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Efficacy of biopesticides and insecticides against Garlic thrips

Wayal CB, Aghav ST and Pawar DB

Abstract
A field experiment was conducted at All India Co-ordinated Research Project on Vegetable Crops, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri during *Rabi* 2014 and *Rabi* 2015 to evaluate the efficacy of biopesticides and insecticides against garlic thrips, *Thrips tabaci* Lind. The results indicated that, fipronil 5 SC @ 1.5 ml/L was the most potential treatment with least thrips population (5.58 thrips/plant) and recorded the highest garlic bulb yield (166.83 q/ha). It was followed by the treatments with prophenofos 50 EC @ 1.0 ml/L (6.00 thrips/plant) and thiamethoxam 25 WG @ 0.40 g/L (6.59 thrips/plant) which were at par with each other with garlic bulb yield of 164.22 and 161.65 q/ha, respectively. Among the biopesticides, *Lecanicillium lecanii* 1.15 WP (10.28 thrips/plant) and *Metarrhizium anisopliae* 1.15 WP @ 4.0 g/L, each (11.75 thrips/plant) maintained their superiority over untreated control (28.54 thrips/plant). However, *Beauveria bassiana* 1.15 WP @ 4.0 g/L (13.92 thrips/plant) found less effective as compared to other treatments. As regards to bio pesticide treatments, *L. lecanii* 1.15 WP @ 4.0 g/L recorded highest garlic bulb yield of 149.17 q/ha followed by the treatment with *M. anisopliae* 1.15 WP @ 4.0 g/L with garlic bulb yield of 146.53 q/ha and were at par with each other. The highest Incremental Cost Benefit Ratio (ICBR) was registered by prophenofos 50 EC @ 1.0 ml/L (1:73.49) and it was followed by acephate 75 SP @ 0.80 g/L (1:73.22), acetamiprid 20 SP @ 0.25 g/L (1:65.21), fipronil 5 SC @ 1.5 ml/L (1:51.11), thiamethoxam 25 WG @ 0.40 g/L (1:49.86) and Clothianidin 50 WDG @ 0.12 g/L (1:46.50). Among the biopesticides, the highest ICBR was recorded by *L. lecanii* 1.15 WP @ 4.0 g/L (1:59.39) which was followed by *M. anisopliae* 1.15 WP @ 4.0 g/L (1:56.25). Lowest ICBR of 1:37.50 was registered with *B. bassiana* 1.15 WP @ 4.0 g/L.

Keywords: Garlic thrips, biopesticides, bulb yield, incremental cost benefit ratio

1. Introduction
Garlic (*Allium sativum* Linnaeus) is native to Central Asia and northeastern Iran, and has long been a common seasoning worldwide, with a history of several thousand years of human consumption and use. Garlic is one of the most popular spices in the world. It is the second most important bulb crop grown throughout the plains of India for spices and condiments. It is mostly used for culinary purposes and as a condiment for different food items. Garlic has higher nutritive value than other bulb crops and it is rich in proteins, phosphorus, potash, calcium, magnesium and carbohydrates (Bhonde and Prakash, 2006) [3]. Currently, the interest in garlic is highly increasing due to nutritional and pharmaceutical value including high blood pressure and cholesterol, atherosclerosis and cancer. In production China ranks 1st (12.09 lakh tones) followed by India (6.45 lakh tones) and South Korea (3.25 lakh tones) (Patel and Patel, 2012) [11]. China represents 45 per cent of the production, India ranks second with 2 per cent of production (Anon., 2015) [1]. The average productivity of garlic in India is quite low (5.00 t/ha) as compared to other garlic growing countries (Singh *et al.*, 2012) [15]. Area under garlic crop in India is 2.80 lakh ha with production of 16.17 lakh MT having productivity of 5.76 t/ha. On the other hand, in Maharashtra area under garlic crop is 2050 ha with production of 12690 MT and productivity is 6.19 t/ha (Anon., 2017) [2]. Many factors affecting the production and productivity of garlic, of which infestation of insect pests is major one. Of the various insect pests, thrips, *Thrips tabaci* Lindman is an important and major biological constraint in garlic production causing heavy economical loss, if infestation starts at bulb initiation stage. Hot and dry weather favors thrips population and the severity of thrips injury to garlic. Both nymphs and adults attack all stages of its growth, resulting in reduction of yield and quality. Thrips lacerate the tissues and suck the oozing cell sap there by develop spotted appearance on leaves which later on turn into white patches.

