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Evaluation of new molecules for the management of chilli pest complex (Cv. Byadgi Dabbi)

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Abstract
Field experiments were conducted to evaluate the efficacy of novel insecticides against thrips (*Scirtothrips dorsalis* Hood) and mites (*Polyphagotarsonemus latus* Banks) on chilli (Cv. Byadgi dabbi) during November, 2016 at HREC, Haveri. Among all the chemicals, thiamethoxam 25 WG at 0.20 g a.i. ha^{-1} was found superior with a lowest mean thrips population, Leaf Curl Index (LCI) and highest dry chilli yield, per cent reduction over control and per cent increase in yield over control of 0.81, 0.7 and 9.55, 80.00 and 43.45 per cent, respectively followed by cyantraniliprole 10 OD @ 1.00 g a.i. ha^{-1}. The highest net profit was obtained from the treatment thiamethoxam 25 WG at 0.20 g a.i. ha^{-1} (Rs. 97660) with benefit cost ratio (1: 3.71). Likewise, diafenthiuron 50 WP 1.0 g a.i. ha^{-1} and Spiromesifen 24 SC @ 1.0 ml/l found significantly superior against mites incidence. Diafenthiuron 50 WP 1.0 g a.i. ha^{-1} recorded least mean mite population (3.07 mite/plant). Spiromesifen 24 SC @ 1.0 ml/l registered lowest (LCI), highest dry chilli yield, per cent increase in yield over control and per cent reduction over control of 0.74, 11.94, 43.47 and 77.84 with a net returns of (Rs. 127660) and (1:4.23) of benefit cost ratio. Suggesting that these are feasible, excellent in managing the chilli sucking pests and adoptable by the farming community.

Keywords: Chilli, sucking pests, novel insecticides, *Scirtothrips dorsalis, Polyphagotarsonemus latus*

1. Introduction
Chilli (*Capsicum annuum* L.) is an important versatile spice as well as vegetable crop grown in the country. India being the largest chilli producer, the number of limiting factors has been identified for the low productivity [10]. A major bottle neck in the production is the pest complex of chilli with more than 293 insects and mite species debilitating the crop in the field as well as in storage [1]. Pests are dynamic in nature and successions of pests occur with the nature of an agro-ecosystem and reports are available on the successions of the insect pests of chilli from the different parts of the country [11]. The estimated the crop loss by major pests, where, 30-50 % by thrips (*S. dorsalis*), 30-70 % by mites (*P. latus*). These pests causes serious damage to chilli crop by transmitting deadly disease called "leaf curl disease" or "Murda complex" and 30-40 % by fruit borers *Helicoverpa armigera* Hubner and *Spodoptera litura* Fabricius [4]. Due to monocropping of chilli in major growing areas, the pest build up is uncontrollable for which insecticides are playing dominating role in controlling the chilli pests. Farmers rely on chemical insecticides for the management of pest because of easy adaptability, immediate and spectacular knockdown effects [9]. Continuous and indiscriminate use of chemical insecticides found to be ecologically unsafe and resulted in accumulation of pesticide residue on fruits. It is learnt that Byadgi chilli was rejected at the international ports by the importing countries very often due to maximum pesticide residues [11]. From these reports, it is evident that the attack of these insect pests is a key factor in reducing the quality and quantity of the fruits. The conventional insecticides like organophosphates and carbamates were extensively used to control these pests which resulted in development of resistance and resurgence to the most of the common insecticides used in chilli ecosystem [12]. The awareness of the safer use of the pesticide had always lead in the limelight. Therefore, it has become necessary to evaluate the new molecules for maximum reduction in sucking pests with least or no ill-effects on plant, consumer and environment [3]. The newer molecules are used at lowest dosage with highest efficacy compared to the conventional insecticides in reducing the pesticide load on the environment and in the plants [8]. Further, new insecticides are more target-specific, activated in unique ways inside the target cells of insects resulting in reduced threat to other organisms.

Selective toxicity to insects and safety to natural enemies have made the new class of insecticides more user and eco-friendly. Keeping this in view, the present study was aimed to study the evaluation of new molecules against chilli thrips (*S. dorsalis*), mites (*P. latus*) under field conditions.

2. Material and Methods

The present field investigation was conducted during November, 2016 at HREC, Haveri to study the efficacy of new molecules against chilli thrips (*S. dorsalis*) and mites (*P. latus* Banks). Seedlings of chilli (Cv. Byadgi dabbi) were raised in nursery and transplanted in well ploughed and fertilized plots on 2^{nd} July 2016 during *kharif* season at the spacing of 60 cm X 60 cm. Gap filling was done to ensure uniform plant population in 4.8 x 4.2 m plot.

2.1 Thrips

To study the efficacy of new molecules against chilli thrips, experiment was laid out in Randomized Block Design replicated thrice consisting of 11 treatments. During the season, four rounds of treatments were imposed against thrips and three rounds of common sprays comprising two sprays of acaricides, dicofol 18.5 EC @ 2.5 ml/l and one spray of thiodicarb 75 WP @ 1.0 g/l to combat mite and fruit borer complex was followed. Both nymphs and adult population were counted on three half to fully opened young top leaves from five randomly selected plants. The thrips were directly counted using 10 x magnification lens in the field. The observations were recorded one day prior to spray and one day, three, seven and fourteen days after imposing the treatment then subjected to statistical analysis. The data recorded from all the observations was pooled and analyzed with the help of MSTAT-C statistical software.

2.2 Mites

The experiment was laid out in a randomized block design with three replications and 13 treatments. During the season, two rounds of treatments were imposed against mite and four rounds of common sprays comprising three sprays of systemic insecticides to combat thrips *viz.*, imidacloprid 17.8 SL @ 0.3 ml/l and one spray of thiodicarb 75 WP @ 1.0 g/l to combat fruit borer complex. Five plants were selected randomly in each plot and tagged. The mite along with the leaf were collected from top, middle and bottom and kept in the perforated polythene bag of size 16 x 18 cm and the samples were brought to laboratory and examined under 20x magnification binocular microscope. Total number of mites from each leaf were counted and expressed in terms of number of mites per leaf. The observation was recorded on one day before spray and one day, three, seven and fourteen days after each treatment imposition and subjected for statistical analysis.

Calculations

The mean (%) reduction over control and % increase in yield over control were calculated by using following formula.

$$\text{Increase in yield (\%)} = \frac{T - U}{U} \times 100$$

Where,
T = Treated plot yield, U = Untreated plot yield
Per cent Reduction in Fruits Damage (PRFD) over control was calculated by following formulae.

$$PRFD = \frac{FDTP - FDUP}{FDTP} \times 100$$

Where,
FDTP = Fruits Damage in Treated Plot, FDUP = Fruits Damage in Untreated Plot.
Red chilli fruit yield at each picking was averaged for each treatment and converted to hectare basis. The data was converted in to arc sine transformation, adopting one - way frequency table with the help of MSTAT-C statistical software to arrive the conclusion.

