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BIOEFFICACY AND COST-BENEFIT ANALYSIS OF BIOPESTICIDES AGAINST THRIPS, *THRIPS TABACI* IN GARLIC

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ABSTRACT

A field experiment was conducted at Navsari Agricultural University during *Rabi* 2024-25 to evaluate the efficacy of biopesticides against *Thrips tabaci* in garlic (Gujarat Garlic-7). Eight treatments, including *Metarhizium anisopliae*, *Beauveria bassiana*, *Lecanicillium lecanii*, fresh cow urine, azadirachtin 10000 ppm, Novel Plus, NSKE (5%) and a control, were applied twice at 14-day intervals. Azadirachtin (0.04%) was most effective in reducing thrips (6.32 thrips/plant), followed by NSKE (7.18) and Novel Plus (8.24). *L. lecanii*, *M. anisopliae*, and *B. bassiana* showed moderate control, while cow urine was least effective. All treatments significantly increased bulb yield over control (40.00 q/ha), with the highest in azadirachtin (64.91 q/ha), NSKE (62.50 q/ha) and novel Plus (52.98 q/ha). NSKE yielded the highest net return (` 105025/ha), followed by azadirachtin (` 68241/ha) and Novel Plus (` 62648/ha). The highest ICBR was recorded with novel Plus (1:17.65), while azadirachtin, despite high efficacy, showed the lowest (1:1.16) due to its cost.

Key words : Garlic, *Thrips tabaci*, ICBR, Eco-friendly pest management.

Introduction

Garlic (*Allium sativum* L.) is a significant bulbous vegetable crop produced in the world as a source of culinary, medicinal and therapeutic values. Gujarat contributes largely to the production of garlic in India, which is a major producer of garlic (Anonymous, 2022). Allicin, an antimicrobial bioactive compound is present in garlic (Augusti, 1977). Garlic is also susceptible to a number of biotic stresses especially the insect pests despite its economic and health importance. One of them is *Thrips tabaci* Lindeman, a major pest that has major damage on the crops of Garlic. The pest associates with rasping and sucking of the leaf sap hence causing silvering, curling, drying of the tip and decline of photosynthesis consequently decreasing the yield and quality of the bulbs (Butani, 1976). Thrips also serve as vectors of different plant viruses besides causing direct losses, which makes their presence to worsen crop losses (Jones, 2005).

Traditional thrips management is based majorly on the use of chemical insecticides. Nevertheless, their excessive use has led to resistance to pesticides, resurgence and adverse effects to the environment due to pests (Ahmadi, 2004). This has seen a surge in the interest in safer and eco-friendly methods of pest control. Neem seed kernel extract (NSKE) and azadirachtin are examples of botanical that appear to be effective in thrips management and have antifeedant, ovicidal and growth-inhibiting properties (Nareshchandra, 2016). Entomopathogenic fungi such as *Beauveria bassiana*, *Metarhizium anisopliae* and *Lecanicillium lecanii* have gained recognition in recent years as biopesticides since they can naturally infect insect pests and kill them (Ain, 2021).

The seasonal changes and efficacy of biopesticide in controlling *T. tabaci* in onion have been also reported

in a few studies (Dewangan, 2021). Nevertheless, not much has been done in regards to the comparative analysis of various biopesticides on garlic under the agro- climatic conditions. Therefore, the current study was conducted to determine the effectiveness of the chosen biopesticides such as botanicals and microbial agents against the *T. tabaci* in garlic. The objective of the study was also to establish their effects on the yield of the bulb and financial gains on the basis of cost-benefit.

Materials and Methods

The experiments was conducted under field condition at college farm, Navsari Agricultural University in the *Rabi* season 2024-25 to evaluate the efficacy of eight bio pesticides (*Metarhizium anisopliae*, *Beauveria bassiana* and *Lecanicillium lecanii* (1.15% WP; 1 × 10x CFU ml^{-1}) each at 0.007% (60 g/10 L), fresh cow urine at 5% (1000 ml/10 L), azadirachtin 10,000 ppm at 0.04% (400 ml/10 L), Novel Plus at 2% (200 ml/10 L), neem seed kernel extract (NSKE) at 5% (500 g/10 L), and an untreated control) against thrips, *T. tabaci*. The sowing was done during the fourth week of November. The variety Gujarat Garlic-7 (GG-7) was sown with a spacing of 15 × 10 cm between plants in 1.3 × 1.8 m^2 plots (Total area- 200 m^2). The experiment was carried out in Randomized Block Design (R.B.D.) with ten treatments and three replications.

