Comparative bio-efficacy of *Metarhizium anisopliae*based bio-insecticide Met 52 OD in Chilli (*Capsicumannuum* L.) for the control of sucking insect pests

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by

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CERTIFICATE I

This is to certify that the thesis entitled ***"*Comparative Bio-efficacy of *Metarhizium anisopliae* based bio-insecticide Met 52 OD in Chilli (*Capsicum annuum* L.) for the control of sucking insect pests*"*** submitted in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURE (ENTOMOLOGY)** of Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior is a record of the bonafide research work carried out by **Mr. Nilesh Raghuvanshi,** I.D. No. RA/IN/829/2009, under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and Director of Instruction.

No part of the thesis has been submitted for any other degree or diploma (Certificate awarded etc.) has been published/published part has been fully acknowledged. All the assistance and help received during the course of the investigation has been acknowledged by him.

(Dr. S.B. Singh)
Chairman of the Advisory Committee

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

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CERTIFICATE II

This is to certify that the thesis entitled ***"*****Comparative Bio-efficacy of Metarhizium anisopliae based bio-insecticide Met 52 OD in Chilli *(Capsicum annuum* L.) for the control of sucking insect pests*"*** submitted by **Mr. Nilesh Raghuvanshi,** I.D. No. RA/IN/829/2009 to Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, in partial fulfillment of the requirements for the degree of **Master of Science in Agriculture** in the Department of **Entomology,** has been, after evaluation, approved by the External Examiner and by the Student's Advisory Committee after an oral examination on the same.

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ABBREVIATIONS

S.N.	Legends	Description
1.	ANOVA	Analysis of variance
2.	AVRDC	Asian Vegetable Research and Development Center
3.	@	At the rate of
4.	CD	Critical difference
5.	Check	Untreated control plot
6.	CV	Coefficient of Variation
7.	DAS	Days after spray
8.	d.f.	Degree of freedom
9.	EMS	Error means sum of square
10.	*et al.*	Allied (and other)
11.	fig.	Figure
12.	Kg/ ha	Kilo gram per hectare
13.	i.e.	That is (in reference to)
14.	Max.	Maximum
15.	Met	*Metarhizium anisopliae*
16.	min.	Minimum
17.	ml ha^{-1}	Milli litre per hectare
18.	m.ha	Million hectare
19.	MSS	Mean Sum of Square
20.	MT	Metric tons
21.	NS	Non-significant
22.	OD	Oil dispersible
23.	%	Per cent

24.	RBD	Randomized block design
25.	RH	Relative humidity
26.	S.Em.±	Standard error of mean
27.	SC	Suspension concentrate
28.	Sp.	Species
29.	SMW	Standard Meteorological Week
30.	S.S.	Sum of Square
31.	S.V.	Source of variance

CHAPTER 1

INTRODUCTION

Chilli, *Capsicum annum* Linnaeus belongs to the family Solanaceae, is one of the important commercial vegetable crops grown in all over India. Being a crop of tropical and sub-tropical region, it requires a warm humid climate. It is a native of tropical America and West Indies and believed to have been introduced to India by the Portuguese during 17th century (Sreeramulu, 1976). Chilli is used as a paste, powder or in whole form. A number of varieties are grown for vegetables, spices, condiments, sauce, ketchup and pickles etc. It is one of the chief sources of vitamin A, C and E. Its paste is externally used as a rubefacient and as a local stimulant for the tonsils in tonsillitis. Chilli is also known to have medicinal value, as it prevents heart attack by dilating the blood vessels (www.ikisan.com).Of late, the export value of capsaicin, further led to increase in production of chilli in India. Chilli has two important commercial qualities.Some varieties are famous for red colour because of the capsanthin and others are known for biting pungency attributed by capsaicin. Out of total production of chilli90-95 per cent consumed within the country and about 5-10 per cent exported in the form of dry chilli, chilli powder and oleoresins (Singhal, 2003).