3. Results and Discussion

The mean thrips and mite population, Leaf Curl Index (LCI), per cent reduction over control, per cent increase in yield over control, dry chilli yield and benefit cost ratio were calculated to evaluate extent of sucking pests incidence during the study.

3.1 Results of thrips efficacy

The results revealed that thiamethoxam 25 WG @ 0.20 g/l recorded significantly lowest thrips population (0.81 thrips/plant) after first, second, third and fourth sprays during the experimentation which was at par with cyantraniliprole 10 OD @ 1.00 g/l (0.84 thrips/plant) indicating the superiority of both the treatments against chilli thrips from Table 1 to 4 (Fig. 1). The lowest LCI was also recorded from the thiamethoxam (0.70 %). Further, the per cent reduction over control indicated that both thiamethoxam 25 WG @ 0.20 g/l and cyantraniliprole 10 OD @ 1.00 g/l registered more than 75 per cent in thrips damage. Whereas, other new molecules (clothianidin 50 WG, fipronil 5 SC and acetamiprid 20 SP) recorded more than 40 per cent reduction due to thrips damage indicating moderate in their efficacy. Similarly, per cent increase in yield over control indicated that thiamethoxam 25 WG @ 0.2 g/l, cyantraniliprole 10 OD @ 1.00 g/l, fipronil 5 SC @ 1.0 ml/l and clothianidin 50 WG @ 0.1 g/l registered more than 40.00 per cent increase in yield (Table 5) (Fig. 2). The data clearly indicated that highest dry chilli yield was registered in thiamethoxam 25 WG @ 0.20 g/l (9.55 q ha^{-1}) which was statistically on par with cyantraniliprole 10 OD @ 1.00 g/l (9.20 q ha^{-1}). Thiamethoxam 25 WG @ 0.2 g/l registered the maximum net returns (Rs. 97660/ha) with highest B:C ratio (1: 3.71) suggesting thiamethoxam 25 WG is cost effective and feasible (Fig. 3; Table 6). The efficacy of thiamethoxam 25 WG may be attributed due to its unique mode of action against thrips as it is a thionicotinyl compound which acts as agonists of nicotinic acetylcholine receptor. In insects, acetylcholine is the major excitatory neurotransmitter in brain. Neonicotinoids mimic Ach to activate nAChRs, causes an influx of Na^+ ions and generation of action potentials. Normally the synaptic action of Ach is terminated by acetylcholineesterase enzyme, which rapidly hydrolyses the neurotransmitter. These insecticides not hydrolyzed by AchE owing to its persistent activation leads to an overstimulation of cholinergic synapses. This results in hyperexcitation and paralysis, death of insect [13]. Thiamethoxam (90.1 %) recorded as most effective insecticide followed by acetamiprid (89.8 %), fipronil (88.8 %), clothianidin (87.4 %) and oxydemeton-methyl (76.9 %) [5].

3.2 Results of mites efficacy

The mean mite population after the first and second spraying was lowest in diafenthiuron 50 WP 1.0 g/l (3.07 mite/plant) and spiromesifen 24 SC @ 1.0 ml/l (3.22 mite/plant) which were on par with each other from Table 7 to 8 (Fig. 4). LCI (Leaf Curl Index) at 13 and 15 WAT (Weeks after transplanting) was minimum in spiromesifen 24 SC @ 1.0 ml/l (0.74 %). Similarly, per cent reduction over control indicated that both diafenthiuron 50 WP 1.0 g/l and spiromesifen 24 SC @ 1.0 ml/l recorded more than 65 per cent reduction in mites damage. Similarly, per cent increase in yield over control indicated that spiromesifen 24 SC @ 1.0 ml/l and milbemectin 1 EC @ 0.5 ml/l and bifenthrin 10 EC @ 0.5 ml/l registered more than 40.00 per cent increase in yield (Table 9) (Fig. 5). The highest dry chilli yield was registered in spiromesifen 24 SC @ 1.0 ml/l (11.94 q ha^{-1}) which was statistically on par with milbemectin 1 EC @ 0.5 ml/l (11.50 q ha^{-1}) indicating both the molecules were equally effective in recording highest yield (Table 10) (Fig.6). Fipronil 80 WG and spiromesifen 22.9 SC were found significantly superior against mite infestation on chilli [6]. The percent reduction of mite population was highest in spiromesifen 240 SC @ 120 g a.i./ha. It belongs to ketoenols which acts as inhibitors of acetyl CoA carboxylase, besides inhibiting acetyl CoA carboxylase enzyme, it also regulates the lipid biosynthesis of the insects and inhibits the normal growth and development Cost economics indicated that among the different treatments, spiromesifen 24 SC @ 1.0 ml/l registered the maximum net returns (Rs. 127660/ha) with highest B:C ratio (4.23) [7]. Similar findings were reported in both spiromesifen 22.9 % EC @ 1 ml/l and diafenthiuron 1 g/l were significantly superior to all other treatments. Diafenthiuron acts as an inhibitors of oxidative phosphorylation, disruptors of ATP formation [2].

Table 1: Evaluation of new molecules against chilli thrips 5 weeks after transplanting (First Spray)

Treatments	Dosage (per litre)	Mean number of thrips / leaf											
		Precount		1 DAS		3 DAS		7 DAS		14 DAS		Mean	
T1 - Imidacloprid 17.8 SL	0.30 ml	8.66	(3.03) a	5.51	(2.45) b	3.03	(1.88) b	1.40	(1.38) b	0.87	(1.17) a	2.70	(1.79) d
T2 - Acetamiprid 20 SP	0.20 g	8.97	(3.08) a	5.44	(2.44) b	3.02	(1.88) b	1.37	(1.37) b	0.83	(1.15) a	2.66	(1.78) cd
T3 - Thiamethoxam 25 WG	0.20 g	8.20	(2.95) a	2.90	(1.84) a	1.44	(1.39) a	0.87	(1.17) a	0.73	(1.11) a	1.48	(1.41) a
T4 - Thiacloprid 21.7 SC	0.20 ml	7.55	(2.84) a	5.56	(2.46) b	3.10	(1.90) b	1.50	(1.41) b	1.05	(1.24) ab	2.80	(1.82) d
T5 - Clothianidin 50 WDG	0.10 g	8.33	(2.97) a	4.68	(2.28) b	2.58	(1.75) b	1.16	(1.29) a	0.79	(1.14) a	2.30	(1.67) b
T6 - Cyantraniliprole 10 OD	1.00 g	7.82	(2.88) a	3.06	(1.89) a	1.47	(1.40) a	0.92	(1.19) a	0.69	(1.09) a	1.53	(1.43) a
T7 - Dimethoate 30 EC	1.70 ml	8.71	(3.04) a	4.61	(2.26) b	3.42	(1.98) c	2.37	(1.70) b	1.08	(1.26) bc	2.87	(1.84) d
T8 - Fipronil 5 SC	1.00 ml	8.36	(2.98) a	4.91	(2.33) b	2.76	(1.80) b	1.26	(1.33) b	0.71	(1.10) a	2.41	(1.71) bc
T9 - *Lecanicillium lecanii* (1x10^8 CFU/g)	5.00 g	7.94	(2.91) a	7.59	(2.84) c	6.02	(2.55) d	3.30	(1.95) c	1.90	(1.55) cd	4.70	(2.28) e
T10 - Azadirachtin 10,000 ppm	1.00 ml	8.24	(2.96) a	7.91	(2.90) c	5.54	(2.46) d	3.51	(2.00) c	2.07	(1.60) d	4.76	(2.29) e
T11 - Untreated control	---	8.39	(2.98) a	9.62	(3.18) d	10.30	(3.29) e	11.22	(3.42) d	12.56	(3.61) e	10.93	(3.38) f
S. Em ±		NS		0.09		0.07		0.06		0.05		0.07	
C.D. at 5%		-		0.26		0.21		0.17		0.15		0.20	

