under field conditions. Observations on per cent pod and grain damage were recorded at harvest and subjected to statistical analysis.

The results revealed that all insecticidal treatments significantly reduced pod and grain damage compared to the untreated control. Among the treatments, Chlorantraniliprole 9.3% + Lambda-cyhalothrin 4.6% ZC was the most effective in minimizing pod and grain damage. However, the highest grain yield (14.03 q/ha) was recorded by Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC. The untreated control recorded the maximum pod and grain damage by pod borer complex at harvest. 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: Pigeon pea, Efficacy, Pod fly, Lepidopteran pod borer, Chlorantraniliprole + Lambda-cyhalothrin, Thiamethoxam + Lambda-cyhalothrin

Introduction
Pigeonpea (*Cajanus cajan* (L.) Millisp.), commonly known as red gram, arhar or tur, is a major pulse crop in India and an important source of food and nutritional security. It contains about 22% protein, nearly three times that of cereals and is rich in lysine, riboflavin, thiamine, niacin and iron (Singh & Yadav, 2005) [10]. It is widely consumed as split pulse (dal) and complements cereal-based diets when combined with rice or wheat. In addition to its nutritional importance, pigeonpea improves soil fertility through biological nitrogen fixation and nutrient recycling, thereby supporting sustainable cropping systems (Snapp *et al.*, 2002) [13].

Over 300 insect species belonging to eight orders and 61 families have been recorded as pests of pigeonpea but the pod borer complex is responsible for approximately 60% of total yield loss (Wadaskar *et al.*, 2013) [17]. This complex primarily includes *Helicoverpa armigera*, *Melanagromyza obtusa* and *Exelastis atomosa*. *H. armigera* alone is capable of causing significant damage; the presence of a single larva per plant may result in yield losses of 10-15 kg/ha. Yield losses due to pod borers may range from 60-90% under favourable condition. (Subharani & Singh, 2007) [14]. The incidence of insect pests on pigeonpea has risen in recent years due to the increased cultivation of this crop over larger areas. Chemical control remains the most effective method for suppressing insect pests and achieving higher yields in pigeonpea. (Prasad and Singh, 1992) [8].

Damage by lepidopteran pod borers during flowering and pod formation, along with pod fly infestation during pod filling and maturity, poses a major challenge to achieving optimal yields (Wadaskar *et al.*, 2012) [16]. Farmers primarily rely on insecticides for pest management owing to their effectiveness and accessibility. Recently, combination insecticides have gained attention for improved control and reduced resistance development.

Given the economic importance of pigeonpea and severe losses due to the pod borer complex, this study was undertaken to evaluate the efficacy of combination insecticides against pod borer complex on pigeonpea at harvest and to identify effective, economically viable management strategies.

Materials and Methods

Materials

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.

Methods

1. Pod damage caused by Lepidopteran pod borers at harvest

At maturity, the number of pods showing Lepidopteran pod borer damage out of the total number of pods from five selected plants was recorded and expressed as percent pod damage.

2. Pod damage caused by pod fly at harvest

All the pods from 5 randomly selected plants at harvest were randomly collected from each plot and carefully observed to determine the damage caused by the pod fly.

3. Grain damage caused by pod fly at harvest

At harvest, grains from the pods of five selected plants were subjected to pod analysis for damage.

4. Grain yield

In order to compare the efficacy of different treatments the grain yield of net plot from each treatment was recorded after harvest of crop and the yield per plot were converted into per hectare yield.

5. Economics of different treatments

The Incremental Cost Benefit Ratio (ICBR) was worked out based on the realized net profits considering the cost of plant protection to exhibit the economic viability from the perspective of managing the pod borer complex infesting pigeonpea. To calculate the ICBR, the net profit, determined by deducting the cost of plant protection from the value of the extra yield was divided by the cost of plant protection.

The data on per cent damage was calculated by adopting the following formulae.

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

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

6. Statistical analysis

The statistical analysis was done to test the level of significance and to compare the efficacy of the treatments. The yield data also statistically analyzed after appropriate transformation to find out the effectiveness of various treatments.

