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COMPARATIVE EFFICACY OF BOTANICALS, BIOPESTICIDES AND CHEMICAL CONTROL ON THRIPS AND THEIR NATURAL ENEMIES IN GARLIC

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ABSTRACT

A study evaluated the effectiveness of various insecticides, biopesticides and botanicals against garlic thrips under field conditions. Fipronil 5 SC at 1 ml/l proved to be the most effective, consistently showing the lowest thrips populations across multiple observation periods. Profenophos 50 EC and Spinosad 45 SC also provided significant control. Among biopesticides, *Lecanicillium lecanii* ($2x10^8$ cfu/g) at 4g was superior to lower concentrations, demonstrating improved efficacy due to higher spore density and better coverage. Nimbecidine was less effective and Pongamia crude oil outperformed it. Diafenthiuron and dimethoate were less effective, with the latter possibly due to thrips resistance. Overall, Fipronil, Profenophos and Spinosad showed the best results for thrips management.

Key words : Biopesticides, Botanicals, Resistance, Spore density, Thrips.

Introduction

Among the spices, garlic (*Allium sativum*) commonly referred to as the "stinking rose" due to its potent aroma, is a bulbous flowering plant belonging to the genus Allium within the family Amaryllidaceae. The term "garlic" originates from Old English "garleac," which combines "gar" (spear) and "leek," resembling a pear-shaped leek. Its botanical kin encompass the leek, onion, shallot, Welsh onion, and Chinese onion. In Sanskrit, garlic is termed "Mahosudha," signifying its curative properties. It contains 60% Diallyl disulfide an organosulfur compound which imparts the true garlic odour. Indigenous to South Asia, Central Asia, and northeastern Iran, garlic's primary cultivation centres are in China and India.

Garlic cultivation spans across various states in India, with notable production centres in Gujarat, Madhya Pradesh, Uttar Pradesh, Rajasthan and Punjab. Gujarat and Madhya Pradesh alone contribute to over 50 percent of the total production. The crop can be cultivated during two key seasons, either from June to July or from October to November, contingent upon the specific region. It is grown in both the kharif and rabi seasons in states such as Tamil Nadu, Karnataka, Maharashtra, Gujarat, Madhya Pradesh and Chhattisgarh. The total production of Garlic in India is 3.52 mt with an area of 0.43 mha with productivity of 8170 kg/ha. Although, India ranks second in terms of garlic cultivation area 0.43 mha and production 3.52 mt, the productivity of garlic is 8170 kg/ha which falls significantly behind countries like the Netherlands, USA and China. This disparity can be attributed to factors such as poor-yielding varieties, short-day genotypes, susceptibility of available genotypes to major pests and diseases, and inadequate utilization of production technologies and management, all contributing to decreased productivity.

One of the key pests affecting garlic is the thrips *Thrips tabaci* (L.) (Thysanoptera: Thripidae), which inflicts a considerable yield loss of 35-45% and serves as a vector for various plant viral diseases (Soumia *et al.*, 2017). These thrips primarily feed on the inner leaf fold and protected inner leaves near the bulb, leading to leaf scarring, reducing the photosynthetic area, and creating entry points for foliar diseases. Damage is caused by both nymphs and adults, with severely affected foliage exhibiting a silvery appearance. Additionally, garlic is susceptible to infestations by red spider mite, bulb mite, cutworm, onion maggot and leaf miners.

Materials and Methods

The experiment was conducted for the evaluation of insecticides for the management of thrips of garlic at Main Agricultural Research Station (MARS), UAS, Dharwad during 2023-24. The experiment was laid in Randomized complete block design (RCBD) with 10 treatments and 3 replications having plot size of 3 m × 1.2 m. The treatments were imposed when the incidence of pests reached its ETL and second spray was given 15 days after the first spray.

Treatment details for the management of insect pests of garlic

Treatment number	Treatment details	Dosage (ml or g/l)
T_1	Nimbicidine 10,000 ppm	1.0 ml
T_2	Pongamia crude oil	4.0 ml
T_3	*Lecanicillium lecanii* ($2x10^8$ cfu/g)	2 .0 g
T_4	*Lecanicillium lecanii* ($2x10^8$ cfu/g)	4 .0 g
T_5	Spinosad 45 SC	0.2 ml
T_6	Fipronil 5 SC	1.0 ml
T_7	Profenophos 50 EC	2.0 ml
T_8	Dimethoate 30 EC	1.7 ml
T_9	Diafenthiuron 50 WP	1.0 g
T_{10}	Untreated Control	-

The count of thrips was taken a day before spraying and again at 3, 5 and 10 days after spraying. This assessment was performed on five randomly selected plants from each treatment plot within each replication. The population count of the natural enemies also recorded from five randomly selected plants on receptive dates of observation and expressed as average number of natural enemies/plants.