The early bulb enlargement stage of garlic growth is most sensitive to thrips feeding. In case of severe infestation, the bulbs remain undersized and distorted (Patel *et al.*, 2012) [12]. Thrips prefer to feed on newly emerged leaves in the centre of neck, therefore, majority of thrips are found at the base of the youngest leaves in the lower centre of neck. According to Changela (1993) [4], losses of 15.35 per cent to 46.82 per cent in garlic bulb yield was recorded due to infestation of this pest. At present day, the main tactic used to manage *T. tabaci* infestation on garlic crop is the frequent use of insecticides. This strategy is not suitable for two main reasons. First, *T. tabaci* is difficult to control because insects are found mainly in the narrow space between the inner leaves and secondly, some populations of *T. tabaci* have developed resistance to pyrethroids and organophosphates (Mehra and Singh, 2013) [9]. However, the demands for clean and ecologically sound control envisages, careful planning for rationalizing the insecticides interventions. The conventional plant protection measures using chemicals for the control of this pest is undesirable from the point of view of residual effects and health hazards, as the garlic bulbs are used for consumption.

To give suitable and effective alternative to chemical pesticides, the experiment was conducted to evaluate the efficacy of bio pesticides and insecticides against garlic thrips, *T. tabaci*.

2. Materials and Methods

The experiments was conducted under field condition at All India Co-ordinated Research Project on Vegetable Crops, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri ($19^0$23' North latitude, $74^0$39' East latitude, 511 m amsl), Maharashtra, India during two consecutive seasons of *Rabi* 2014 and *Rabi* 2015 to evaluate the efficacy of bio pesticides and insecticides against garlic thrips, *T. tabaci.* The sowing was completed during the third week of September. The variety Phule Baswana was sown at a spacing of 15 cm between rows and 10 cm between plants in 3 m x 2 m plots. The experiment was laid out in Randomized Block Design (R.B.D.) with ten treatments and three replications. The crop was raised following all the recommended agronomic practices except insecticide applications. The treatment details are presented in Table 1.

Table 1: Treatment details

Tr. No.	Treatment	Concentration (CFU/ml or %)	Dose (g or ml/L.)
1	*Lecanicillium lecanii* 1.15 WP	$2x10^8$ CFU/g	4.0 g
2	*Beauveria bassiana* 1.15 WP	$2x10^8$ CFU/g	4.0 g
3	*Metarrhizium anisopliae* 1.15 WP	$2x10^8$ CFU/g	4.0 g
4	Fipronil 5 SC	0.0075	1.50 ml
5	Acetamiprid 20 SP	0.005	0.25 g
6	Thiamethoxam 25 WG	0.01	0.40 g
7	Clothianidin 50 WDG	0.006	0.12 g
8	Profenofos 50 EC	0.05	1.0 ml
9	Acephate 75 SP	0.06	0.80 g
10	Untreated control	-	-

2.1 Method of application insecticides

The first spray of respective insecticides (Table 1) was applied when thrips population crossed to ETL (15 thrips/plant) and subsequent sprays were applied at 15 days interval using manually operated knapsack sprayer. Every care was taken to avoid drifting of insecticide to adjutants plot.

2.2 Method of recording observations

The effectiveness biopesticides and insecticides was evaluated on the basis of reduction of thrips population per plant as well as garlic bulb yield. For recording observations on thrips, five plants were selected randomly in each treatment plot. The observations on number of thrips per plant were recorded in the central leaf axis at one day before spray as pre-count and at 3, 10 and 14 days after each spray. The yield data were recorded at harvest and then converted into quintal per hectare.

