International Journal of Economic Plants

https://ojs.pphouse.org/index.php/IJEP

Crossref

IJEP March 2026, 13(2): 01-05

Article IJEP6860b

Full Research

Natural Resource Management

Doi: HTTPS://DOI.ORG/10.23910/2/2026.6860b

Bio-efficacy of Novel Acaricides against Bean Spider Mite, *Tetranychus ludeni* Zacher on Cowpea, (*Vigna unguiculata* L.)

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Article History

Received on 08th December, 2025
Received in revised form on 14th February, 2026
Accepted in final form on 01st March, 2026
Published on 09th March, 2026

Abstract

A Field experiment was conducted during summer (April–July), 2024 at vegetable research farm, Hi-Tech Horticulture, RPCAU, Pusa to evaluate bio-efficacy and economics of new generation acaricides against cowpea bean spider mite, *Tetranychus ludeni*. The experiment was organized using Randomized Block Design with seven treatments including an untreated control, replicated three times. Two foliar sprays were applied 15days after infestation reaching economic threshold level, recorded mite population density one day prior to spraying, 1, 3, 7 and 14 days after each spray application. The results after the first spray indicated that Abamectin 1.9 EC had the greatest efficacy mean (9.29 mites leaf^{-1}) followed by Fenpyroximate 5 EC (11.08 mites leaf^{-1}) and Bifenazate 50 WP (12.62 mites leaf^{-1}) compared to the untreated control (44.93 mites leaf^{-1}). Similar results were observed after the second spray application, as Abamectin 1.9 EC showed the maximum efficacy with a mean mite count of 0.64 mites leaf^{-1} followed by Fenpyroximate 5 EC (2.49 mites leaf^{-1}) and Bifenazate 50 WP (2.69 mites leaf^{-1}). In case of yield and B:C ratio, Abamectin 1.9 EC recorded the highest pod yield and B:C ratio (13.013 t ha^{-1} & 4.75:1 respectively). This was followed by Fenpyroximate 5 EC (12.234 t ha^{-1} & 4.05:1) and Bifenazate 50 WP (11.587 t ha^{-1} & 3.94:1), Propargite 57 EC (107.48 t ha^{-1} and 3.84:1), Chlorfenapyr 10 SC (10.126 t ha^{-1} and 3.38:1), Hexythiazox 5.45 EC (9.280 t ha^{-1} and 3.20:1) compared to untreated control (7.733 t ha^{-1} and 2.71:1).

Keywords: Abamectin, benefit cost ratio, bio-efficacy, cowpea

1. Introduction

Cowpea (*Vigna unguiculata* Linn.) is a member of Leguminosae family and is a key pulse crop and ranks second only to groundnut among major leguminous crops. Its widely grown as a grain legume, vegetable, fodder, green manure, cover crop and is commonly referred to as black-eyed pea or lobia in India (Abebe and Alemayehu, 2022). Cowpea exhibits diverse growth habits, ranging from erect and semi-erect to prostrate, trailing, or ascending forms. Its grains are notable for their high nutritional value, containing approximately 23–27% protein 1.8% fat, 60.3% carbohydrate along with essential vitamins and minerals, making it a valuable crop in efforts to combat global food insecurity (Singh et al., 2023). Cowpea adapts well to both low and high rainfall conditions and plays a vital role in various cropping systems such as catch cropping, intercropping, mixed cropping and as a green manure crop (Rajpoot and Rana, 2016; Osipitan et al., 2021). As a legume, cowpea possesses the ability to fix atmospheric nitrogen, enriching soil fertility, even under suboptimal conditions (Mekonnen et al., 2022; Becker et al., 2024). Cowpea is widely cultivated across India, with major production concentrated in states such as Uttar Pradesh, Andhra Pradesh, Karnataka, Punjab, Bihar, Madhya Pradesh, Haryana and Rajasthan. In Bihar, it holds considerable agricultural importance due to its short maturity period, high productivity and rapid growth. The principal cowpea-growing districts in the state include Muzaffarpur, Samastipur, Nalanda, Bhojpur, Vaishali, West Champaran and East Champaran. Farmers in these regions cultivate cowpea not only for its grains and vegetables but also to a limited extent for fodder purposes. Despite its significance cowpea production is suffered by numerous insect pests. Among these pests, on bio-efficacy and economics of six new generation acaricides against cowpea bean spider mite, *Tetranychus ludeni*. Zacher and *Tetranychus urticae* Koch (Tetranychidae) were the main species associated with the various crops (Reichert et al., 2024). However, *T. ludeni* has been gaining more attention due to its increasing occurrence (Reichert et al., 2024). This mite is a highly polyphagous species, known to infest over 250 plant hosts (Gotoh et al., 2015; Ragusa et al., 2019). It poses a serious threat to a range of crops including beans, carrots, eggplants, pumpkins and various cucurbits. Tetranychid mites, when feeding on plant cells, cause cytoplasm coagulation, nucleus destruction, modification of cell wall structure, and chloroplast degeneration, resulting in oxidation of the attacked areas with bronzed tones, necrotic spots and leaf drop (Moraes et al., 2024), which can cause reductions in plant productivity. On vegetables alone, yield losses due to mite infestations have been estimated at 10–15% (Shukla et al., 2017). Notably, this species is the only reported Tetranychid mite in India known to transmit plant viral diseases, especially the Dolichos Enation Mosaic Virus (DEMV) (Rajagopalan, 1974; Davis et al., 1982).