The pre-treatment count of thrips the day before and the post-treatment counts at 1, 3, 5, 7, 10 and 14 days after spraying were recorded randomly for 10 plants from each plot for both the first and second spray. The bulb yield was also recorded separately after harvest from each plot and converted to hectare basis. The data was converted into square root transformation and reduction over control. The mean comparisons were made by Duncan's new multiple range test (DNMRT). The data obtained was analyzed through OPSTAT software.

The economics of different biopesticides were evaluated against thrips and the Incremental cost-benefit ratio (ICBR) was worked out. For this purpose, the total cost of plant protection was calculated based on the biopesticide formulation used and labour charges for their application. Realization over control was worked out by considering the prevailing market price of garlic for each treatment. ICBR is achieved by dividing the net gain over control with cost of treatment.

The treatments were applied at the time of thrips incidence (13th January, 2025) and with a battery-operated knapsack sprayer using 500 litres per hectare. The sprayer and measuring cylinder were cleaned thoroughly before the application of each treatment and the subsequent spray was done at 14 days interval (28th January, 2025). Every care was taken to avoid drifting to adjacent plots.

Results and Discussion

First spray

The thrips population across treatments ranged from 7.36 to 18.45 thrips/plant (Table 1). Azadirachtin 10000 ppm (0.04%) recorded the lowest population (7.36 thrips/plant), followed by NSKE 5% (8.07) and Novel Plus 2% (8.96), which were at par. *Lecanicillium lecanii* (0.007%) was next most effective (11.70), followed by *Metarhizium anisopliae* (12.33), *Beauveria bassiana* (12.53) and cow urine 5% (13.04). The highest thrips population (18.45 thrips/plant) was observed in the untreated control.

Second spray

The second spray are presented in Table 2 revealed that the thrips population varied from 5.28 to 24.95 thrips per plant azadirachtin 10000 ppm at 0.04 per cent recorded significantly the lowest (5.28 thrips/plant) thrips population per plant followed by NSKE at 5 per cent (6.28 thrips/plant), which was at par with novel plus at 2 per cent (7.53 thrips/plant). The next effective treatment was *L. lecanii* at 0.007 per cent (10.34 thrips/plant) followed by *M. anisopliae* at 0.007 per cent (10.98 thrips/plant) which was at par with *B. bassiana* at 0.007 per cent (11.33 thrips/plant). The less effective treatment was fresh cow urine at 5 per cent (11.82 thrips/plant). The maximum (24.95 thrips/plant) number of thrips population was found in control.

Pooled over

Pooled data over different periods of observation after the second spray are presented in Table 3 revealed that the thrips population varied from 5.28 to 24.95 thrips per plant.

Azadirachtin 10000 ppm at 0.04 per cent recorded significantly the lowest (5.28 thrips/plant) population per plant followed by NSKE at 5 per cent (6.28 thrips/plant) which was at par with novel plus at 2 per cent (7.53 thrips/plant). The next effective treatment was *L. lecanii* at 0. (10.98 thrips/plant) which was at par with *B. bassiana* at 0.007 per cent (11.33 thrips/plant). The less effective treatment was fresh cow urine at 5 per cent (11.82 thrips/plant). The maximum (24.95 thrips/plant) number of thrips population was found in control. The present findings align with Patel *et al*. (2019), who reported cow urine (100%) + neem oil (1%) as highly effective against thrips and other sucking pests. Cow urine alone or with NSKE was also found effective. Wayal *et al*. (2019) observed that *L. lecanii* caused the highest thrips mortality in garlic, followed by *M. anisopliae* and

Table 1 : Efficacy of different biopesticides against thrips, *T. tabaci* on garlic during *Rabi*, 2024 -25 (First spray).