Yield and economic analysis

Bulb yield(q/ha)

The bulb yield for each treatment and replication was measured using a sensitive balance and then converted to yield per hectare.

Gross returns

The market price of bulbs was utilized in calculating the gross return and expressed as Rs/ha.

Gross return (Rs/ha) = Total yield (q/ha) × Market price (Rs/q)

Net returns

Net return (Rs/ha) was calculated by subtracting the cost of cultivation (Rs/ha) from the gross return (Rs/ha)

Net return (Rs/ha) = Gross return (Rs/ha)- cost of cultivation (Rs/ha)

Cost- Benefit ratio

C:B ratio was calculated by dividing the gross returns (Rs/ha) by cost of cultivation (Rs/ha)

C:B ratio = Gross returns (Rs/ha)/ Total cost of cultivation (Rs/ha)

The statistical analysis of the data obtained from management trails was done by the analysis of variance (ANOVA). After analysis, data were accommodated in the table as per the needs of the objective for the interpretation of results. The interpretation of data was done by using the critical difference value calculated at the 0.05 probability level.

Results and Discussion

Across two sprays, Fipronil 5 SC consistently showed the most effective control of garlic thrips, recording the lowest populations at all observation intervals. After both sprays, three days after application (DAS), Fipronil 5 SC achieved the lowest thrips counts (5.01-5.12 per plant), followed by Profenophos 50 EC (5.78-6.12 per plant) and Spinosad 45 SC (6.22-8.31 per plant), which were statistically on par but significantly superior to other treatments. At 5 DAS, a similar trend was observed, with Fipronil maintaining the lowest counts (6.12-6.18 per plant), followed by Profenophos and Spinosad. By 10 DAS, Fipronil remained the most effective (12.04-12.18 per plant), with Profenophos and Spinosad closely following (Table 1). Among the other chemicals, Diafenthiuron and Dimethoate showed moderate effectiveness, while biopesticides like *Lecanicillium lecanii* (2×10x cfu/g) at 4g and botanicals like Nimbecidine 10,000 ppm and Pongamia crude oil were less effective but still significantly reduced thrips populations compared to the untreated control. Untreated plants consistently had the highest thrips populations, underscoring the efficacy of all tested treatments.

The present findings support the results of Jadhav *et al.* (2004), who noted that Fipronil 5 SC @ 100 g *a.i.*/ha was highly effective against sucking pests and enhanced chili crop yields. Lawande *et al.* (2009) also observed minimal onion thrips presence with Fipronil. Kadam and Dethe (2012) found Spinosad @ 56.25 g a.i./ha to be highly effective against pomegranate thrips. Hosamani

Table 1 : Evaluation of botanicals, biopesticides and insecticides against thrips.