Results and Discussion

1. Effect of different treatments on per cent pod damage at harvest

A. Effect of different treatments on per cent pod damage and per cent reduction over control by Lepidopteran pod borer at harvest

The data pertaining to pod damage by Lepidopteran pod borers is presented in table 1 and depicted in fig 1. Varied from 4.57 per cent to 14.42 per cent.

The lowest pod damage was recorded in T_4 (Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6% ZC) with 4.57 per cent and was followed by T_3 (Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC) with 5.22 per cent, T_6 (Novaluron 5.25% + Indoxacarb 4.5% SC) with 5.85 per cent and T_1 (Profenofos 40% + Cypermethrin 4% EC) with 6.10 per cent with 68.30, 63.80, 59.53 and 57.69 per cent reduction over control respectively and were found at par with each other.

The next treatment T_5 (Cypermethrin 10% + Indoxacarb 10% SC) recorded 6.31 per cent pod damage with 56.24 per cent reduction over control and was followed by T_8 (Beta-cyfluthrin 8.49% + Imidacloprid 19.81% ZC) with 6.91 per cent, T_2 (Pyriproxyfen 5% + Fenpropathrin 15% EC) with 6.98 per cent and T_7 (Acephate 50% + Imidacloprid 1.8% SP) with 7.29 per cent pod damage with 52.08, 51.59 and 49.44 per cent reduction over control respectively and were found at par with each other. The highest per cent pod damage was observed in T_9 (Untreated control) with 14.42 per cent which was statistically, inferior over all the treatments.

B. Effect of different treatments on per cent pod damage and per cent reduction over control caused by pod fly at harvest

The data pertaining to pod damage by pod fly is presented in table 1 and depicted in fig 2. Varied from 3.27 per cent to 12.66 per cent.

The lowest pod damage was recorded in T4 (Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6% ZC) with 3.27 per cent and was followed by T3 (Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC) with 4.81 per cent, T6 (Novaluron 5.25% + Indoxacarb 4.5% SC) with 5.37 per cent and T_1 (Profenofos 40% + Cypermethrin 4% EC) with 6.03 per cent with 74.17, 62.00, 57.58 and 52.36 per cent reduction over control respectively and were found at par with each other.

The next treatment T5 (Cypermethrin 10% + Indoxacarb 10% SC) recorded 6.19 per cent pod damage with 51.10 per cent reduction over control and was followed by T_8 (Beta-cyfluthrin 8.49% + Imidacloprid 19.81% ZC) with 7.16 per cent, T_7 (Acephate 50% + Imidacloprid 1.8% SP) with 7.70 per cent and T2 (Pyriproxyfen 5% + Fenpropathrin 15% EC) with 8.24 per cent pod damage with 43.44, 39.17 and 34.91 per cent reduction over control respectively and were found at par with each other. The highest per cent pod damage was observed in T9 (Untreated control) 12.66 per cent which was statistically, inferior over all the treatments.

C. Effect of different treatments on per cent pod damage and per cent reduction over control by pod borer complex at harvest

The data pertaining to pod damage by pod borer complex is presented in table 1 and depicted in fig 3. Varied from 7.84 per cent to 27.08 per cent.

The lowest pod damage was recorded in T_4 (Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6% ZC) with 7.84 per cent and was followed by T_3 (Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC) with 10.03 per cent, T_6 (Novaluron 5.25% + Indoxacarb 4.5% SC) with 11.22 per cent and T_1 (Profenofos 40% + Cypermethrin 4% EC) with 12.13 per cent with 71.04, 62.96, 58.56 and 55.20 per cent reduction over control respectively and were found at par with each other.

The next treatment T5 (Cypermethrin 10% + Indoxacarb 10% SC) recorded 12.50 per cent pod damage with 53.84 per cent reduction over control and was followed by T_8 (Beta-cyfluthrin 8.49% + Imidacloprid 19.81% ZC) with 14.07 per cent, T_7 (Acephate 50% + Imidacloprid 1.8% SP) with 14.99 per cent and T2 (Pyriproxyfen 5% + Fenpropathrin 15% EC) with 15.22 per cent pod damage with 48.04, 44.64 and 43.79 per cent reduction over control respectively and were found at par with each other. The highest per cent pod damage was observed in T9 (Untreated control) 27.08 per cent which was statistically, inferior over all the treatments.