S. no.	Treatments	No. of thrips/plant							
		BS	1 DAS	3 DAS	5 DAS	7 DAS	10 DAS	14 DAS	Pooled
T_1	*Metarhizium anisopliae* 1.15% x (1 x 10^8 CFU/ml)	14.23(3.82)	13.77(3.77)	13.10(3.68)^{def}	12.20(3.55)^{de}	11.23(3.42)^{de}	11.50(3.46)^{de}	12.20(3.56)^{cde}	12.33(3.57)^{de}
T_2	*Beauveria bassiana* 1.15% x (1 x 10^8 CFU/ml)	14.13(3.81)	13.85(3.78)	13.40(3.72)^{efg}	12.50(3.59)^{defg}	11.34(3.43)^{def}	11.60(3.47)^{def}	12.50(3.60)^{def}	12.53(3.60)^{def}
T_3	*Lecanicillium lecanii* 1.15% x (1 x 10^8 CFU/ml)	14.33(3.84)	13.40(3.72)	12.73(3.63)^{cde}	11.98(3.52)^{d}	10.10(3.25)^{d}	10.51(3.31)^{cd}	11.50(3.46)^{cd}	11.70(3.48)^{d}
T_4	Fresh cow urine	14.83(3.90)	14.23(3.83)	12.69(3.62)^{cd}	12.40(3.58)^{def}	12.70(3.63)^{defg}	12.95(3.66)^{defg}	13.24(3.70)^{efg}	13.04(3.67)^{defg}
T_5	Azadirachtin 10000 ppm	13.76(3.76)	11.10(3.40)	7.50(2.82)^{a}	6.40(2.62)^{a}	5.78(2.50)^{a}	6.40(2.62)^{a}	7.00(2.73)^{a}	7.36(2.80)^{a}
T_6	Novel plus	13.67(3.75)	12.63(3.61)	9.20(3.11)^{abc}	7.60(2.84)^{abc}	7.10(2.75)^{abc}	7.90(2.89)^{bc}	9.30(3.12)^{abc}	8.96(3.05)^{bc}
T_7	NSKE	14.43(3.85)	11.80(3.50)	8.10(2.93)^{ab}	7.00(2.73)^{ab}	6.50(2.64)^{ab}	7.10(2.75)^{ab}	7.90(2.89)^{ab}	8.07(2.91)^{ab}
T_8	Control (water spray)	14.36(3.85)	14.32(3.84)	16.10(4.06)^{h}	17.20(4.19)^{h}	19.20(4.43)^{h}	21.30(4.66)^{h}	22.00(4.73)^{h}	18.45(4.33)^{h}
S.Em. ± Treatment (T)		0.26	0.21	0.19	0.19	0.15	0.16	0.17	0.07
P		-	-	-	-	-	-	-	0.06
T x P		-	-	-	-	-	-	-	0.18
C D at (5%) Treatment (T)		N.S.	N.S.	0.56	0.58	0.44	0.48	0.53	0.20
P		-	-	-	-	-	-	-	0.18
T x P		-	-	-	-	-	-	-	0.50
C V %		11.73	9.69	9.32	10.06	7.74	8.21	8.62	9.01

Note: NSKE: Neem Seed Kernel Extract; BS: Before Spray; DAS: Days After Spray; Figures in the parentheses are square root transformed (“ (x + 0.5)) values and those outside are original values; Means followed by same letter in a column do not differ significantly by DNMRT (p=0.05).

Table 2 : Efficacy of different biopesticides against thrips, *T. tabaci* on garlic during *Rabi*, 2024-25 (Second spray).