India is the world's largest producer of chilli and the crop is grown all over the country, occupies an area of 7.94 lakh hectares with the total production of 13.04 MT. In Madhya Pradesh, chilli occupies an area of 0.54 lakh hectares with the production of 0.93 MT (Anon., 2013). Andhra Pradesh is the largest producer of chilli in India and contributes about 30% to the total area, followed by Karnataka (20%), Maharashtra (15%), Orissa (9%), Tamil Nadu (8%) while other states contributing nearly 18% to the total area under chilli.

The main constraints for low productivity of inferior fruit quality in chilli are due to ravages caused by insect pest irrespective of seasons and geographic locations. It has been observed that leaf curl symptoms of chilli are also caused by other causal agents like thrips (*Scirtothrips dorsalis* Hood) and mites (*Polyphagotarsonemus latus* Bank) beside virus attack (Naitam *et. al*. 1990). The symptoms produced by mites, thrips and virus are in general similar but, they distinctly differ from each other under critical observation (Karmakar,1995).

Nearly 25 insects have been recorded attacking chilli leaves and fruits in India, of which thrips, *Scirtothrips dorsalis* Hood (Thripidae: Thysanoptera) is considered as the most serious and important pest (Ananthakrishnan, 1971; Butani, 1976; Krishna Kumar, 1995 and Krishna Kumar *et al.,* 1996). The symptoms of chilli leaf curl caused by feeding injury of thrips was described by Amin (1979), which is locally known as "*Kokadava*" in Gujarat. The yield losses 60.5 to 74.3 per cent of green chilli due to thrips were estimated by Patel and Gupta (1998) at Udaipur (Rajasthan). Thrips, mites, aphids and whiteflies have been identified as sucking pests of chilli in Karnataka of which chilli leaf curl caused by mite and thrips are serious (Puttarudriah, 1959). Besides, a number of viruses are transmitted by aphids, whiteflies etc which result into a complex of murda (Gundannavar *et al.,* 2007). Economic yield loss may be 11-75% quantitatively and 60-80% qualitatively in the event of serious infestation (Ghosh *et.al*. 2009). One of the practical means of increasing chilli production is to minimize losses caused by major sucking pests.Surveys conducted by AVRDC in Asia revealed that, the major sucking pests that attack chilli are thrips (*Scirtothrips dorsalis* Hood), mite (*Polyphagotarsonemus latus* Banks) and aphids (*Myzus persicae* Sulzer, *Aphis gossypii* Glover) (Berke and Sheih, 2000). Chilli thrips multiply appreciably at a faster rate during dry weather periods and causes a yield loss of 30 to 50 per cent in South India.

Chilli leaf curl is one of the most destructive syndromes affecting chilli growth in India and considered to be caused by thrips. Nymphs and adults of thrips suck the sap from tender crop canopy, resulting shriveling of leaves. Patel and Gupta (1992) reported that thrips *S. dorsalis* was responsible for cause of leaf curling in chilli. The infested leaves curled upward (adaxially) presenting a boat shaped appearance and they suggested thrips management to overcome the malady of leaf curling.In addition to eruption of internal areas and puckering of leaves, upward curling of leaves is also noticed. The affected leaves and fruits are deformed, twisted, brittle and crumpled (Reddy and Puttaswamy 1983). Feeding symptoms of the mite are downward curling, crinkling of leaves and elongation of leaf petiole followed by blister patches. If the plant is attacked at flowering stage, the flowers are transformed into leafy shoots and may wither and dry (Karupachamy *et al.,* 1993).

Now-a-days buildup of thrips in chilli is so much that farmers have many spray of chemical insecticides to manage it. Number of sprays increased over the years, but in vain and on the contrary, cost of cultivation has increased enormously making cultivation of chilli highly risky. In addition to this, pesticidal sprays became a threat to chilli ecosystem causing problems of resistance, resurgence of pests, pesticides residue and menace to natural enemy fauna (David,1986).