Treatments	Dosage (ml or g/l)	Number of thrips/plant								Mean	%ROC
		1st spray				2nd spray					
		1 DBS	3 DAS	5 DAS	10 DAS	1 DBS	3 DAS	5 DAS	10 DAS		
Nimbecidine 10000 ppm	1.0	31.04(5.61)	14.51(3.87)^{fg}	17.68(4.26)^{f}	23.51(4.90)^{ef}	33.92(5.86)^{ab}	14.67(3.89)^{d}	15.74(4.02)^{d}	18.41(4.34)^{cd}	17.42	63.53
Pongamia crude oil	4.0	32.35(5.71)	15.34(3.97)^{g}	18.25(4.33)^{f}	25.78(5.12)^{f}	36.51(6.08)^{b}	15.49(3.99)^{d}	16.71(4.14)^{d}	20.45(4.57)^{d}	18.67	60.91
Lecanicillium lecanii (2×10^8 cfu/g)	2.0	34.67(5.93)	12.78(3.64)^{ef}	14.49(3.87)^{e}	22.60(4.80)^{de}	34.29(5.89)^{a}	10.82(3.36)^{c}	12.66(3.62)^{c}	16.82(4.16)^{bc}	15.02	68.54
Lecanicillium lecanii (2×10^8 cfu/g)	4.0	32.33(5.72)	10.91(3.37)^{de}	13.87(3.79)^{de}	20.56(4.58)^{de}	32.67(5.75)^{ab}	10.48(3.31)^{c}	12.35(3.58)^{c}	14.72(3.90)^{b}	13.81	71.08
Spinosad 45 SC	0.2	35.48(5.99)	6.22(2.59)^{ab}	8.04(2.92)^{ab}	15.02(3.93)^{ab}	32.13(5.71)^{ab}	8.31(2.96)^{b}	9.20(3.11)^{ab}	11.10(3.40)^{a}	9.64	79.80
Fipronil 5 SC	1.0	31.56(5.66)	5.01(2.34)^{a}	6.12(2.57)^{a}	12.04(3.54)^{a}	30.73(5.58)^{a}	5.12(2.37)^{a}	6.18(2.58)^{a}	9.00(3.08)^{a}	7.24	84.83
Profenophos 50 EC	2.0	34.56(5.92)	5.78(2.50)^{a}	8.35(2.97)^{ab}	14.11(3.82)^{ab}	33.67(5.84)^{ab}	6.12(2.57)^{ab}	7.01(2.74)^{a}	10.34(3.29)^{a}	8.61	81.95
Dimethoate 30 EC	1.7	31.75(5.67)	9.54(3.16)^{cd}	11.87(3.51)^{cd}	19.95(4.52)^{cd}	36.71(6.10)^{b}	10.91(3.37)^{c}	12.78(3.64)^{c}	15.09(3.94)^{c}	13.35	72.04
Diafenthiuron 50 WP	1.0	34.46(5.91)	8.20(2.94)^{bc}	10.48(3.31)^{c}	17.21(4.20)^{bc}	31.43(5.65)^{ab}	9.28(3.12)^{c}	11.63(3.48)c	14.44(3.86)^{b}	11.87	75.14
Untreated control		33.67(5.84)	35.84(6.02)^{h}	37.15(6.13)^{g}	43.28(6.61)^{g}	49.33(7.23)^{c}	51.78(7.36)^{e}	52.95(7.46)^{e}	55.21(7.86)^{e}	47.77	0
S.Em(±)	**NS**	**0.70**	**0.79**	**1.06**	**1.60**	**0.88**	**0.93**	**1.08**			
CD @ 5%		**2.09**	**2.37**	**3.17**	**4.78**	**2.64**	**2.78**	**3.21**			
CV (%)	**8.55**	**9.83**	**9.46**	**8.64**	**8.87**	**10.63**	**10.18**	**9.77**			

DBS = Days Before Spray, DAS = Days After Spray, ROC = Reduction over control, NS = Non-Significant
Values in parentheses represent square root transformations (√x + 0.5)
Means with the same letter in the column are not significantly different according to DMRT (p = 0.05)

et al. (2012) reported that Fipronil 80 WG @ 60 g a.i./ha was the most efficient for reducing thrips on onions.

Profenophos 50 EC emerged as the next most effective treatment for thrips control. Srinivas *et al.* (2012) and Tripathy *et al.* (2013) observed similar results, noting Profenophos's high efficacy against onion thrips. Kalola *et al.* (2017) further confirmed that Profenophos 0.05 per cent was the most effective for garlic thrips control, leading to the highest garlic bulb yield (4016 kg/ ha).

Wayal *et al.* (2019) reported Fipronil 5 SC @ 1.5 ml/L as the most effective treatment for garlic thrips, achieving the lowest thrips numbers (5.58 thrips/plant) and the highest garlic yield (166.83 q/ha). Profenophos 50 EC @ 1.0 ml/L and Thiamethoxam 25 WG @ 0.40 g/L were also effective, with *Lecanicillium lecanii* 1.15 WP and *Metarhizium anisopliae* 1.15 WP @ 4.0 g/L showing promising results among biopesticides.

Fipronil proved to be the most effective in controlling thrips populations compared to other chemicals and was followed by Profenophos and Spinosad. Although Profenophos and dimethoate are both organophosphates, dimethoate was less effective in controlling thrips. This reduced efficacy may be due to the long history of dimethoate use and the development of resistance in thrips population (Herron *et al*, 2008). Spinosad, derived from soil bacteria, also showed effectiveness in managing thrips. However, Diafenthiuron, which belongs to the thiourea class of compounds, was less effective in controlling thrips.