2.3 Statistical analysis of data

The data on number of thrips per plant were analyzed after transforming them into square root (Panse and Sukhatme, 1985) [10] while, the data on yield per plot was converted on hector basis and were analyzed. The data were pooled over periods and sprays to see the consistency of the treatment performance protection from the gross income. By deducting the realization of control from realization of each treatment, net gained over control was calculated. Gross ICBR for each treatment was calculated by dividing net gained over control by total cost of plant protection. Finally, net ICBR for each treatment was calculated by deducting one from gross ICBR. To calculate percentage of yield increase over control following formula was adopted.

$$\text{Percentage of yield increase over control} = \frac{X1 - X2}{X1} \times 100$$

Where,

X1= Yield in treated plot (q/ha)

X2= Yield in control plot (q/ha)

3. Results and Discussion

The data on average number of thrips per plant during *Rabi* 2014 and *Rabi* 2015 is presented in Table 2. From the results it was revealed that, average number of thrips per plant ranged from 5.02 to 26.18 and 6.14 to 30.89 thrips per plant during *Rabi* 2014 and *Rabi* 2015, respectively.

Table 2: Field efficacy of bio pesticides and newer insecticides against garlic thrips, *T. tabaci* (Average of *Rabi* 2014 and *Rabi* 2015)

Tr. No.	Treatment	Dose/L. g or ml)	Av. Number of thrips/plant		
			Rabi 2014	Rabi 2015	Mean
1	*Lecanicillium lecanii* 1.15 WP	4.0 g	9.71(3.11)*	10.84(3.26)	10.28(3.19)
2	*Beauveria bassiana* 1.15 WP	4.0 g	13.30(7.00)	14.54(3.85)	13.92(5.42)
3	*Metarrhizium anisopliae* 1.15 WP	4.0 g	11.02(3.34)	12.48(3.48)	11.75(3.41)
4	Fipronil 5 SC	1.5 ml	5.02(2.15)	6.14(2.36)	5.58(2.26)
5	Acetamiprid 20 SP	0.25 g	7.83(2.74)	8.69(2.88)	8.26(2.81)
6	Thiamethoxam 25 WG	0.40 g	5.97(2.41)	7.20(2.56)	6.59(2.49)
7	Clothianidin 50 WDG	0.12 g	7.37(2.64)	7.95(2.73)	7.66(2.69)
8	Prophenofos 50 EC	1.0 ml	5.60(2.28)	6.41(2.46)	6.00(2.37)
9	Acephate 75 SP	0.80 g	6.90(2.54)	7.70(2.71)	7.30(2.62)
10	Untreated control	-	26.18(5.14)	30.89(5.59)	28.54(5.37)
SE (m) +			0.12	0.09	0.11
CD at 0.05%			0.36	0.27	0.33
CV%			14.83	15.69	15.27

3.2 *Rabi* 2014
From the data it was revealed that, fipronil 5 SC @ 1.5 ml/L was the most potential treatment with least average thrips population (5.02 thrips/plant) and also significantly superior to remaining all the treatments except the treatment with prophenofos 50 EC @ 1.0 ml/L (5.60 thrips/plant) and thiamethoxam 25 WG @ 0.40 g/L (5.97 thrips/plant) which were at par with each other. However, the next potent treatments were acephate 75 SP @ 0.80 g/L, Clothianidin 50 WDG @ 0.12 g/L and acetamiprid 20 SP @ 0.25 g/L which recorded 6.90, 7.37 and 7.83 thrips per plant, respectively. Among the bio pesticides, *L. lecanii* 1.15 WP (9.71 thrips/plant) and *M. anisopliae* 1.15 WP @ 4.0 g/L, each (11.02 thrips/plant) maintained their superiority over untreated control (26.18 thrips/plant).

3.3 *Rabi* 2015
During *Rabi* 2015 similar trend of efficacy was observed and minimum of 6.14 thrips per plant were noticed in the treatment with fipronil 5 SC @ 1.5 ml/L. However, it was at par with prophenofos 50 EC @ 1.0 ml/L and thiamethoxam 25 WG @ 0.40 g/L with 6.41 and 7.20 thrips per plant. The treatment with acephate 75 SP @ 0.80 g/L was found to be next promising treatment with 7.70 thrips per plant and was at par with Clothianidin 50 WDG @ 0.12 g/L which recorded 7.95 thrips per plant. On the other hand, among the bio pesticides *L. lecanii* 1.15 WP @ 4.0 g/L was found effective and recorded 10.84 thrips per plant which was followed by *M. anisopliae* 1.15 WP @ 4.0 g/L (12.48 thrips/plant) and were at par with each other. However, untreated control recorded maximum of 30.89 thrips per plant.