Of the various pests attacking chilli, the thrips *S. dorsalis* is considered as one of the most destructive insect pest in India. Now- a- days, a large number of newer insecticides and biopesticide are available in market. Bioefficacy of these insecticides and biopesticides need to be studied for formulating effective and economical management strategies of any insect pest.

In view of above parameters, following objectives were framed for detail study.

1) To study the bio-efficacy of *Metarhizium anisopliae* against sucking insect pests of chilli.
2) To assess the phytotoxic effect of *Metarhizium anisopliae* on chilli.
3) To assess the yield performance of different treatments.
4) To find out the economics of treatments.

CHAPTER 2

REVIEW OF LITERATURE

Chilli is an important spice crop and infested by a number of pests. Chilli thrips, Whitefly and Mites are some of the major pests to cause considerable economic loss. This chapter deals with the literature, which is relevant to present work entitled **"**Comparative bio-efficacy of *Metarhizium anisopliae* based bio-insecticide Met 52 OD in chilli (*Capsicum annuum* L.) for the control of sucking insect pests.**"** with following objectives as summarised below.

1. Bio-efficacy of *Metarhizium anisopliae* against sucking insect pests of chilli.
2. Phytotoxic effect of *Metarhizium anisopliae* on chilli.
3. The yield performance in different treatments.
4. The economics of treatments.

Bioefficacy of *Metarhizium anisopliae* against sucking insect pests of chilli.

Walunj and Pawar (2004) evaluated thiacloprid at 36, 54 and 72 g.*a.i.*/ha was equally effective against aphids,in chilli with the least survival of all treatments at 3, 7 and 14 days after each spray. All insecticide treatments decreased the numbers of aphids and whiteflies at 14 days after spraying.

Reddy *et al*., (2005) evaluated certain new insecticides against chilli thrips (*Scirtothrips dorsalis*) and mites (*Polyphagotarsonemus latus*) and found that fipronil, followed by thiamethoxam, acetamiprid and dimethoate, was the most effective against the thrips, while carbaryl, followed by phosalone and chlorpyrifos, was the least effective.

Thungrabeab *et al*., (2006) studied on possibilities for biocontrol of the onion thrips *Thrips tabaci* Lindeman (Thys., Thripidae) using different entomopathogenic fungi from Thailand andresult showed that mortalities caused by *Metarhizium spp*. ranged from 23.5% to 97.3%, in which *Metarhizium sp.* isolates were more pathogenic than *M. anisopliae. M. anisopliae* isolates were also more pathogenic than *Metarhizium flavoviride* GAMS & ROZSYPAL.

Chaudhary and Jaipal (2006) tested insecticidal applications that cause significant reduction of whitefly population in sugarcane (71.1-89.5%) compared to untreated control. Removal of whitefly puparia bearing leaves from the plants had no significant effects in reducing white fly population. New insecticides *i.e.* regent 5SC (fipronil) and confidor 200SL (imidacloprid) applied on foliage at 0.05% each were most effective and caused 85.1 and 83.1% reduction in whitefly population. The next effective group of insecticides were carbosulfan 25EC (76.6%) and acephate 75SP (73.7%) at 0.05.

Ansari *et al*., (2007) studied the pathogenicity of the fungus *Metarhizium anisopliae* (Metchnikoff) Sorokin (Ascomycota: Clavicipitaceae) against different species of thrips in western flower and found *Metarhizium anisopliae* V275 was more efficacious than chemical insecticides (imidacloprid, fipronil) in killing pupae of the western flower thrips (70–90% versus 20–50%) in a range of horticultural growing media (peat, coir, bark and peat blends with 10% and 20% composted green waste).

Reddy *et al.,* (2007) studied the efficacy of certain new insecticides against pest complex of chilli (*Capsicum annum* L.) and found that fipronil 5% SC @ 2ml was the best treatment against thrips followed by spinosad 45% SC @ 0.3 and 0.2 ml/litre.