Table 2 : Effect of botanicals, biopesticides and insecticides on natural enemies.

Tr. No.	Treatments	Dosage (g or ml /l)	Mean number of coccinellids/ plant		Mean number of spiders/ plant	
			Before spray	After spray	Before spray	After spray
T_1	Nimbecidine 10000 ppm	1.0	2.20	1.19(1.30)^{d}	1.22	0.78(1.13)^{de}
T_2	Pongamia crude oil	4.0	2.22	1.28(1.33)^{cd}	1.23	0.82(1.14)^{cd}
T_3	*Lecanicillium lecanii* (2×10^8 cfu/g)	2.0	2.31	1.45(1.39)^{bc}	1.21	0.89(1.17)^{bc}
T_4	*Lecanicillium lecanii* (2×10^8 cfu/g)	4.0	2.15	1.48(1.40)^{b}	1.20	0.92(1.19)^{b}
T_5	Spinosad 45 SC	0.2	2.18	0.96(1.20)^{e}	1.22	0.70(1.09)^{ef}
T_6	Fipronil 5 SC	1.0	2.33	0.68(1.08)^{f}	1.21	0.45(0.97)^{i}
T_7	Profenophos 50 EC	2.0	2.30	0.73(1.10)^{f}	1.20	0.49(0.99)^{hi}
T_8	Dimethoate 30 EC	1.7	2.11	0.84(1.15)^{ef}	1.23	0.62(1.05)^{fg}
T_9	Diafenthiuron 50 WP	1.0	2.28	0.79(1.13)^{ef}	1.21	0.58(1.03)^{gh}
T_{10}	Untreated control	-	2.11	3.01(1.87)^{a}	1.20	1.48(1.40)^{a}
S.Em. (±)			**NS**	**0.06**	**NS**	**0.03**
CD @ 5%				**0.18**		**0.10**
CV (%)			**10.38**	**9.23**	**10.04**	**10.47**

NS- Non-Significant Values in parentheses represent square root transformations ($\sqrt{x + 0.5}$)
Means with the same letter in the column are not significantly different according to DMRT (p = 0.05)

Of the biopesticides and botanicals evaluated, *Lecanicillium lecanii* (2×10^8 cfu/g) @ 4g and Nimbecidine 10000ppm found superior. Among the biopesticides, *Lecanicillium lecanii* ($2x10^8$ cfu/g) @ 4g was effective against thrips than *Lecanicillium lecanii* ($2x10^8$ cfu/g) @ 2g may be due to higher spore density, increased exposure and infection rates, better coverage and improved efficacy as noted by Saito (1992), who found it to cause 42-48% mortality in *Thrips palmi*. Ramarethinam *et al.* (2002) also supported these findings. Nimbecidine was less effective in controlling thrips compared to Pongamia crude oil may be due to its potent insecticidal properties, proven field performance and ability to act as anti feedant.

Effect of botanicals, biopesticides and insecticides against natural enemies

Coccinellids

A day prior to spraying, the coccinellid populations across all treatments did not show significant differences, indicating a uniform distribution in the field. The number of coccinellid grubs and adults per plant ranged from 2.11 to 2.33.

According to the data presented in the Table 2 showed that maximum count of coccinellids was recorded in untreated control (3.01/plant) followed by *Lecanicillium lecanii* ($2x10^8$ cfu/g) 4g (1.48/plant) which was at par with *Lecanicillium lecanii* ($2x10^8$ cfu/g) 2g (1.45/plant), Pongamia crude oil (1.28/plant) and Nimbecidine 10000ppm (1.19/plant). Among the chemical insecticides, Spinosad 45 SC at 0.2 ml per plant (0.96/plant) recorded the highest number of coccinellids. Treatment plots treated with Fipronil 5 SC (0.68/plant) recorded the least population and was at par with Profenophos 50 EC (0.73/ plant), Diafenthiuron 50 WP (0.79/plant) and Dimethoate 30 EC (0.84/plant) (Table 2).

Spiders

A day before spray , the spider populations across all treatments did not show significant differences, indicating a uniform distribution in the field. The number of spider juveniles and adults per plant ranged from 1.20 to 1.23.