3.4 Pooled mean of *Rabi* 2014 and *Rabi* 2015
The data presented in Table 2 on pooled mean population of thrips per plant showed that, average number of thrips per plant were ranged from 5.58 to 28.54 thrips per plant. Further, the results indicated that fipronil 5 SC @ 1.5 ml/L was the most potential treatment with least thrips population (5.58 thrips/plant) and also significantly superior to remaining all the treatments except the treatment with prophenofos 50 EC @ 1.0 ml/L (6.00 thrips/plant) and thiamethoxam 25 WG @ 0.40 g/L (6.59 thrips/plant) which were at par with each other. However, the next potent treatments in order of efficacy were acephate 75 SP @ 0.80 g/L, Clothianidin 50 WDG @ 0.12 g/L and acetamiprid 20 SP @ 0.25 g/L which recorded 7.30, 7.66 and 8.26 thrips per plant, respectively. Among the bio pesticides, *L. lecanii* 1.15 WP (10.28 thrips/plant) and *M. anisopliae* 1.15 WP @ 4.0 g/L, each (11.75 thrips/plant) maintained their superiority over untreated control (28.54 thrips/plant). However, *B. bassiana* 1.15 WP @ 4.0 g/L (13.92 thrips/plant) found less effective as compared to other treatments. The present results on superiority of fipronil 5 SC are in conformity with the Jadhav *et al.* (2004) [6] who found that fipronil 5 SC @ 100 g a. i./ha recorded lowest population of sucking pests and highest yield of chilli crop. The reports of Lawande *et al.* (2009) [8] are also in agreement with this results who reported that occurrence of onion thrips, *Thrips tabaci* L. was very low with fipronil. The next promising treatment in reducing thrips population was prophenofos 50 EC. Results of the present findings are in accordance with Pawar *et al.* (2005) [13] who noticed that prophenofos @ 0.08 was found most effective treatment with lowest number of thrips. Among the bio pesticides, the effectiveness of *L. lecanii* 1.15 WP against thrips were earlier reported by Saito (1992) [14] who reported that, *Verticillium lecanii* @ 2.0, 4.0 and 5.0 g brought about 42 to 48 per cent mortality of *Thrips palmi* Karni on cucumber and cotton. Thus finding of earlier research workers are in close agreement with the present finding.

3.5 Bulb yield
Looking to the garlic bulb yield (Table 3), crop treated with fipronil 5 SC @ 1.5 ml/L recorded the highest garlic bulb yield of 166.83 q/ha (69.56 per cent increased) and was significantly superior over rest of the treatments under study except the treatments with prophenofos 50 EC @ 1.0 ml/L (66.91 per cent increased) and thiamethoxam 25 WG @ 0.40 g/L (64.30 per cent increased) which recorded 164.22 and 161.65 q/ha garlic bulb yield, respectively. As regards to bio pesticide treatments, *L. lecanii* 1.15 WP @ 4.0 g/L (51.61 per cent increased) recorded highest garlic bulb yield of 149.17 q/ha followed by the treatment with *M. anisopliae* 1.15 WP @ 4.0 g/L (48.93 per cent increased) with garlic bulb yield of 146.53 q/ha and were at par with each other. Moreover, *B. bassiana* 1.15 WP @ 4.0 g/L (32.91 per cent increased) proved to be less effective (130.77 q/ha) as compared to other treatments except untreated control. These findings are in close conformity with Jadhav *et al.* (2004) [6] who found that fipronil 5 SC @ 100 g a.i./ha recorded highest yield of chilli crop and Horseman *et al.* (2012) [5] who also reported that, fipronil 80 WG @ 60 g a.i./ha was most effective in reducing the thrips population with increased yield of onion. Similar trend was noticed by Kalola *et al.* (2017) [7] who reported that, prophenofos 0.05 per cent recorded maximum bulb yield of garlic (4016 kg/ha).