To minimize the substantial losses caused by mite infestations, it is crucial to adopt effective control strategies. Farmers commonly use chemical pesticides to control mite damage during different developmental stages of cowpea. However, the excessive and indiscriminate use of these chemicals often results in pest resurgence and negatively affects beneficial organisms, including natural predators and non-target species. Considering these challenges, newly developed acaricides when applied at recommended rates offer a more sustainable approach, as they can be effective even at lower concentrations.

2. Materials and Methods

2.1. Experimental details

Evaluated the bio-efficacy of new generation acaricides against *Tetranychus ludeni* on cowpea, a field experiment was conducted using a Randomized Block Design (RBD) at the vegetable research farm near Hi-Tech Horticulture, RPCAU, Pusa. The study included seven treatments and replicated thrice across 2×2 m^2 plots with 50×30 cm^2 spacing. Standard agronomic practices were followed. The sowing was done on March 10, 2024, with regular irrigation and intercultural operations like weeding and hoeing carried out at timely intervals. A total of two sprays were applied at 15-day intervals using a knapsack sprayer, with the first application initiated after infestation of mites. The acaricides tested included (T_1: Bifenazate 50% WP, T_2: Chlorfenapyr 10% SC, T_3: Fenpyroximate 5% EC, T_4- Abamectin 1.9% EC, T_5- Hexythiazox 5.45% EC, T_6: Propargite 57%EC (standard check) and T_7: Control).

2.2. Observations on bean spider mite

Observations were recorded from five randomly tagged plants per plot. From each plant, three leaves (top, middle, bottom) were sampled and mite counts were done under a stereoscopic binocular microscope. Data on mite population were collected one day before spraying (pre-treatment) and at 1, 3, 7 and 14 days after spray. For statistical analysis, the collected data were transformed using the square root formula √(x+0.5), and analysis of variance (ANOVA) was performed. Treatment differences were assessed using the critical difference (CD) at a 5% significance level.

2.3. Yield and benefit cost ratio (B:C ratio)

The impact of acaricide treatments on yield and economic returns was also evaluated. Pod yields were recorded separately for each treatment and later converted into kg ha^{-1}. Benefit Cost Ratio was calculated by considering the cost of insecticides, labour wages and equipment, summed up as variable and total costs. Gross returns were computed based on market prices and net returns were derived by subtracting total costs from gross returns. This comprehensive evaluation helped determine not only the biological effectiveness of the acaricides but also their economic viability for farmers.

3. Results and Discussion

3.1. Efficacy against mite population

The first spray as presented in (Table 1), indicated of various acaricides on cowpea against *Tetranychus ludeni* showed promising results in reducing mite populations. Among the tested treatments, Abamectin 1.9 EC was found the most effective in controlling the incidence of the *T. ludeni*, with the overall mean (9.29 mites $leaf^{-1}$). This was followed by Fenpyroximate 5 EC (11.08 mites $leaf^{-1}$) and Bifenazate 50 WP with 12.62 mites $leaf^{-1}$. Further, highest population of mites were recorded in Hexythiazox 5.45 EC (14.74 mites $leaf^{-1}$) followed by Cholrfenapyr 10 SC (13.93 mites $leaf^{-1}$) and Propargite 57 EC (standard check) with 13.82 mites $leaf^{-1}$. However, control plot was recorded significantly highest population with 44.93 mites $leaf^{-1}$. The second spray as presented in (Table 2), reinforced the effectiveness of the acaricides, with similar trends observed in mite population suppression. Abamectin 1.9 EC consistently demonstrated that the most effective reduction of *T. ludeni* with overall mean population of 0.64 mites $leaf^{-1}$. Fenpyroximate 5 EC (2.49 mites $leaf^{-1}$) and Bifenazate 50 WP (2.69 mites $leaf^{-1}$) also maintained effective control but slightly lagged behind Abamectin, while Chlorfenapyr 10 SC (3.66 mites $leaf^{-1}$) and Hexythiazox 5.45 EC (4.02 mites $leaf^{-1}$) were found less effective, although they still outperformed the control. Propargite 57 EC (standard check) showed moderate efficacy throughout the observation period. Overall, the trend in effectiveness was the same as observed during the first spray, reinforcing the consistency of Abamectin's superior performance in mite control. The present finding was in conformity with (Singh et al., 2018; Gamit and Verma, 2024) who observed that Abamectin 1.5 EC was the most effective up to 14^{th} days in reducing mite population and performed better efficacy compared to the rest of all acaricides. Raina (2016) found that after fourteen days of first spray, the best effect was given by Abamectin 1.8 EC