The data presented in the table 13 showed that maximum count of coccinellids was recorded in untreated control (1.48/plant) followed by *Lecanicillium lecanii* ($2x10^8$ cfu/g) 4g (0.92/plant) which was at par with *Lecanicillium lecanii* ($2x10^8$ cfu/g) 2g (0.89/plant), Pongamia crude oil (0.82/plant) and Nimbecidine 10000ppm (0.78/plant). Among the chemical insecticides, Spinosad 45 SC at 0.2 ml per plant (0.70/plant) recorded the highest number of coccinellids. The treatments *viz.*, Fipronil 5 SC (0.45/plant) recorded the least population and was at par with Profenophos 50 EC (0.49/plant),

Table 3 : Cost economics involved in the management of garlic thrips.

S. no.	Treatment	Dosage (g or ml/l)	Bulb yield (q/ha)	Gross income (Rs/ha)	Cost of plant protection (Rs/ha)	Total Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
T_1	Nimbecidine 10000ppm	1.0	25.47^{c}	356580	3175	156840	199739	2.26
T_2	Pongamia crude oil	4.0	24.85^{c}	347900	2520	156860	191039	2.21
T_3	*Lecanicillium lecanii* (2×10^8 cfu/g)	2.0	26.43^{bc}	376180	2270	156590	219589	2.36
T_4	*Lecanicillium lecanii* (2×10^8 cfu/g)	4.0	27.31^{bc}	382340	2540	156840	225499	2.43
T_5	Spinosad 45 SC	0.2	31.46^{a}	440440	3840	157840	282599	2.78
T_6	Fipronil 5 SC	1.0	32.15^{a}	450100	2470	156790	293309	2.87
T_7	Profenophos 50 EC	2.0	31.82^{a}	445480	2718	157170	288309	2.83
T_8	Dimethoate 30 EC	1.7	29.48^{ab}	412720	2657	156808	255912	2.62
T_9	Diafenthiuron 50 WP	1.0	28.72^{abc}	402080	3057	158180	243899	2.55
T_{10}	Untreated control	–	19.01^{d}	266140	–	154340	111799	1.72
S.Em.(±)		1.39						
CD @ 5%		3.56						
CV (%)		8.70						

Means showing similar alphabets do not differ significantly by DMRT (P=0.05)
B:C ratio = Benefit cost ratio, Cost of garlic/kg: Rs.140, Cost of cultivation: Rs. 154340

Diafenthiuron 50 WP (0.58/plant) and Dimethoate 30 EC (0.62/plant) (Table 2).

Yield

The garlic bulb yield was recorded from all the experimental plots in the *rabi* season of 2023-2024 and expressed in per-hectare basis.

Each of the treatments exhibited a substantial increase in yield relative to the control. Fipronil 5 SC @1ml/l recorded the highest bulb yield of 32.15 q/ha and was superior over other treatments and followed by Profenophos 50 EC @ 2ml/l and Spinosad 45 SC @ 0.2 ml/l recorded 31.82 and 31.46 q/ha, respectively. The yield recorded with Diafenthiuron @1ml/l and dimethoate 30 EC @1.7 ml/l was 29.48 and 28.72 quintals hectare^{-1}, respectively which was comparable to yield obtained from entomopathogens 26.43 to 27.31 quintals hectare^{-1}. While the yield obtained from botanicals also ranged from 24.85 to 25.47 quintals hectare^{-1}. Lowest yield of 19.01 quintals hectare^{-1} was recorded in untreated check (Table 3).

Cost economics

The cost economics of different treatments was calculated and are presented in Table 3. The highest net profit was in Fipronil 5 SC (Rs. 293309/ha), followed by Profenophos 50 EC (Rs. 288309/ha), Spinosad 45 SC (Rs. 282599/ha), Diafenthiuron (Rs. 255912/ha), Dimethoate 30 EC (Rs. 243899 /ha), *Lecanicillium lecanii* (2×10^8 cfu/g) @ 4g (Rs. 225499/ha), *Lecanicillium lecanii* (2×10^8 cfu/g) @ 2g (Rs. 219589/ha), Nimbecidine 10,000 ppm (Rs. 199739/ha). Pongamia crude oil (Rs. 191039/ha) and the lowest net return was recorded in untreated check (Rs.111799/ha) (Table 3).

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