WAT: Weeks After Transplanting, DAS: Days After Spraying. Figures in the parenthesis are √x + 0.5 transformed values
In a column, means followed by same alphabet do not differ significantly (*p*= 0.05) by DMRT

Table 2: Evaluation of new molecules against chilli thrips 7 weeks after transplanting (Second Spray)

Treatments	Dosage (per litre)	Mean number of thrips / leaf											
		Precount		1 DAS		3 DAS		7 DAS		14 DAS		Mean	
T1 - Imidacloprid 17.8 SL	0.30 ml	9.38	(3.14) a	4.05	(2.13) b	3.00	(1.87) b	1.82	(1.52) b	1.66	(1.47) b	2.63	(1.77) b
T2 - Acetamiprid 20 SP	0.20 g	9.21	(3.12) a	4.06	(2.14) b	2.74	(1.80) b	1.75	(1.50) b	1.59	(1.45) b	2.53	(1.74) b
T3 - Thiamethoxam 25 WG	0.20 g	10.25	(3.28) a	1.51	(1.42) a	1.01	(1.23) a	0.72	(1.10) a	0.73	(1.11) a	0.99	(1.22) a
T4 - Thiacloprid 21.7 SC	0.20 ml	10.46	(3.31) a	4.19	(2.17) bc	3.14	(1.91) b	2.08	(1.61) cd	1.77	(1.51) b	2.80	(1.82) b
T5 - Clothianidin 50 WDG	0.10 g	11.72	(3.50)	3.51	(2.00)	2.50	(1.73)	1.58	(1.44)	1.42	(1.38)	2.25	(1.66)

			a		b		ab		b		b		b
T6 - Cyantraniliprole 10 OD	1.00 g	10.08	(3.25) a	1.53	(1.43) a	1.02	(1.23) a	0.75	(1.12) b	0.74	(1.11) a	1.01	(1.23) a
T7 - Dimethoate 30 EC	1.70 ml	9.20	(3.11) a	3.84	(2.08) b	3.27	(1.94) bc	2.60	(1.76) d	1.84	(1.53) b	2.89	(1.84) b
T8 - Fipronil 5SC	1.00 ml	10.01	(3.24) a	3.59	(2.02) b	2.59	(1.76) b	1.41	(1.38) b	1.40	(1.38) b	2.25	(1.66) b
T9 - *Lecanicillium lecanii* ($1x10^8$ CFU/g)	5.00 g	10.38	(3.30) a	5.42	(2.43) cd	4.46	(2.23) cd	3.22	(1.93) d	2.49	(1.73) c	3.90	(2.10) c
T10 - Azadirachtin 10,000 ppm	1.00 ml	11.66	(3.49) a	5.51	(2.45) d	4.59	(2.26) d	3.51	(2.00) e	2.60	(1.76) c	4.05	(2.13) c
T11 - Untreated control	---	10.70	(3.35) a	7.77	(2.88) d	7.99	(2.91) d	8.62	(3.02) f	8.13	(2.94) d	8.13	(2.94) d
S.Em ±		NS		0.07		0.07		0.06		0.05		0.06	
C.D. at 5%		--		0.22		0.19		0.17		0.15		0.18	

WAT: Weeks After Transplanting, DAS: Days after Spraying, Figures in the parenthesis are √x + 0.5 transformed values
In a column, means followed by same alphabet do not differ significantly (p= 0.05) by DMRT

Table 3: Evaluation of new molecules against chilli thrips 9 weeks after transplanting (Third Spray)

Treatments	Dosage (per litre)	Mean number of thrips / leaf											
		Precount		1 Das		3 Das		7 Das		14 Das		Mean	
T1 - Imidacloprid 17.8 SL	0.30 ml	10.96	(3.39) a	2.69	(1.78) b	1.84	(1.53) bc	1.22	(1.31) b	1.04	(1.24) b	1.70	(1.48) b
T2 - Acetamiprid 20 SP	0.20 g	10.09	(3.25) a	2.62	(1.77) b	1.81	(1.52) b	1.18	(1.29) b	1.02	(1.23) b	1.66	(1.47) b
T3 - Thiamethoxam 25 WG	0.20 g	11.15	(3.41) a	0.87	(1.17) a	0.51	(1.01) a	0.45	(0.97) a	0.39	(0.94) a	0.55	(1.03) a
T4 - Thiacloprid 21.7 SC	0.20 ml	11.38	(3.45) a	2.84	(1.83) c	2.02	(1.59) c	1.45	(1.39) bc	1.24	(1.32) cd	1.89	(1.55) c
T5 - Clothianidin 50 WDG	0.10 g	12.54	(3.61) a	2.22	(1.65) b	1.56	(1.43) b	1.04	(1.24) b	0.85	(1.16) b	1.42	(1.38) b
T6 - Cyantraniliprole 10 OD	1.00 g	10.84	(3.37) a	0.87	(1.17) a	0.53	(1.01) a	0.50	(1.00) a	0.42	(0.96) a	0.58	(1.04) a
T7 - Dimethoate 30 EC	1.70 ml	10.00	(3.24) a	2.67	(1.78) b	2.24	(1.66) cd	1.81	(1.52) cd	1.13	(1.28) bc	1.96	(1.57) c
T8 - Fipronil 5SC	1.00 ml	10.52	(3.32) a	2.18	(1.64) b	1.59	(1.44) b	1.00	(1.23) b	0.85	(1.16) b	1.40	(1.38) b
T9 - *Lecanicillium lecanii* ($1x10^8$ CFU/g)	5.00 g	11.25	(3.43) a	3.76	(2.06) d	3.19	(1.92) cd	2.22	(1.65) de	1.59	(1.44) d	2.69	(1.79) d
T10 - Azadirachtin 10,000 ppm	1.00 ml	12.41	(3.59) a	3.99	(2.12) d	3.51	(2.00) e	2.59	(1.76) e	2.14	(1.63) e	3.06	(1.89) d
T11 - Untreated control	---	11.68	(3.49) a	5.99	(2.55) e	5.68	(2.48) f	6.10	(2.57) f	6.19	(2.59) f	5.99	(2.55) e
S.Em ±		NS		0.06		0.05		0.05		0.04		0.05	
C.D. at 5%		--		0.17		0.15		0.13		0.12		0.15	