Table 3: Effect of insecticide treatments on bulb yield of garlic and per cent increase over control

Tr. No.	Treatment	Dose/L. (go ml)	Rabi 2014		Rabi 2015		Pooled mean	
			Bulb yield (q/ha)	% Increase over control	Bulb yield (q/ha)	% Increase over control	Bulb yield (q/ha)	%Increase over control
1	*Lecanicillium lecanii* 1.15 WP	4.0 g	147.74	52.86	150.60	50.40	149.17	51.61
2	*Beauveria bassiana* 1.15 WP	4.0 g	129.88	34.38	131.65	31.48	130.77	32.91
3	*Metarrhizium anisopliae* 1.15 WP	4.0 g	145.23	50.26	147.82	47.63	146.53	48.93
4	Fipronil 5 SC	1.5 ml	165.81	71.56	167.85	67.63	166.83	69.56
5	Acetamiprid 20 SP	0.25 g	150.09	55.29	151.25	51.05	150.67	53.14
6	Thiamethoxam 25 WG	0.40 g	160.41	65.97	162.90	62.69	161.65	64.30
7	Clothianidin 50 WDG	0.12 g	151.60	56.85	153.58	53.38	152.59	55.09
8	Prophenofos 50 EC	1.0 ml	163.19	68.85	165.25	65.04	164.22	66.91
9	Acephate 75 SP	0.80 g	154.45	59.80	157.49	57.29	155.97	58.52
10	Untreated control	-	96.65	---	100.13	---	98.39	---
SE (m) +			1.83	---	1.89	---	2.08	---
CD at 0.05%			5.49	---	5.62	---	6.17	---
CV			15.18	---	16.27	---	15.74	---

3.6 Cost economics of insecticidal treatments

The data on economics of three applications of the different ten insecticides given against thrips of garlic during *Rabi* 2014 and 2015 are presented in Table 4. Among the evaluated insecticides the highest gross income was obtained in the plot protected with three sprays of fipronil 5 SC @ 1.5 ml/L (Rs. 5.84 lakh/ha). It was followed by prophenofos 50 EC @ 1.0 ml/L (Rs. 5.75 lakh/ha) and thiamethoxam 25 WG @ 0.40 g/L (Rs. 5.66 lakh/ha). The treatments with acephate 75 SP @ 0.80 g/L, Clothianidin 50 WDG @ 0.12 g/L and acetamiprid 20 SP @ 0.25 g/L proved to be the next best treatments with gross income of Rs. 5.46 lakh/ha, Rs. 5.34 lakh/ha and Rs. 5.27 lakh/ha, respectively. However, gross income in case of bio pesticides *i.e. L. lecanii* 1.15 WP @ 4.0 g/L was Rs. 5.22 lakh/ha and it was followed by *M. anisopliae* 1.15 WP @ 4.0 g/L (Rs. 5.13 lakh/ha) and *B. bassiana* 1.15 WP @ 4.0 g/L (Rs. 4.58 lakh/ha). Similar trend was observed in the data regarding additional income over control (Rs./ha). From the results it was noticed that the highest income was recorded in the treatment fipronil 5 SC @ 1.5 ml/L (Rs. 2.40 lakh/ha) followed by prophenofos 50 EC @ 1.0 ml/L (Rs. 2.30 lakh/ha), thiamethoxam 25 WG @ 0.40 g/L, (Rs. 2.21 lakh/ha), acephate 75 SP @ 0.80 g/L (Rs. 2.01 lakh/ha), Clothianidin 50 WDG @ 0.12 g/L (Rs. 1.90 lakh/ha) and acetamiprid 20 SP @ 0.25 g/L (Rs. 1.80 lakh/ha). Among the bio pesticides *viz. L. lecanii* 1.15 WP @ 4.0 g/L, *M. anisopliae* 1.15 WP @ 4.0 g/L and *B. bassiana* 1.15 WP @ 4.0 g/L, each also registered additional income over untreated control by Rs. 1.78, 1.68 and 1.13 lakhs per ha, respectively. The highest Incremental Cost Benefit Ratio (ICBR) was registered by prophenofos 50 EC @ 1.0 ml/L (1:73.49). It was followed by acephate 75 SP @ 0.80 g/L (1:73.22), acetamiprid 20 SP @ 0.25 g/L (1:65.21), fipronil 5 SC @ 1.5 ml/L (1:51.11), thiamethoxam 25 WG @ 0.40 g/L (1:49.86) and Clothianidin 50 WDG @ 0.12 g/L (1:46.50). Among the bio pesticides, the highest ICBR was recorded by *L. lecanii* 1.15 WP @ 4.0 g/L (1:59.39) and it was followed by *M. anisopliae* 1.15 WP @ 4.0 g/L (1:56.25). However, the lowest ICBR was registered by *B. bassiana* 1.15 WP @ 4.0 g/L (1:37.50). Though the insecticides *viz.*, fipronil and thiamethoxam proved their superiority in controlling the insect pests and exhibited relatively higher net realization, but failed to meet adequate ICBR due to their higher market price. Maximum ICBR was found in prophenofos which is in conformity with the report of Patel and Patel (2012) [11] who reported highest incremental cost benefit ratio in prophenofos (1:73.05) against *T. tabaci* and Kalola *et al.* (2017) [7] who also noticed that the highest incremental cost benefit ratio (1:38.97) was obtained with treatment prophenofos 0.05%.