Reddy*et al.*, (2007) evaluated certain new insecticides against chilli thrips (*Scirtothrips dorsalis*) and mites (*Polyphagotarsonemus latus*) and found that among 17 insecticides tested, fipronil5% SC at 0.01% followed by triazophos 40 EC at 0.06%, phosalone 50EC at 0.075 and carbaryl 50WDP at 0.15% were found to be more effective against thrips, as they reduced thrips population, while, endosulfan 35 EC at 0.07%, quinalphos 25 EC at 0.055 and indoxacarb 14.5SC at 0.0145% were found to be least effective.

Gouli *et al*., (2008) studied entomopathogenic fungi against Western Flower Thrips (WFT), and under research conditions, formulations based on *Beauveria bassiana* (Balsamo) *Vuillemin*, *Metarhizium anisopliae* (Metschnikoff) Sorokin and *Lecanicillium lecanii* (Zimmermann) Zareet W. Gams, have been reported to significantly reduce WFT populations in green house vegetable and floral crops.

Maketon *et al.,* (2008) reported 12 entomopathogenic fungi for controlling broad mite *Polyphagotarsonemus latus* (Banks) in mulberry and found that

Metarhizium anisopliae CKM-048 was the most virulent strain in controlling both larvae and adult broad mites at the concentration of $2x10^8$ conidia/ml.

Mahalingappa *et al*., (2008) studied the bio-efficacy of certain insecticides against thrips (*Scirtothrips dorsalis* Hood) and mite (*Polyphagotarsonemus latus* Banks) infesting chilli (*Capsicum annuum* L.) and results indicated that fipronil 0.01 and triazophos 0.08 per cent were most effective against thrips in chilli, which were followed by profenofos 0.10, ethion 0.10 and cypermethrin 0.0012 per cent. Chlorpyriphos 0.0012 per cent was least effective against thrips. Profenofos 0.10 per cent was most effective against mite.

Mahmudunnabi *et al*., (2009) determined the efficacy of plant products, chemical insecticides and biocontrol agent (Green lace wing) for the control of onion thrips. The chemical insecticides, fipronil (ascend 50SC) and biocontrol agent showed the better performance against onion thrips and the highest yield was obtained from fipronil 50SC treated plot.

Reddy and Sreehari (2009) studied on efficacy of fipronil 80 WG a new formulation and other chemicals against chilli thrips and found that fipronil80 WG @ 50 g.*a.i*./ha recorded lowest number of thrips and is on par with fipronil 80 WG @ 40 g.*a.i*./ha, regent 5% SC @ 40 g.*a.i*./ha and acephate 75% sp @ 468.75 g.*a.i*./ha, whereas confidor 200 SL and fipronil 80 WG @ 30 g.*a.i*./ha were found least effective against thrips. None of the treatments had shown any phytotoxicity symptoms on chilli crop.

Ghosh *et al.,* (2009) evaluated insecticides against chilli thrips (*Scirtothrips dorsalis* Hood) and reported that fipronil at 100 g.*a.i*./ha recorded lowest population of thrips on chilli. They further reported that treatments with thiamethoxam followed by acetamiprid were found to be effective in lowering thrips population which gave 88.8% mortality of S. dorsalis in chilli.

Patil *et al.,* (*2009)* evaluated bioefficacy of new molecule fipronil5% SC against sucking pest complex in Bt cotton and revealed that fipronil 5% SC @ 800 g/ ha registered least number of thrips (8.47 / 3 leaves) and found to be on par with acetamiprid 20 SP @ 100 g/ha, (7.80 /3 leaves) and significantly highest seed cotton yield of 27.23 q/ha (2007) and 27.50 q/ha (2008) was harvested with higher dosage of fipronil 5% SC @ 800 g/ha respectively proving them to be on par with acetamiprid 20 SP.