WAT: Weeks After Transplanting, DAS: Days After Spraying. Figures in the parenthesis are √x + 0.5 transformed values
In a column, means followed by same alphabet do not differ significantly (p= 0.05) by DMRT

Table 4: Evaluation of new molecules against chilli thrips 11 weeks after transplanting (Fourth Spray)

Treatments	Dosage (per litre)	Mean number of thrips / leaf											
		Precount		1 DAS		3 DAS		7 DAS		14 DAS		Mean	
T1 - Imidacloprid 17.8 SL	0.30 ml	7.09	(2.75) a	2.10	(1.61) d	1.40	(1.38) c	0.95	(1.20) b	0.81	(1.14) b	1.31	(1.35) b
T2 - Acetamiprid 20 SP	0.20 g	6.69	(2.68) a	2.05	(1.60) c	1.40	(1.38) c	0.91	(1.19) b	0.79	(1.14) b	1.29	(1.34) b
T3 - Thiamethoxam 25 WG	0.20 g	6.81	(2.70) a	0.32	(0.91) a	0.20	(0.84) a	0.17	(0.82) a	0.15	(0.81) a	0.21	(0.84) a
T4 - Thiacloprid 21.7 SC	0.20 ml	7.17	(2.77) a	2.16	(1.63) d	1.57	(1.44) e	1.13	(1.28) bc	0.97	(1.21) bc	1.46	(1.40) c
T5 - Clothianidin 50 WDG	0.10 g	7.78	(2.88) a	1.66	(1.47) b	1.20	(1.30) b	0.80	(1.14) b	0.64	(1.07) ab	1.08	(1.26) b
T6 - Cyantraniliprole 10 OD	1.00 g	6.68	(2.68) a	0.32	(0.91) a	0.20	(0.84) a	0.18	(0.82) ab	0.16	(0.81) a	0.22	(0.85) a
T7 - Dimethoate 30 EC	1.70 ml	6.43	(2.63) a	2.06	(1.60) d	1.68	(1.48) de	1.41	(1.38) cd	0.86	(1.17) b	1.50	(1.41) c
T8 - Fipronil 5SC	1.00 ml	6.41	(2.63) a	1.72	(1.49) b	1.23	(1.31) bc	0.81	(1.14) b	0.67	(1.08) b	1.11	(1.27) b

T9 - *Lecanicillium lecanii* ($1x10^8$ CFU/g)	5.00 g	6.86	(2.71) a	2.93	(1.85) e	2.48	(1.73) e	1.72	(1.49) d	1.24	(1.32) c	2.09	(1.61) cd
T10 - Azadirachtin 10,000 ppm	1.00 ml	7.55	(2.84) a	3.10	(1.90) e	2.69	(1.79) e	2.01	(1.59) d	1.69	(1.48) d	2.37	(1.70) d
T11 - Untreated control	---	7.41	(2.81) a	4.79	(2.30) e	4.54	(2.24) f	5.34	(2.42) e	4.95	(2.33) e	4.91	(2.32) e
S.Em ±		NS		0.05		0.04		0.04		0.04		0.04	
C.D. at 5%		--		0.15		0.13		0.12		0.10		0.13	

WAT: Weeks After Transplanting, DAS: Days After Spraying. Figures in the parenthesis are $\sqrt{x + 0.5}$ transformed values
In a column, means followed by same alphabet do not differ significantly (p= 0.05) by DMRT

Table 5: Evaluation of new molecules on leaf curl index per plant due to chilli thrips infestation

Treatments	Dosage (per litre)	*LCI due to thrips							
		5 Wat	7 Wat	9 Wat	11 Wat	Mean	% reduction over control	Yield (q/ha)	% increase in yield over control
T1 - Imidacloprid 17.8 SL	0.30 ml	2.35 d	1.63 b	1.85 b	2.02 c	1.96 b	44.00	7.84 d	31.12
T2 - Acetamiprid 20 SP	0.20 g	2.08 b	1.70 b	1.58 b	1.72 b	1.77 b	49.42	8.20 d	34.15
T3 - Thiamethoxam 25 WG	0.20 g	1.34 a	0.68 a	0.50 a	0.27 a	0.70 a	80.00	9.55 f	43.45
T4 - Thiacloprid 21.7 SC	0.20 ml	2.16 cd	1.82 b	2.10 c	1.82 b	1.98 bc	43.42	7.78 d	30.59
T5 - Clothianidin 50 WDG	0.10 g	2.14 bc	1.51 b	1.70 b	1.43 b	1.70 b	51.42	9.04 e	40.26
T6 - Cyantraniliprole 10 OD	1.00 g	1.39 a	0.58 a	0.72 a	0.25 a	0.74 a	78.85	9.20 e	41.30
T7 - Dimethoate 30 EC	1.70 ml	2.80 e	2.42 b	2.10 c	2.83 c	2.54 c	27.42	7.12 c	24.15
T8 - Fipronil 5 SC	1.00 ml	2.75 d	1.64 b	1.67 b	1.68 b	1.94 b	44.57	9.14 e	40.92
T9 - *Lecanicillium lecanii* ($1x10^8$ CFU/g)	5.00 g	2.25 d	2.91 c	2.87 d	2.99 c	2.76 c	21.14	7.00 c	22.85
T10 - Azadirachtin 10,000 ppm	1.00 ml	3.00 e	3.03 c	2.92 d	3.10 d	3.01 d	14.00	6.51 b	17.05
T11 - Untreated control	---	3.60 f	3.38 d	3.45 e	3.55 d	3.50 d	-----	5.40 a	-----
S.Em ±		0.34	0.31	0.33	0.32	0.33		0.10	
C.D. at 5%		1.01	0.94	0.97	0.93	0.97		0.31	

LCI: Leaf Curl Index, WAT: Weeks After Transplanting

Table 6: Cost economics of new molecules against chilli thrips, *Scirtothrips dorsalis*