S. no.	Treatments	No. of thrips/plant							
		BS	**1 DAS**	**3 DAS**	**5 DAS**	**7 DAS**	**10 DAS**	**14 DAS**	**Pooled**
T_1	*Metarhizium anisopliae* 1.15% x (1 x 10^8 CFU/ml)	12.20(3.56)^{cde}	12.00(3.52)^{cde}	11.70(3.48)^{def}	10.60(3.32)^{cde}	9.80(3.20)^{de}	10.60(3.32)^{de}	11.20(3.41)^{cde}	10.98(3.37)^{de}
T_2	*Beauveria bassiana* 1.15% x (1 x 10^8 CFU/ml)	12.50(3.60)^{def}	12.30(3.56)^{cdef}	11.90(3.51)^{defg}	11.06(3.39)^{def}	10.30(3.28)^{def}	10.80(3.35)^{def}	11.60(3.47)^{def}	11.33(3.43)^{def}
T_3	*Lecanicillium lecanii* 1.15% x (1 x 10^8 CFU/ml)	11.50(3.46)^{cd}	11.30(3.42)^{bcd}	10.91(3.37)^{cd}	10.10(3.25)^{cd}	9.30(3.12)^{d}	9.90(3.22)^{cd}	10.50(3.31)^{cd}	10.34(3.28)^{d}
T_4	Fresh cow urine	13.24(3.70)^{efg}	12.80(3.63)^{defg}	11.40(3.44)^{cde}	11.18(3.41)^{efg}	11.69(3.48)^{defg}	12.12(3.54)^{efg}	11.70(3.49)^{efg}	11.82(3.50)^{efg}
T_5	Azadirachtin 10000 ppm	7.00(2.73)^{a}	6.50(2.64)^{a}	5.90(2.52)^{a}	5.00(2.34)^{a}	4.10(2.14)^{a}	4.70(2.28)^{a}	5.50(2.44)^{a}	5.28(2.40)^{a}
T_6	Novel plus	9.30(3.12)^{abc}	8.60(3.00)^{abc}	7.90(2.89)^{bc}	7.20(2.77)^{abc}	6.40(2.62)^{bc}	7.00(2.73)^{abc}	8.10(2.93)^{abc}	7.53(2.82)^{bc}
T_7	NSKE	7.90(2.89)^{ab}	7.40(2.80)^{ab}	6.80(2.70)^{ab}	6.10(2.56)^{ab}	5.30(2.40)^{ab}	5.80(2.50)^{ab}	6.30(2.60)^{ab}	6.28(2.60)^{ab}
T_8	Control (water spray)	22.00(4.73)^{h}	22.30(4.76)^{h}	23.60(4.90)^{h}	24.70(5.00)^{h}	24.30(4.97)^{h}	26.90(5.22)^{h}	27.30(5.26)^{h}	24.95(5.03)^{h}
S.Em. ± Treatment (T)		0.17	0.23	0.18	0.19	0.18	0.17	0.17	0.08
P		-	-	-	-	-	-	-	0.07
T x P		-	-	-	-	-	-	-	0.19
C D at (5%) Treatment (T)		0.53	0.71	0.55	0.58	0.55	0.52	0.52	0.22
P		-	-	-	-	-	-	-	0.19
T x P		-	-	-	-	-	-	-	0.53
C V %		8.62	11.76	9.41	10.15	9.99	9.08	8.73	9.93

Note: NSKE: Neem Seed Kernel Extract; BS: Before Spray; DAS: Days After Spray; Figures in the parentheses are square root transformed (“ (x + 0.5)) values and those outside are original values; Means followed by same letter in a column do not differ significantly by DNMRT (p=0.05).

Table 3 : Efficacy of different biopesticides against *T. tabaci* on garlic during *Rabi* 2024-25 (pooled over).