D. Effect of different treatments on per cent grain damage caused by pod fly at harvest

The data pertaining to grain damage by pod fly is presented in table 1 and depicted in fig 4. Varied from 3.43 per cent to 12.73 per cent.

The lowest grain damage was recorded in T_4 (Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6% ZC) with 3.43 per cent and was followed by T_3 (Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC) with 4.56 per cent, T_6 (Novaluron 5.25% + Indoxacarb 4.5% SC) with 5.88 per cent, T_1 (Profenofos 40% + Cypermethrin 4% EC) with 6.16 per cent with 73.05, 64.17, 53.80 and 51.61 per cent reduction over control respectively and were found at par with each other.

The next treatment T_5 (Cypermethrin 10% + Indoxacarb 10% SC) recorded 6.70 per cent grain damage with 47.36 per cent reduction over control and was followed by T_8 (Beta-cyfluthrin 8.49% + Imidacloprid 19.81% ZC) with 7.40 per cent, T_7 (Acephate 50% + Imidacloprid 1.8% SP) with 7.58 per cent and T_2 (Pyriproxyfen 5% + Fenpropathrin 15% EC) with 9.22 per cent grain damage with 41.86, 40.45 and 27.57 per cent reduction over control respectively and were found at par with each other. The highest per cent grain damage was observed in T_9 (Untreated control) 12.73 per cent which was statistically, inferior over all the treatments.

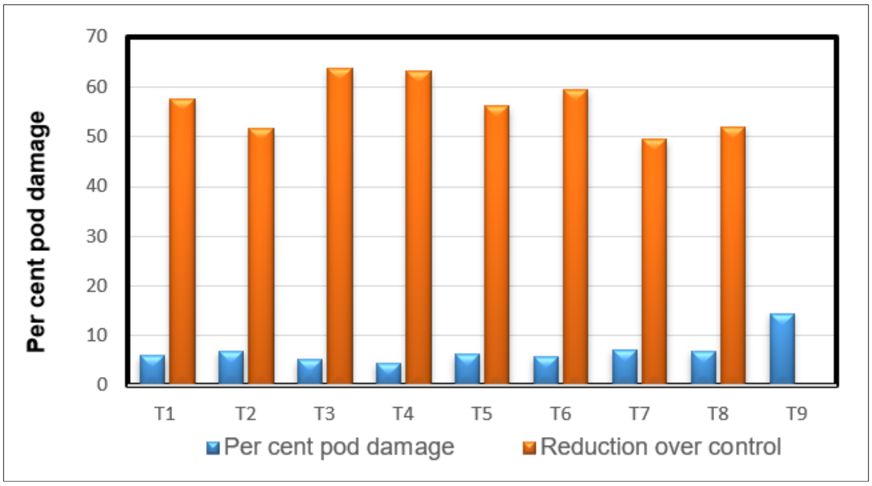

Fig 1: Effect of different treatments on per cent pod damage and per cent reduction over control by Lepidopteran pod borer at harvest

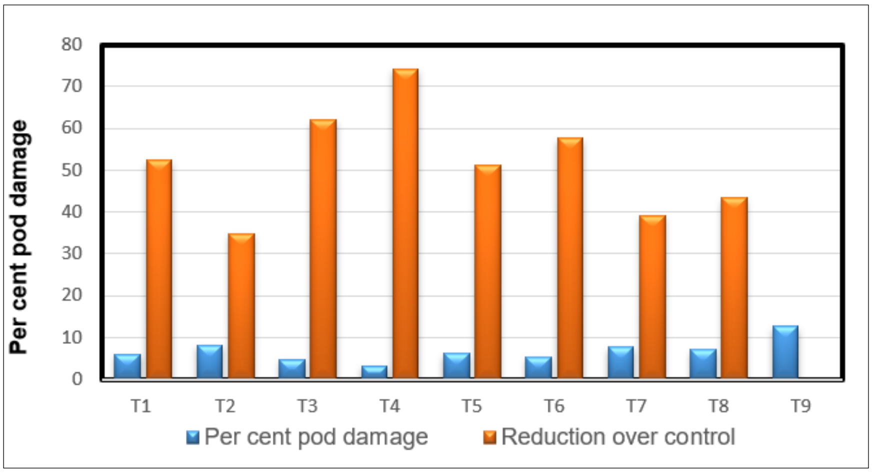

Fig 2: Effect of different treatments on per cent pod damage and per cent reduction over control by pod fly at harvest