Treatments	Dosage (per litre)	Yield (q/ha)	Cost of plant protection (Rs/ha)	Total cost of production (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C Ratio
T1 - Imidacloprid 17.8 SL	0.30 ml	7.84	3896	38896	109760	70864	2.82
T2 - Acetamiprid 20 SP	0.20 g	8.20	5820	40820	114800	73980	2.81
T3 - Thiamethoxam 25 WG	0.20 g	9.55	1040	36040	133700	97660	3.71
T4 - Thiacloprid 21.7 SC	0.20 ml	7.78	1120	36120	108920	72800	3.02
T5 - Clothianidin 50 WDG	0.10 g	9.04	2304	37304	126560	89256	3.39
T6 - Cyantraniliprole 10 OD	1.00 g	9.20	23160	58160	128800	70640	2.21
T7 - Dimethoate 30 EC	1.70 ml	7.12	1600	36600	99680	63080	2.72
T8 - Fipronil 5 SC	1.00 ml	9.14	2032	37032	127960	90928	3.46
T9 - *Lecanicillium lecanii* ($1x10^8$ CFU/g)	5.00 g	7.00	800	35800	98000	62200	2.74
T10 - Azadirachtin 10,000 ppm	1.00 ml	6.51	4300	39300	91140	51840	2.32
T11 - Untreated control	---	5.40	0	35000	75600	40600	2.16

Gross return = Yield x Market price of Byadgi dabbi (Rs. 14000/q) Net Returns = Gross returns - Total Cost of production
B:C ratio = Gross Returns / Total Cost

Table 7: Evaluation of new molecules of acaricides against chilli mites at 13 weeks after transplanting (First Spray)

Treatments	Dosage (per litre)	Mean number of mites / leaf											
		Precount		1* DAS		3 DAS		7 DAS		14 DAS		Mean	
T1 - Spiromesifen 24 SC	1.0 ml/l	19.85	(4.51) a	9.43	(3.15) a	3.68	(2.04) a	1.76	(1.50) a	0.79	(1.14) a	3.91	(2.10) a
T2 - Fenpropathrin 30 EC	2.0 ml/l	16.77	(4.16) a	9.91	(3.23) a	5.31	(2.41) ab	3.89	(2.09) c	2.19	(1.64) b	5.32	(2.41) b
T3 - Vertimec 1.9 EC	0.5 ml/l	19.21	(4.44) a	10.40	(3.30) a	6.50	(2.64) b	4.78	(2.30) c	2.17	(1.63) b	5.96	(2.54) b

T4 - Ethion 50 EC	1.5 ml/l	17.65	(4.26) a	11.81	(3.51) a	7.19	(2.77) c	5.21	(2.39) d	2.95	(1.86) c	6.79	(2.70) c
T5 - Bifenthrin 10 EC	0.5 ml/l	19.64	(4.49) a	11.85	(3.51) a	5.62	(2.47) b	2.54	(1.74) b	1.19	(1.30) a	5.30	(2.41) b
T6 - Chlorfenapyr 10 EC	1.0 ml/l	18.35	(4.34) a	10.73	(3.35) a	6.50	(2.65) b	4.77	(2.30) c	2.09	(1.61) b	6.02	(2.55) b
T7 - Dicofol 18.5 EC	2.5 ml/l	17.83	(4.28) a	12.00	(3.54) a	6.87	(2.71) c	4.91	(2.33) d	4.63	(2.27) d	7.10	(2.76) c
T8 - Diafenthiuron 50 WP	1.0 g/l	18.66	(4.38) a	9.78	(3.21) a	4.38	(2.21) a	1.95	(1.57) a	0.80	(1.14) a	4.23	(2.17) a
T9 - Azadirachtin 10,000 ppm	1.0 ml/l	17.16	(4.20) a	11.31	(3.44) a	7.51	(2.83) cd	5.89	(2.53) d	6.04	(2.56) de	7.69	(2.86) c
T10 - Milbemectin 1 EC	0.5 ml/l	17.40	(4.23) a	10.72	(3.35) a	5.37	(2.42) b	2.40	(1.70) ab	1.09	(1.26) a	4.89	(2.32) a
T11 - Fenpyroximate 5 EC	0.5 ml/l	17.79	(4.28) a	10.19	(3.27) a	6.84	(2.71) c	4.86	(2.31) c	1.99	(1.58) b	5.97	(2.54) b
T12 - Fenazaquin 10 EC	2.0 ml/l	17.89	(4.29) a	10.56	(3.32) a	6.65	(2.67) bc	4.88	(2.32) cd	2.69	(1.79) bc	6.19	(2.59) b
T13 - Untreated control	-----	17.68	(4.26) a	17.01	(4.18) b	14.25	(3.84) d	15.33	(3.98) e	16.14	(4.08) f	15.68	(4.02) d
S. Em ±		NS		0.14		0.10		0.08		0.07		0.09	
C.D. at 5%		--		0.40		0.28		0.23		0.19		0.28	

WAT: Weeks After Transplanting, DAS: Days After Spraying. Figures in the parenthesis are √x + 0.5 transformed values
In a column, means followed by same alphabet do not differ significantly (p= 0.05) by DMRT

Table 8: Evaluation of new molecules of acaricides against chilli mites at 15 weeks after transplanting (Second Spray)