Naik and Shekharappa (2009) studied the bioefficacy of entomopathogenic fungal formulations against sucking pests of okra. The results showed that *Beauveria bassiana* oil and *Metarhizium anisopliae* oil and their WP formulations recorded 96.67% mortality of leafhoppers at 10 DAT.The efficacy against mite was 96.67 and 94.67 per cent in *M. anisopliae* oil and WP followed by *B. bassiana* oil (94.00%).The yield of okra was significantly higher in oil based formulation of *M. anisopliae* (38.80 q/ha) and *V. lecanii* (38.50 q/ha) with monitory returns of Rs. 14720 and Rs. 14480/ha, respectively followed by *B. bassiana*. However, highest the benefit cost ratio of 18.40:1 and 16.68:1 were recorded in *V. lecanii* and *M. anisopliae* wettable powder formulation, respectively.

Sabbour (2009) evaluated two entomopathogenic fungi against *Bemicia tabaci* and *Aphis gossypii* infesting tomato crops in Egypt and found under laboratory, greenhouse and field conditions. Results showed that percentage infestations decreased after treatment with the fungi. Under laboratory conditions, LC50 values for *B. tabaci* were 111.6×10^8 spores/ml for B.b. and 122.4×10^8 spores/ml for M.a., whereas the values for *A. gossypii* were 110.1×10^8 spores/ml for B.b. and 117.4×10^8 spores/ml for M.a. In the greenhouse, LC50 values for *B. tabaci* were 56.4×10^8 spores/ml for B.b. and 76.6×10^8 spores/ml for M.a., and for *A. gossypii* they were 68×10^8 spores/ml for B.b. and 88x108 spores/ml for M.a. Under field conditions, the percentage of infested plants with *B. tabaci* and *A. gossypii* significantly decreased after treatments with both B.b. and M.a., as compared with the control treatment, on the El-Esraa (Nobaria region) and El-Kassaseen (Ismailia) farms. The tomato yield weight for El-Esraa was 3,487 and 3,448 kg/feddan when B.b. and M.a. was applied, compared to 1,000 kg/faddan for the control, whereas it was 3,531 kg/feddan for El-Kassaseen when B.b. was applied and 3,400 kg/feddan when M.a. was applied, as compared to 977 kg/feddan in the control.

Kandekar *et al*., (2010) evaluated efficacy of fipronil 5% SC at different doses against aphids and leaf hopper in cotton and found fipronil @ 200 & 400 g.*a.i*./ha was found the most effective against aphids and leaf hopper, but it was not safer to ladybird beetles. At population 100 g.a.i./ha, it provided optimum control of aphids and leaf hopper and was comparatively safer to ladybird beetles (*Coccinella spp.).*

Shanmugapriyan and Mathew Babu (2010) evaluated *Metarhizium anisopliae* (Kalichakra 1% W.P.) and Derimax against tea thrips under laboratory conditions and found *M. anisopliae* at 3.75 g/litre recorded 96.7% mortality after 96 h. The herbal product, Derimax recorded 100% mortality at 0.375 ml/litre within 72 h after treatment.

Shreekanth and Reddy (2011) determined the efficacy of different insecticides against sucking pests of cotton and reported that against thrips AT 3 DAS, the mortality of thrips was high in thiamethoxam (78.52%) and fipronil (75.23%) followed by imidachloprid (70%) and they are at par with each other. The observations recorded at 7 DAS showed that thiamethoxam performed better with 80% mortality as compared to fipronil (76.55%), imidacloprid (72%) and acetamaprid (68%).