Table 4: Marketable bulb yield of garlic and economics of management

Tr. No.	Treatment	Dose/L. (g or ml)	Yield (q/ha)	Gross realization (Rs./ha)	Net realization over control (Rs./ha)	Cost of plant protection (Rs./ha)	Total cost of protection* (Rs./ha)	Net gain (Rs./ha)	ICBR
1	*Lecanicillium lecanii* 1.15 WP	4.0 g	149.17	522095	177730	900	2943	174787	1:59.39
2	*Beauveria bassiana* 1.15 WP	4.0 g	130.77	457695	113330	900	2943	110387	1:37.50
3	*Metarhizium anisopliae* 1.15 WP	4.0 g	146.53	512855	168490	900	2943	165547	1:56.25
4	Fipronil 5 SC	1.5 ml	166.83	583905	239540	2554	4597	234943	1:51.11
5	Acetamiprid 20 SP	0.25 g	150.67	527345	179980	675	2718	177262	1:65.21
6	Thiamethoxam 25 WG	0.40 g	161.65	565775	221410	2310	4353	217057	1:49.86
7	Clothianidin 50 WDG	0.12 g	152.59	534065	189700	1950	3993	185707	1:46.50
8	Profenofos 50 EC	1.0 ml	164.22	574770	230405	1050	3093	227312	1:73.49
9	Acephate 75 SP	0.80 g	155.97	545895	201530	672	2715	198815	1:73.22
10	Untreated control	-	98.39	344365	-	-	-	-	-

Where, rates of

L. lecanii 1.15 WP	Rs. 150/kg	*M. anisopliae* 1.15 WP	Rs. 150/kg	*B. bassiana* 1.15 WP	Rs. 150/kg
Fipronil 5 SC	Rs. 1135/L.	Acetamiprid 20 SP	Rs. 1800/kg	Thiamethoxam 25 WG	Rs. 3850 kg
Clothianidin 50WDG	Rs. 10833/kg	Prophenofos 50 EC	Rs. 700/L.	Acephate 75 SP	Rs.560/ kg

4. Conclusion

In general, chemical treatments were superior over the bio pesticides. However, the efficacy of bio pesticides was also significantly superior over untreated control. The spray treatment of fipronil 5 SC @ 1.5 ml/L and prophenofos 50 EC @ 1.0 ml/L promisingly suppressed the thrips population with galic bulb yield. Among the bio pesticide group *L. lecanii* 1.15 WP and *M. anisopliae* 1.15 WP @ 4.0 g/L, each were found to be superior in reducing thrips population.

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