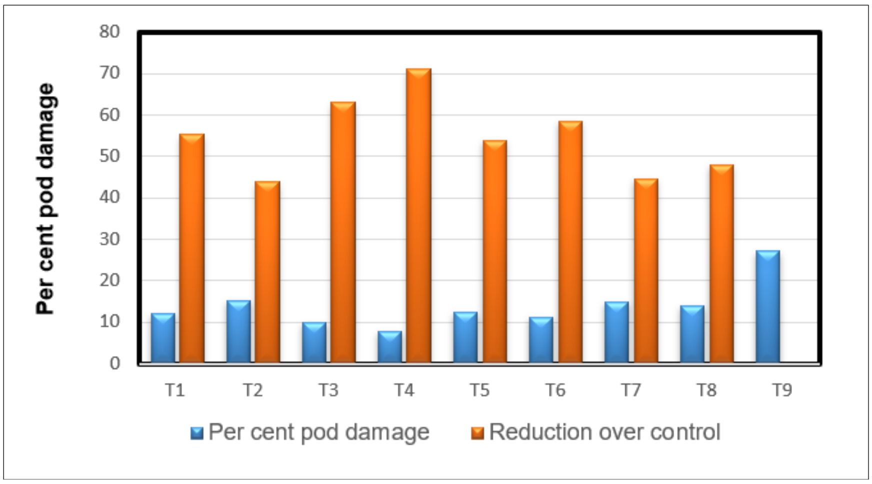

Fig 3: Effect of different treatments on per cent pod damage and reduction over control by pod borer complex at harvest

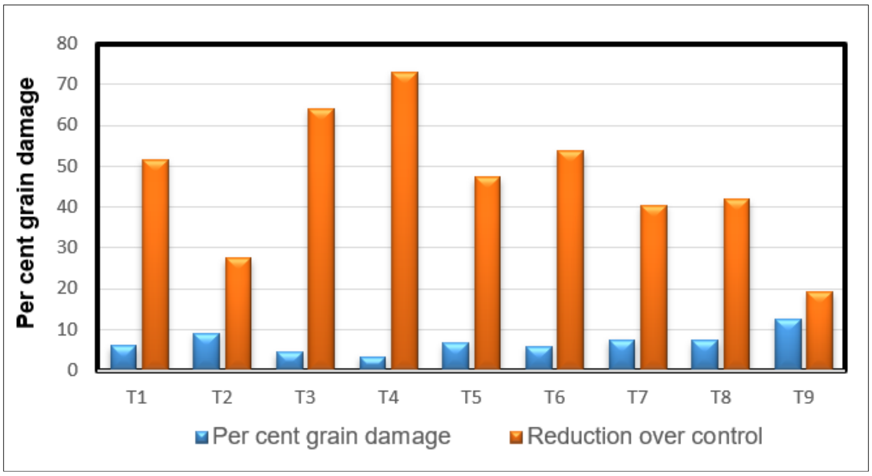

Fig 4: Effect of different treatments on per cent grain damage and reduction over control by pod fly at harvest

Table 1: Effect of different treatments on per cent pod damage and grain damage by pod borer complex at harvest