Treatments	Dosage (per litre)	Mean number of mites / leaf											
		Precount		1 Das		3 Das		7 Das		14 Das		Mean	
T1 - Spiromesifen 24 SC	1.0 ml/l	12.70	(3.63) a	6.06	(2.56) a	3.15	(1.91) a	0.74	(1.11) a	0.15	(0.81) a	2.53	(1.74) a
T2 - Fenpropathrin 30 EC	2.0 ml/l	12.19	(3.56) a	5.96	(2.54) a	4.82	(2.31) bc	3.70	(2.05) c	1.66	(1.47) b	4.03	(2.13) c
T3 - Vertimec 1.9 EC	0.5 ml/l	13.62	(3.76) a	8.26	(2.96) bc	5.19	(2.39) c	4.03	(2.13) c	2.04	(1.59) b	4.88	(2.32) c
T4 - Ethion 50 EC	1.5 ml/l	12.99	(3.67) a	9.16	(3.11) c	5.80	(2.51) c	4.37	(2.21) c	2.71	(1.79) c	5.51	(2.45) d
T5 - Bifenthrin 10 EC	0.5 ml/l	13.58	(3.75) a	8.35	(2.98) c	3.18	(1.92) a	1.22	(1.31) b	0.22	(0.85) a	3.24	(1.94) bc
T6 - Chlorfenapyr 10 EC	1.0 ml/l	13.44	(3.73) a	7.93	(2.90) b	5.26	(2.40) c	4.04	(2.13) c	1.89	(1.55) b	4.78	(2.30) c
T7 - Dicofol 18.5 EC	2.5 ml/l	12.96	(3.67) a	9.67	(3.19) c	6.13	(2.57) c	4.78	(2.30) d	4.40	(2.21) d	6.24	(2.60) d
T8 - Diafenthiuron 50 WP	1.0 g/l	13.42	(3.73) a	4.64	(2.27) a	2.23	(1.65) a	0.53	(1.02) a	0.20	(0.84) a	1.90	(1.55) a
T9 - Azadirachtin 10,000 ppm	1.0 ml/l	13.03	(3.68) a	10.80	(3.36) d	7.56	(2.84) d	5.86	(2.52) d	6.07	(2.56) e	7.57	(2.84) e
T10 - Milbemectin 1 EC	0.5 ml/l	11.69	(3.49) a	7.05	(2.75) b	3.85	(2.08) b	0.93	(1.20) a	0.20	(0.84) a	3.00	(1.87) b
T11 - Fenpyroximate 5 EC	0.5 ml/l	12.84	(3.65) a	6.39	(2.62) ab	6.37	(2.62) cd	3.56	(2.01) c	2.27	(1.66) b	4.65	(2.27) c
T12 - Fenazaquin 10 EC	2.0 ml/l	12.56	(3.61) a	6.94	(2.73) b	4.50	(2.23) b	3.49	(2.00) c	2.14	(1.62) b	4.27	(2.18) c
T13 - Untreated control	-----	12.81	(3.65) a	10.00	(3.24) c	10.18	(3.27) e	10.95	(3.38) e	11.53	(3.47) f	10.66	(3.34) f
S. Em ±		NS		0.11		0.09		0.08		0.07		0.08	
C.D. at 5%	-	--		0.33		0.27		0.23		0.20		0.23	

WAT: Weeks After Transplanting, DAS: Days After Spraying. Figures in the parenthesis are √x + 0.5 transformed values
In a column, means followed by same alphabet do not differ significantly (p= 0.05) by DMRT

Table 9: Evaluation of new molecules of acaricides on leaf curl index per plant due to chilli mites infestation

Treatments	Dosage (per litre)	LCI due to mites					
		13 Wat	15 Wat	Mean	% reduction over control	Yield (q/ha)	% increase in yield over control
T1 - Spiromesifen 24 SC	1.0 ml/l	1.00 a	0.47 a	0.74 a	77.84	11.94 a	43.47
T2 - Fenpropathrin 30 EC	2.0 ml/l	1.41 b	1.12 c	1.27 b	61.97	10.25 b	34.15
T3 - Vertimec 1.9 EC	0.5 ml/l	1.12 a	1.60 c	1.36 b	59.28	10.04 b	32.77

T4 - Ethion 50 EC	1.5 ml/l	2.03^{c}	1.43^{c}	1.73^{bc}	48.20	8.90^{d}	24.15
T5 - Bifenthrin 10 EC	0.5 ml/l	1.46^{b}	0.85^{bc}	1.16^{b}	65.26	11.30^{a}	40.27
T6 - Chlorfenapyr 10 EC	1.0 ml/l	1.60^{b}	1.25^{c}	1.43^{bc}	57.18	9.80^{c}	31.12
T7 - Dicofol 18.5 EC	2.5 ml/l	2.00^{b}	1.80^{d}	1.90^{c}	43.11	8.14^{d}	17.08
T8 - Diafenthiuron 50 WP	1.0 g/l	1.29^{a}	0.93^{bc}	1.11^{b}	66.76	11.20^{a}	39.73
T9 - Azadirachtin 10,000 ppm	1.0 ml/l	2.74^{c}	2.10^{e}	2.42^{d}	27.54	7.75^{c}	12.90
T10 - Milbemectin 1 EC	0.5 ml/l	1.40^{b}	0.61^{a}	1.01^{b}	69.76	11.50^{a}	41.30
T11 - Fenpyroximate 5 EC	0.5 ml/l	1.40^{b}	1.11^{c}	1.26^{b}	62.27	9.72^{c}	30.55
T12 - Fenazaquin 10 EC	2.0 ml/l	2.14^{c}	1.75^{d}	1.95^{c}	41.61	8.75^{d}	22.86
T13 - Untreated control	-----	3.89^{d}	3.53^{f}	3.34^{e}	-----	6.75^{f}	-----
S. Em ±		0.05	0.04	0.04		0.08	
C.D. at 5%		0.14	0.12	0.13		0.22	

LCI: Leaf Curl Index, WAT: Weeks After Transplanting

Table 10: Cost economics of chilli against mites, *Polyphagotarsonemus latus*

Treatments	Dosage (per litre)	Yield (q/ha)	Cost of plant protection (Rs/ha)	Total cost of production (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C Ratio
T1 - Spiromesifen 24 SC	1.0 ml/l	11.94	4500	39500	167160	127660	4.23
T2 - Fenpropathrin 30 EC	2.0 ml/l	10.25	2400	37400	143500	106100	3.84
T3 - Vertimec 1.9 EC	0.5 ml/l	10.92	4250	39250	152880	113630	3.90
T4 - Ethion 50 EC	1.5 ml/l	8.90	1575	36575	124600	88025	3.41
T5 - Bifenthrin 10 EC	0.5 ml/l	10.80	1595	36595	151200	114605	4.13
T6 - Chlorfenapyr 10 EC	1.0 ml/l	9.80	5500	40500	137200	96700	3.39
T7 - Dicofol 18.5 EC	2.5 ml/l	8.14	825	35825	113960	78135	3.18
T8 - Diafenthiuron 50 WP	1.0 g/l	10.90	1694	36694	152600	115906	4.16
T9 - Azadirachtin 10,000 ppm	1.0 ml/l	7.75	1075	36075	108500	72425	3.01
T10 - Milbemectin 1 EC	0.5 ml/l	11.50	3500	38500	161000	122500	4.18
T11 - Fenpyroximate 5 EC	0.5 ml/l	9.72	9250	44250	136080	91830	3.08
T12 - Fenazaquin 10 EC	2.0 ml/l	8.75	4800	39800	122500	82700	3.08
T13 - Untreated control	-----	6.75	0	35000	94500	59500	2.70

Gross return = Yield x Market price of Byadgi dabbi (Rs. 14000/q) Net Returns = Gross returns - Total Cost of production
B:C ratio = Gross Returns / Total Cost