Neelima *et al*. (2011) evaluated thebio-efficacy of ecofriendly products against cotton leafhopper, *Amrasca devastans*(Dist.) and found that fipronil 5% SC @ 50 g.a.i./ha was effective in bringing down the population of leafhoppers up to 72.3% over control at 14 days after spraying. Per cent reduction in leafhopper population was less with bio-control agents viz., *V. lecanii* @ 2500 g/ha (11.0), *M. anisopliae* @ 2500 g/ha (12.3), *B. bassiana* @ 2500 g/ha @ 2500 g/ha (14.9). Other organic compounds like panchagavya @ 5%, cow dung-urine extract @ 10% were ineffective in managing the leafhopper population on cotton.

Hosamani *et al*., (2012) evaluated fipronil 80 WG against thrips during the years 2010 and 2011. During first year trial, fipronil 80 WG @ 60 g.*a.i.*/ha was the best treatment for reduction in thrips population from 22.46 to 1.13 thrips per plant. It was found to be effective up to ten days, recording minimum population of 0.83 thrips/plant at three days, and 0.58 thrips perplant at ten days after spray. During second year trial, results of the first year were confirmed. During first year, highest yield of 29.16 t/ha was obtained due to the treatment with fipronil 80 WG @ 60 g.*a.i.*/ha and was at par with its lower dose .Similar trend was observed during second year trial.

Kalyan *et al*., (2012) studied comparative bio-efficacy of some new molecules against jassids and whitefly in cotton and reported that spinosad, imidacloprid, acephate and fipronil effectively controlled the population of jassids and whiteflies and gave significantly higher seed cotton yield over untreated check and standard check. The highest avoidable losses (52.65%) were recorded in spinosad followed by imidacloprid (42.38%), acephate (31.47%), fipronil (28.23%) and dimethoate (28.12%).

Rohini *et al.,* (2012) studied onmanagement of major sucking pests in Cotton by insecticides and found that fipronil 5 SC @ 2ml/L and acephate 75 SP @ 1.50 g/L were found to be effective against thrips in cotton.

Visalakshy *et al*., (2012) studied on comparative field efficacy of various entomopathogenic fungi against *Thrips tabaci* and found *M. ansiopliae* at a concentration of $1x10^9$ spores/ml with adjuvant (sunflower and Triton-X) recorded the lowest thrips/plant population contributing to 58% reduction and 49.12% increase in yield over control. This study suggests that entomopathogens can substitute chemical pesticides in the management of *Thrips tabaci* in onion.

Arthurs *et al*.,(2013) evaluated entomopathogenic fungi against chilli thrips, *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae), In laboratory assays, LC50 values against adult *S. dorsalis* were 5.1x104 CFU/mL for *Beauveria bassiana* GHA, with higher values 3.1x105 for *Metarhizium brunneum* F52 and 3.8x105 for *Isaria fumosorosea* Apopka 97.In greenhouse cages, compared with controls, three applications of mycoinsecticides and other biorational insecticides at 7 to 14 day intervals reduced overall *S. dorsalis* populations on pepper plants *Capsicum annuum* cv. California Wonder: spinosad reduced populations by 94-99%, *M. brunneum* F52 by 84-93%, *B. bassiana* GHA by 81-94%, *I. fumosorosea* PFR-97 by 62-66%, and different horticultural oils by 58-85%. The proportion of marketable fruit was significantly increased by *M. brunneum* F52, *B. bassiana* GHA, and 2% SuffOil-X treatments. Four applications reduced thrips populations over 10 weeks: spinosad by an average of 91%, *M. brunneum* F52 by an average of 81%, *B. bassiana* GHA by an average of 62%, SuffOil-X by an average of 50%, and *I. fumosorosea*PFR-97 by an average of 44%. The data show that mycoinsecticides can be used in management strategies for low to moderate populations of S. dorsalis and provide resistance management tools for the limited number of insecticides that are effective against this pest.