S. no.	Treatments	No. of thrips/plant			Reduction of thrips population over control (%)
		First spray	Second spray	Pooled over sprays	
T_1	*Metarhizium anisopliae* 1.15% x (1 x 10^8 CFU/ml)	12.33(3.57)^{de}	10.98(3.37)^{de}	11.66(3.48)^{de}	46.27
T_2	*Beauveria bassiana* 1.15% x (1 x 10^8 CFU/ml)	12.53(3.60)^{def}	11.33(3.43)^{def}	11.93(3.52)^{def}	45.02
T_3	*Lecanicillium lecanii* 1.15% x (1 x 10^8 CFU/ml)	11.70(3.48)^{d}	10.34(3.28)^{d}	11.02(3.38)^{d}	49.22
T_4	Fresh cow urine	13.04(3.67)^{defg}	11.82(3.50)^{efg}	12.43(3.59)^{efg}	42.71
T_5	Azadirachtin 10000 ppm	7.36(2.80)^{a}	5.28(2.40)^{a}	6.32(2.59)^{a}	70.88
T_6	Novel plus	8.96(3.05)^{bc}	7.53(2.82)^{bc}	8.24(2.94)^{c}	62.03
T_7	NSKE	8.07(2.91)^{ab}	6.28(2.60)^{ab}	7.18(2.75)^{b}	66.91
T_8	Control (water spray)	18.45(4.33)^{h}	24.95(5.03)^{h}	-	-
	$Em ± Treatment (T)	0.07	0.08	0.05	-
	Season (S)	-	-	0.18	-
	Period (P)	0.06	0.07	0.06	-
	T x S	-	-	0.05	-
	T x P	0.18	0.19	0.17	-
	S x P	-	-	0.06	-
	T x S x P	-	-	0.17	-
	C D at (5%) Treatment (T)	0.20	0.22	0.14	-
	Season (S)	-	-	0.05	-
	Period (P)	0.18	0.19	0.17	-
	T x S	-	-	0.14	-
	T x P	0.50	0.53	0.48	-
	S x P	-	-	0.17	-
	T x S x P	-	-	0.48	-
	C V %	9.01	9.93	8.91	-

Note: NSKE: Neem Seed Kernel Extract; Figures in the parentheses are square root transformed ($\sqrt{(x + 0.5)}$) values and those outside are original values; Means followed by same letter in a column do not differ significantly by DNMRT (p=0.05).

Table 4 : Bulb yield of garlic in different treatments during *Rabi*, 2024.

S. no.	Treatment	Bulb yield (q/ha)
T_1	*Metarhizium anisopliae* 1.15% x (1 x 10^8 CFU/ml)	50.12^{c}
T_2	*Beauveria bassiana* 1.15% x (1 x 10^8 CFU/ml)	49.04^{c}
T_3	*Lecanicillium lecanii* 1.15% x (1 x 10^8 CFU/ml)	51.10^{bc}
T_4	Fresh cow urine	44.00^{cd}
T_5	Azadirachtin 10000 ppm	64.91^{a}
T_6	Novel plus	52.98^{b}
T_7	NSKE	62.50^{ab}
T_8	Control (water spray)	40.00^{d}
	S.Em ±	2.78
	C D at 5%	8.45
	C V %	9.36

Table 4 continued...

Table 4 continued...

B. bassiana. Chavan *et al*. (2020) found neem-based products (NSKE 5% and azadirachtin) effective against sucking pests. Salunkhe *et al*. (2020) reported the lowest thrips population in onion with azadirachtin, followed by *L. lecanii* and *M. anisopliae*. Similarly, Senjaliya (2024) noted maximum thrips reduction with *L. lecanii*, followed

Table 5 : Economics of different biopesticides evaluated against thrips, *T. tabaci* on garlic during *Rabi*, 2024-25.

S. no.	Treatments	Dose/ 10 lit	Quantity of biopesticide required for two sprays (ml or g/ha)	Cost of biopesticide (` /ha)	Labour cost (` /ha)	Treatment cost(` /ha)	Bulb yield (q/ha)	Yield increase over control(q/ha)	Realization over control (` /ha)	ICBR
T_1	*Metarhizium anisopliae* 1.15% x (1 x 10^8 CFU/ml)	60	3900	1447	1600	3047	50.12	10.12	51629	15.94
T_2	*Beauveria bassiana* 1.15% x (1 x 10^8 CFU/ml)	60	3900	1294	1600	2894	49.04	9.04	46087	14.93
T_3	*Lecanicillium lecanii* 1.15% x (1 x 10^8 CFU/ml)	60	3900	1529	1600	3129	51.10	11.10	56627	17.10
T_4	Fresh cow urine	1000	65000	650	1600	2250	44.00	4.00	20400	8.07
T_5	Azadirachtin 10000 ppm	400	26000	57200	1600	58800	64.91	24.91	127041	1.16
T_6	Novel plus	200	13000	1950	1600	3550	52.98	12.98	66198	17.65
T_7	NSKE	500	32500	8125	1600	9725	62.50	22.50	114750	10.80
T_8	Control (water spray)	-	-	-	1600	1600	40.00	--	-	

Note: MSP of garlic per quintal is ` 5100 (2025); Charge of one labour for spraying is Rs. 400, 3: Number of sprays are 2; No of labour needed for one spray per one hectare is 2; Water required for first spray is 300 litres and for second spray 350 litres per ha.

by *M. anisopliae*, *B. bassiana* and *N. rileyi*.