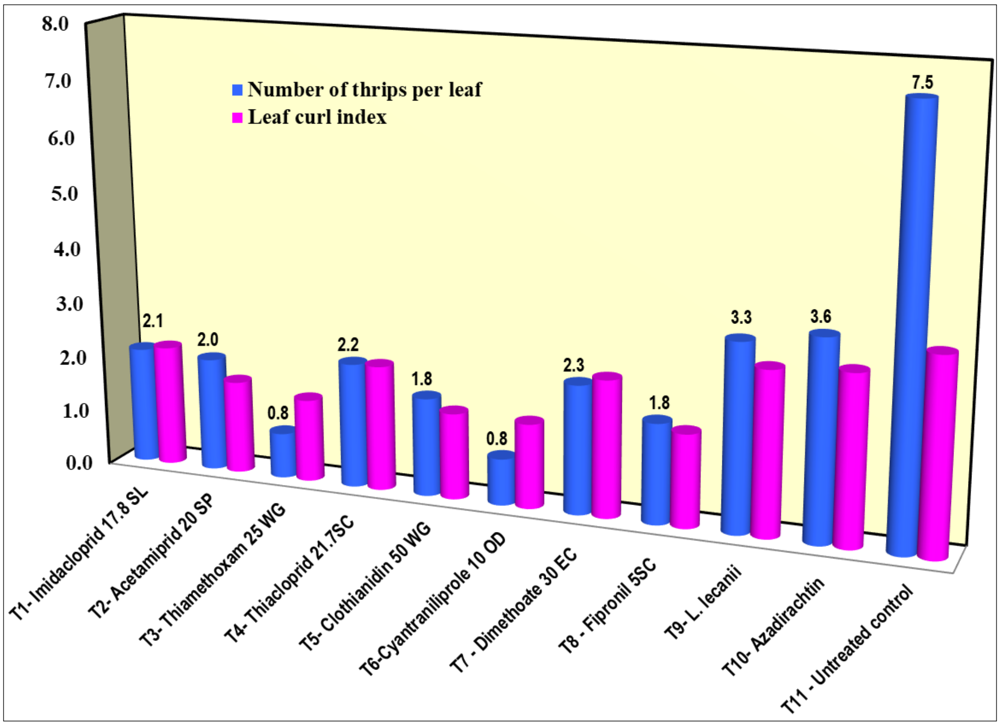

Fig 1: Effect of new molecules on chilli thrips, *Scirtothrips dorsalis* and leaf curl index

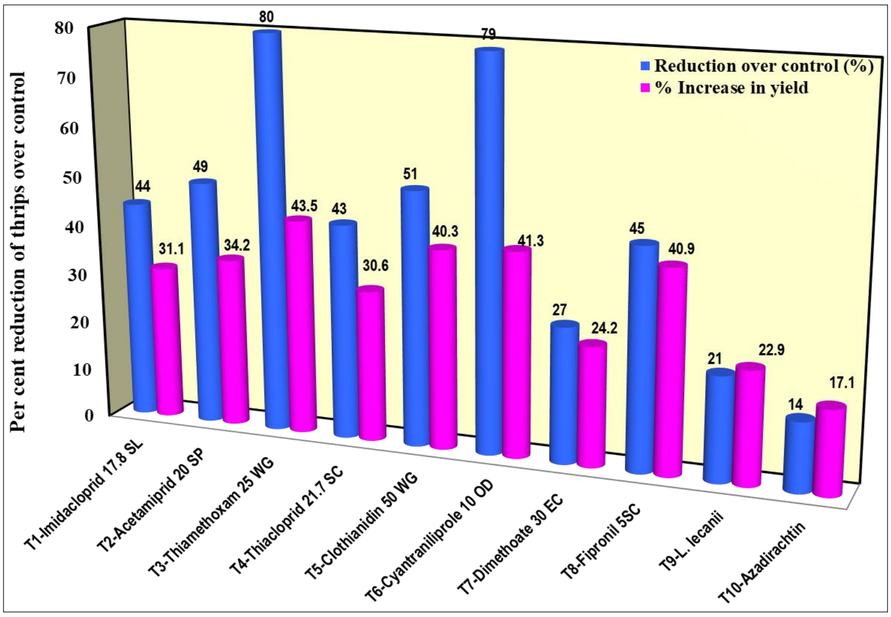

Fig 2: Per cent reduction in thrips, *Scirtothrips dorsalis* population and increase in yield over control

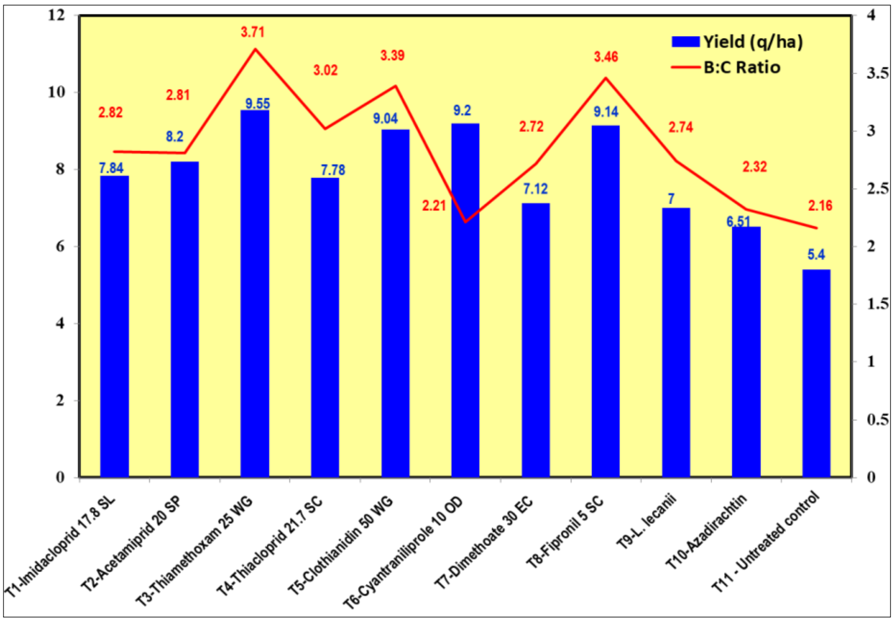

Fig 3: Cost economics of chilli against thrips, *Scirtothrips dorsalis*

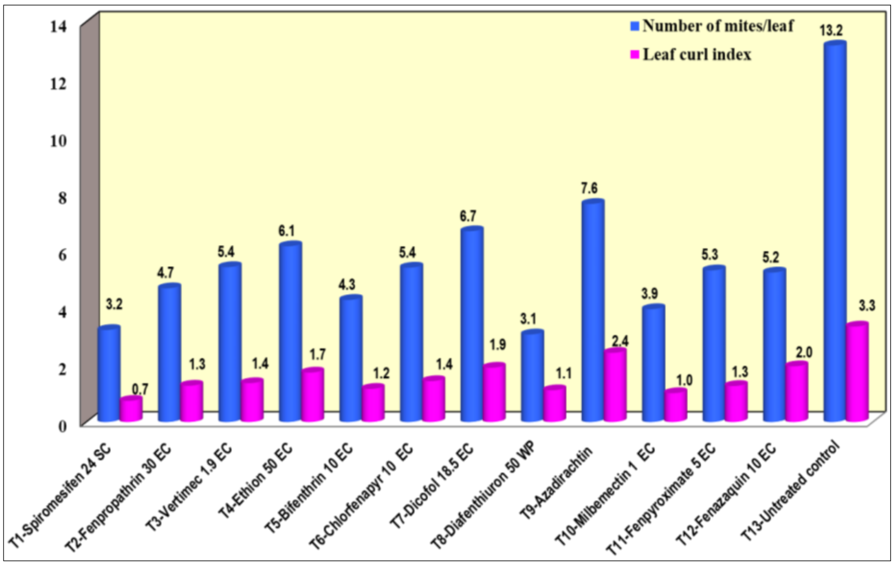

Fig 4: Effect of new molecules on chilli mites, *Polyphagotarsonemus latus* and leaf curl index