Table 1: Bio-efficacy of newer acaricides against *T. ludeni* on cowpea after first spray

Name of the treatment	Dosage ha^{-1}	** Mean number of mites leaf^{-1} after spraying					Mean
		1DBS	1 DAS	3 DAS	7 DAS	14 DAS	
T_1: Bifenazate 50%WP	750 gm	38.93 (6.28)	16.27 (4.10)	10.53 (3.32)	9.47 (3.16)	14.20 (3.83)	12.62 (3.62)
T_2: Chlorfenapyr 10%SC	750 ml	41.47 (6.48)	18.73 (4.39)	11.20 (3.42)	10.27 (3.28)	15.53 (4.00)	13.93 (3.80)
T_3: Fenpyroximate 5% EC	400 ml	37.60 (6.14)	15.60 (4.01)	8.40 (2.98)	8.13 (2.94)	12.20 (3.56)	11.08 (3.40)
T_4: Abamectin 1.9% EC	375 ml	48.93 (7.03)	15.47 (4.00)	8.27 (2.96)	7.20 (2.77)	6.23 (2.59)	9.29 (3.13)
T_5: Hexythiazox 5.45% EC	500 ml	40.93 (6.39)	16.40 (4.11)	14.27 (3.84)	12.27 (3.57)	16.00 (4.06)	14.74 (3.90)
T_6: Propargite 57% EC	750 ml	39.73 (6.33)	19.87 (4.51)	10.67 (3.34)	9.87 (3.22)	14.87 (3.92)	13.82 (3.78)
T_7: Control	-	42.27 (6.54)	39.87 (6.35)	44.93 (6.74)	52.53 (7.28)	55.60 (7.49)	48.23 (6.98)
SEm±	-	0.33	0.25	0.22	0.16	0.18	0.19
CD (p=0.05)	-	NS	0.76	0.68	0.49	0.56	0.57

*Figures in parenthesis are √X+0.5 transformed values; **: Mean of three replications, five plant from each replication and three leaves from each plant; DBS: Day before spray; DAS: Day after spray

Table 2: Bio-efficacy of newer acaricides against *T. ludeni* on cowpea after second spray

Name of the treatment	Dosage ha^{-1}	** Mean number of mites leaf^{-1} after spraying					Mean
		1DBS	1 DAS	3 DAS	7 DAS	14 DAS	
T_1: Bifenazate 50%WP	750 gm	14.20 (3.83)	4.53 (2.24)	1.93 (1.56)	0.30 (0.89)	4.00 (2.12)	2.69 (1.79)
T_2: Chlorfenapyr 10%SC	750 ml	15.53 (4.00)	5.97 (2.54)	2.13 (1.62)	1.67 (1.47)	4.87 (2.32)	3.66 (2.04)
T_3: Fenpyroximate 5% EC	400 ml	12.20 (3.56)	4.50 (2.22)	1.57 (1.44)	0.23 (0.85)	3.67 (2.04)	2.49 (1.73)
T_4: Abamectin 1.9% EC	375 ml	6.23 (2.59)	1.33 (1.35)	1.07 (1.25)	0.13 (0.80)	0.01 (0.71)	0.64 (1.07)
T_5: Hexythiazox 5.45% EC	500 ml	16.00 (4.06)	6.53 (2.64)	2.63 (1.77)	1.83 (1.53)	5.10 (2.37)	4.02 (2.13)
T_6: Propargite 57% EC	750 ml	14.87 (3.92)	6.07 (2.55)	2.00 (1.58)	1.53 (1.43)	4.10 (2.14)	3.43 (1.98)
T_7: Control	-	55.60 (7.49)	46.83 (6.88)	49.93 (7.10)	52.13 (7.25)	58.33 (7.67)	51.81 (7.23)
SEm±	-	0.18	0.12	0.12	0.09	0.11	0.16
CD (p=0.05)	-	0.56	0.37	0.37	0.26	0.34	0.48

*Figures in parenthesis are √X+0.5 transformed values; **: Mean of three replications, five plant from each replication and three leaves from each plant; DBS: Day before spray; DAS: Day after spray

which reduced the bean mite population by 70.32%. This was followed by the treatment of Fenpyroximate 5 EC in different plots. Ramjibhai (2015) also reported that Abamectin was the most effective, resulting in the highest mite mortality of mite followed by fenazaquin at par with each other. Propargite. Chlorfenapyr and Fenpyroximate showed moderate control, while dicofol, diafenthiuron and sulphur were less effective against okra mite. The present finding was partially with (Hasnain et al., 2023) who reported that Acaricide hexythiazon gave comparative better control among all the acaricides.