Tr. No.	Treatment	Lepidopteron pod borers*		Pod fly*		Pod borer Complex**		Pod fly*	
		% pod damage	Reduction over control	% pod damage	Reduction over control	% pod damage	Reduction over control	% Grain damage	Reduction over control
T_1	Profenofos 40% + Cypermethrin 4% EC	6.10 (2.47)	57.69	6.03 (2.45)	52.36	12.13 (20.38)	55.20	6.16 (2.48)	51.61
T_2	Pyriproxyfen 5% + Fenpropathrin 15% EC	6.98 (2.64)	51.59	8.24 (2.86)	34.91	15.22 (22.96)	43.79	9.22 (3.04)	27.57
T_3	Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC	5.22 (2.28)	63.80	4.81 (2.19)	62.00	10.03 (18.46)	62.96	4.56 (2.13)	64.17
T_4	Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6% ZC	4.57 (2.14)	68.30	3.27 (1.80)	74.17	7.84 (16.26)	71.04	3.43 (1.84)	73.05
T_5	Cypermethrin 10% + Indoxacarb 10% SC	6.31 (2.50)	56.24	6.19 (2.48)	51.10	12.50 (20.70)	53.84	6.70 (2.58)	47.36
T_6	Novaluron 5.25% + Indoxacarb 4.5% SC	5.85 (2.41)	59.53	5.37 (2.31)	57.58	11.22 (19.57)	58.56	5.88 (2.42)	53.80
T_7	Acephate 50% + Imidacloprid 1.8% SP	7.29 (2.69)	49.44	7.70 (2.77)	39.17	14.99 (22.78)	44.64	7.58 (2.75)	40.45
T_8	Beta-cyfluthrin 8.49% + Imidacloprid 19.81% ZC	6.91 (2.62)	52.08	7.16 (2.66)	43.44	14.07 (22.03)	48.04	7.40 (2.71)	41.86
T_9	Untreated control	14.42 (3.79)	-	12.66 (3.56)	-	27.08 (31.36)	-	12.73 (3.57)	-
	'F' Test	Sig	-	Sig	-	Sig	-	Sig	-
	SE (m)±	0.14	-	0.13	-	1.41	-	0.10	-
	CD at 5%	0.42	-	0.40	-	3.32	-	0.30	-
	CV (%)	9.31	-	8.93	-	14.59	-	6.70	-

(*Figure in parentheses are the corresponding square root transformed values)

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 in accordance with the findings of Sreekanth *et al.* (2014) [12] who reported that pod damage caused by the pod borer, *H. armigera* was lowest in plots treated with Flubendiamide 480 SC (1.16 percent), Chlorantraniliprole 20 SC (1.26 percent) and Spinosad 45 SC (1.92 percent), with 88.7, 87.7, and 81.2 percent reductions over control respectively.

The present findings are in agreement with Akkabathula and Rana, (2019) [2] who recorded the minimum percent grain damage by *M. obtusa* in case of Thiamethoxam 25 WG (2.90%) whereas maximum percent grain damage was recorded in Acephate 75 SP (4.06%). Percent grain damage by *M. obtusa* recorded in untreated control was 5.40%.

The present results are in agreement with those of Gosalwad *et al.* (1992) [4] who reported crop losses in pigeonpea due to *Helicoverpa armigera, Exelastis atomosa* and *Melanagromyza obtusa* up to 26.61 per cent which can be avoided by application of insecticides. Adgokar *et al.* (1993) [1] who reported avoidable incidence of pod borer complex in four pigeonpea cultivars of varying maturity groups at Akola was 40.55, 57.16 and 70.42 per cent, over C-11, respectively.

Similar findings are Khamoriya *et al.*, (2017) [5] who reported that sequential application of chlorantraniliprole 18.5 SC @ 3gm a.i./ha -indoxacarb 15.8 Ec @ 73 gm a.i./ha acetamiprid 20 SP @ 20 gm a.i./ ha recorded 13.01, 13.22 per cent grain damage in year 2015-16, 2016-17 respectively.

The present findings reported by *Swami et al.*, (2017) [15] 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) [12] 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) [6]. The present findings are consistent with those of Sreekanth *et al.*, (2015)[b] [11] who reported that the ICBR was greatest in Thiamethoxam (1:7.8) followed by Dimethoate (1:6.2), Acetamiprid (1:4.1) and Thiacloprid (1:3.4). The present findings also similar to Kumar *et al.*, (2016) [7] who revealed a higher benefit cost ratio of 3.20 in Thiamethoxam 25 WG as compare to other insecticides. Purohit *et al.*, (2017) [9] also revealed that the maximum protection cost benefit ratio was recorded in the treatment of Imidacloprid (1:11.83). It was followed by Profenofos (1:8.83), Thiamethoxam (1:7.05), Acephate (1:6.43), Diafenthiuron (1:4.72), Fipronil (1:3.61), Buprofezin (1:3.41), Clothianidin (1:1.91) and Neem oil (1:1.66). These findings support the present findings.