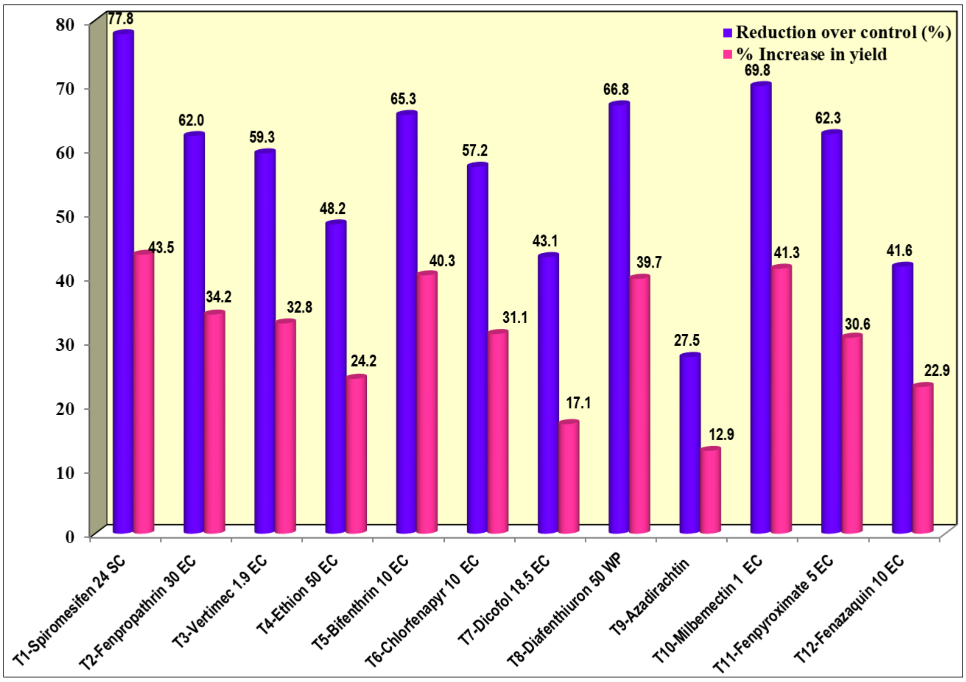

Fig 5: Per cent reduction in mites, *Polyphagotarsonemus latus* population and increase in yield over control

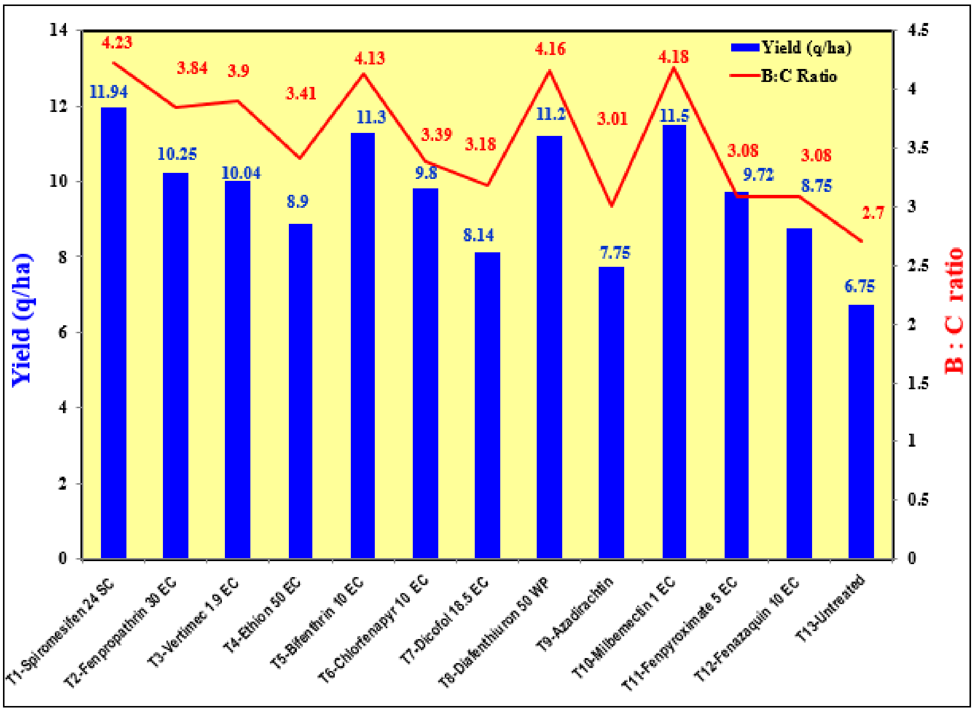

Fig 6: Cost economics of chilli against mites, *Polyphagotarsonemus latus*

5. Conclusion

Among various insecticides tested against thrips, thiamethoxam 25 WG @ 0.20 g/l recorded significantly lowest population of thrips after first, second, third and fourth spray during the experimentation which was at par with cyantraniliprole 10 OD @ 1.00 g/l indicating the superiority of both the treatments against chilli thrips. Cost economics of different treatments indicated that thiamethoxam 25 WG @ 0.20 g/l registered the maximum yield (9.55 q ha^{-1}) and net returns (Rs. 97660/ha) with highest B:C ratio (3.71) suggesting thiamethoxam 25 WG is cost effective and economically feasible. Similarly, evaluation of different acaricides indicated that spiromesifen 24 SC @ 1.0 ml/l and milbemectin 1 EC @ 0.5 ml/l were found effective in suppressing the mite population by recording highest yield (11.94 q ha^{-1}), maximum net returns (Rs. 127660/ha) and highest B:C ratio (4.23). Similarly, milbemectin 1 EC @ 0.5 ml/l recorded highest dry chilli yield (11.50 q ha^{-1}) with higher net returns (Rs. 122500/ha) and B:C ratio (4.18) suggesting both spiromesifen 24 SC and milbemectin 1 EC were more cost effective and most feasible in suppressing mites.

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