3.2. Yield

Following the application of two acaricidal sprays, significant differences were observed in the crop yield of cowpea as influenced by treatments against *T. ludeni* (Table 3). The highest yield as presented in was achieved with Abamectin 1.9 EC, recording 13.013 t ha^{-1} followed by Fenpyroximate 5 EC (12.234 t ha^{-1}), Bifenazate 50 WP (11.587 t ha^{-1}), Propargite 57 EC (10.748 t ha^{-1}) and Chlorfenapyr 10 SC (10.126 t ha^{-1}). Although Hexythiazox 5.45 EC resulted in the lowest yield among the treated plots at 9.28 t ha^{-1}, it still outperformed the control yield of 7.733 t ha^{-1}. These findings were in line with those of Siddhapara and Virani (2016), who reported a notably higher fruit yield with Abamectin treatment, emphasizing its effectiveness against *T. urticae* under field conditions. (Gamit and Verma, 2024) who also reported that the highest yield was recorded in the plot treated with Abamectin.

3.3. Determination of benefit cost ratio

The economic analysis based on benefit-cost (B:C) ratio as presented in (Table 4), indicated further affirmed the superior performance of Abamectin 1.9 EC, which recorded the highest B:C ratio of 4.75:1. Fenpyroximate 5 EC followed with a B:C ratio of 4.05:1, while Bifenazate 50 WP and Propargite 57 EC recorded 3.94:1 and 3.84:1, respectively. Chlorfenapyr 10 SC and Hexythiazox 5.45 EC yielded slightly lower ratios at 3.38:1

Table 3: Effect of acaricidal treatments on yield of cowpea during summer, 2024

Name of the treatment	Dosage ha^{-1}	Mean yield ($q\ ha^{-1}$)	Additional yield over control ($q\ ha^{-1}$)	Yield increase over control (%)
T_1: Bifenazate 50%WP	750 gm	115.87	38.57	49.90
T_2: Chlorfenapyr 10%SC	750 ml	101.26	23.96	31.00
T_3: Fenpyroximate 5% EC	400 ml	122.34	45.04	58.27
T_4: Abamectin 1.9% EC	375 ml	130.13	52.83	68.34
T_5: Hexythiazox 5.45% EC	500 ml	92.80	15.5	20.05
T_6: Propargite 57% EC	750 ml	107.48	30.18	39.04
T_7: Control	-	77.33	-	-

Table 4: Economics of different management treatments applied against bean spider mite on cowpea

Name of the treatment	Common cost	Variable cost	Total cost	Yield ($t\ ha^{-1}$)	Price (₹ ha^{-1})	Gross returns	Net returns	B:C Ratio
		Insecticides+labour (spraying)						
T_1: Bifenazate 50%WP	45890	5727.5	51617.5	11.587	2200	254914	203296.5	3.94:1
T_2: Chlorfenapyr 10%SC	45890	4925	50815	10.126	2200	222772	171957	3.38:1
T_3: Fenpyroximate 5% EC	45890	7440	53330	12.234	2200	269148	215818	4.05:1
T_4: Abamectin 1.9% EC	45890	3939.5	49829.5	13.013	2200	286286	236456.5	4.75:1
T_5: Hexythiazox 5.45% EC	45890	2684	48574	9.280	2200	204160	155586	3.20:1
T_6: Propargite 57% EC	45890	2952.5	48842.5	10.748	2200	236456	187613.5	3.84:1
T_7: Control	45890	0	45890	7.733	2200	170126	124236	2.71:1

*Mean of three replications; Number of spray: 2; Price of marketable cowpea: ₹ @ 2200 q^{-1}; No of labours required :2 persons $spray^{-1}\ ha^{-1}$; Labour charge: 410 $day^{-1}\ person^{-1}$

and 3.20:1, respectively. The untreated control recorded the lowest B:C ratio of 2.71:1. These outcomes align with the observations of Pushpalatha et al. (2021), who also reported that Abamectin had the highest B:C ratio in grape production. Hence, based on both yield and economic returns, Abamectin 1.9 EC proved the most effective treatment, offering substantial benefits over other acaricidal options. The highest B:C ratio was recorded in the plot treated with Fenpyroximate followed by Chlorfenapyr (Rajashekarappa et al., 2024)

4. Conclusion

Abamectin 1.9 EC consistently showed superior efficacy in suppressing *Tetranychus ludeni*, leading to lower mite populations, higher cowpea yield and benefit–cost ratio. This was followed by Fenpyroximate and Bifenazate, while other acaricides Chlorfenapyr 10 SC and Hexythiazox proved moderate control compared to the untreated check.

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