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

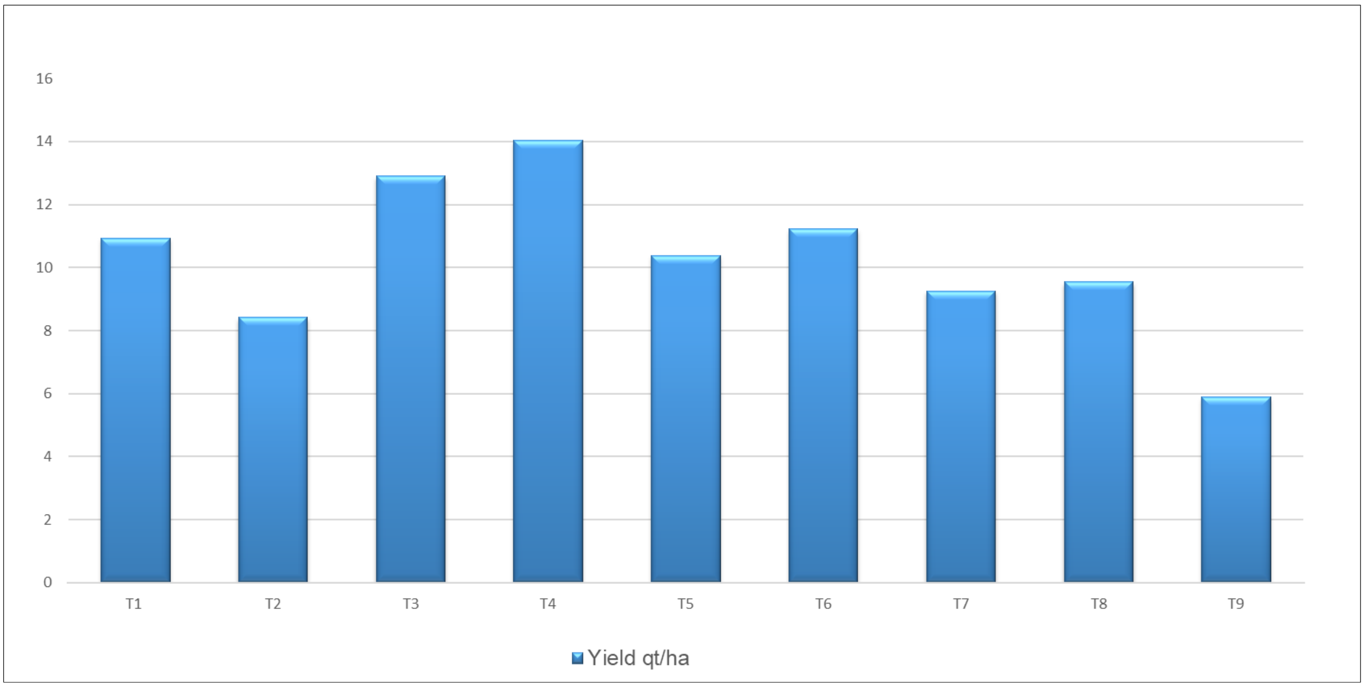

Fig 3: Effect of combination insecticides on grain yield of pigeonpea

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	-	-	-	-	-	5.89	-	-	-	-	-

Conclusion

The present study demonstrated that combination insecticides were effective in managing the pod borer complex on pigeonpea at harvest, significantly reducing pod and grain damage compared to the untreated control. Among the evaluated treatments, Chlorantraniliprole 9.3% + Lambda-cyhalothrin 4.6% ZC proved most effective in minimizing damage, while Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC recorded the highest grain yield and economic returns. The results indicate that judicious use of combination insecticides can offer effective and economically viable management of pod borer complex, thereby reducing yield losses and improving productivity of pigeonpea.

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