Economic estimation of different Biopesticides to control thrips

Bulb yield : All insecticidal treatments significantly increased garlic bulb yield over the control (40.00 q/ha) (Table 4). The highest yield was obtained with azadirachtin 10000 ppm (64.99 q/ha), followed by NSKE 5% (62.50 q/ha) and Novel Plus 2% (52.98 q/ha). Treatments with *L. lecanii, M. anisopliae, B. bassiana* (0.007% each), and fresh cow urine 5% recorded yields of 51.10, 50.12, 49.04, and 44.00 q/ha, respectively.

These results are in line with Singh *et al*. (2011), who reported higher onion yield with *M. anisopliae* and *V. lecanii*; Wayal (2019), who found significantly higher garlic yield with *L. lecanii*, *M. anisopliae*, and *B. bassiana*; and Salunkhe *et al*. (2020), who observed increased onion yield with *L. lecanii*, *M. anisopliae*, and azadirachtin. Similarly, Salame *et al*. (2023) and Senjaliya (2024) reported improved bulb yields in onion with various biocontrol agents and botanical treatments compared to the untreated control.

ICBR : Economic analysis (Table 5) revealed that treatment costs ranged from ` 2,250/ha (cow urine 5%) to ` 58,800/ha (azadirachtin 10000 ppm). All treatments increased bulb yield over control, with the highest increase in azadirachtin (24.91 q/ha), followed by NSKE (22.50 q/ha) and Novel Plus (12.98 q/ha). *L. lecanii*, *M. anisopliae* and *B. bassiana* recorded moderate increases (11.10, 10.12 and 9.04 q/ha), while cow urine had the least (4.00 q/ha). Azadirachtin gave the highest realization over control (¹ 127041/ha), followed by NSKE (` 114750/ha) and Novel Plus (` 66198/ha). However, the highest net gain was in NSKE (` 105025/ha), followed by azadirachtin (¹ 68241/ha) and Novel Plus (¹ 62648/ha). The lowest net gain (` 18150/ha) was from cow urine.

The highest ICBR was with Novel Plus (1:17.65), followed by *L. lecanii* (1:17.10), *M. anisopliae* (1:15.94), *B. bassiana* (1:14.93), NSKE (1:10.80), and cow urine (1:8.07). Azadirachtin, despite high efficacy, had the lowest ICBR (1:1.16) due to its high cost.

These findings align with Wayal (2019) and Salunkhe *et al*. (2020), who also reported high ICBR values for *L. lecanii* and *M. anisopliae* in garlic and onion crops.

Conclusion

Azadirachtin 10000 ppm (0.04%) recorded the lowest thrips population (6.32 thrips/plant), followed by NSKE 5% (7.18) and Novel Plus 2% (8.24). *L. lecanii* (11.02), *M. anisopliae* (11.66) and *B. bassiana* (11.93)

were moderately effective, while cow urine 5% (12.43) was least effective among treatments. The highest population was in the control (21.70). In terms of net gain over control, NSKE 5% gave the highest return (` 105025/ha), followed by azadirachtin (` 68241/ha) and Novel Plus (` 62648/ha). Gains from *L. lecanii*, *M. anisopliae*, and *B. bassiana* ranged between ` 43193–` 53498/ha, with cow urine yielding the lowest (` 18150/ha).

The highest ICBR was with Novel Plus (1:17.65), followed by *L. lecanii* (1:17.10), *M. anisopliae* (1:15.94), *B. bassiana* (1:14.93), NSKE (1:10.80), and cow urine (1:8.07). Azadirachtin showed the lowest ICBR (1:1.16) despite high efficacy.

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