Dhawan and Singh (2013) studied on the bio-efficacy of fipronil (Jump 80 WG) against thrips, *Thrips tabaci* on cotton and that population of thrips per 3 leaves was significantly lower in fipronil @ 50 g.a.i./ha and 60 g.a.i./ha (5.13 and 3.63) a compared to all other treatment after 3 days of spray. However, after 5 and 7 days of spray all the treatments gave better control of *Thrips tabaci* except imidacloprid. After 12 days of spray thrips population per 3 leaves was significantly lower in fipronil @ 60 g.a.i./ha (2.49) which was on par with its lower dose fipronil @ 50 g.a.i./ha (5.06). Significantly high seed cotton yield of 23.49 q/ha was obtained with higher dosage of fipronil 50WG @ 60 g a.i./ha followed by fipronil 80WG @50 g.a.i./ha (23.05 q/ha) among all the treatments.

Mahla *et al*.,(2013) evaluated bio-efficacy of fipronil 200 SC against thrips, *Thrips tabaci* (Lindeman) infesting cotton and found that fipronil 200 SC at 375 ml/ha caused the highest 68.55, 70.63, 64.67; 80.73, 93.65, 88.76 and 64.63, 72.27, 68.19; 80.81, 92.89 and 89.88 percent reduction of thrips followed by fipronil 200 SC at 300 ml/ha. which caused 51.78, 59.64, 56.67; 75.84, 89.83, 82.41and 46.78, 54.61, 51.65; 75.61, 88.95 and 84.46 percent reduction at 3, 7 and 10 days after first and second spray during 2011 and 2012, respectively.The insecticidal treatment regent 5% SC at 1500 ml/ha and imidacloprid 200 SL at 125 ml/ha also recorded lower population of thrips and was significantly superior over other treatments. The highest seed cotton yield of 29.90 and 30.14 q/ha was recorded in case of fipronil 200 SC at 375 ml/ha during kharif 2011 and 2012, respectively followed by fipronil 200 SC at 300, imidacloprid 200 SL at 125 ml/ha and Regent 5% SC which yielded 29.10, 28.92; 27.48, 27.60; 26.00 and 26.35 q /ha during kharif 2011 and 2012, respectively.

Pandey *et al.* (2013) studied the effect of neem based botanicals , chemicals and bio insecticides for the management of thrips in onion and found that the lowest mean thrips population (8.0 nymphs/plant) and the highest marketable yield (362 Q/ha) were achieved by applying fipronil @ 1.5 ml/lt. resulting in the highest cost benefit ratio (1:11.55) leading to an arbitration of spraying fipronil @ 1.5 ml/lt. at fifteen days interval minimize the thrips population and increase the yield of Rabi onion, while neem based formulations were found less effective.

Ahmed *et al*., (2014) determined efficacy of four neonicotinoids viz; nitenpyram 10SL, thiacloprid 480SC, imidacloprid 200SL, acetamaprid 20SL and four traditional insecticides such as profenofos 50EC, methidathion 40EC, bifenthrin 10EC, λ-cyhalothrin 2.5EC at their recommended field doses against sucking insect pests of cotton and reported that minimum number of whitefly was recorded in thiacloprid treated plots (2.03) which was statistically different from number of whitefly (2.33) in nitenpyram treated plots.

Das and Tarikul (2014) evaluated the efficacy of some new generation insecticides against two important sucking insects, *Amrasca devastans* (jassid or leafhopper) and *Bemicia tabaci* (white fly) in brinjal and found that fipronil, imidacloprid and buprofezin were most effective.

Karkar *et al., (*2014) noted that the bio-efficacy of microbial insecticides against insect pests of brinjal and found application of *M. anisopliae* and *L. lecanii* applied at 40 g/10 litres of water was effective against sucking pests.

Nayak *et al.,* (2014) evaluated comparative efficacy of certain insecticides against thrips (*Scirtothrips dorsalis* H.) and aphids (*Aphis gossypii* G.) on chilli and found that among the test chemicals imidacloprid recorded significantly the lowest thrips and aphid population and resulted in the highest marketable fruit yield and net return. Acetamiprid and fipronil were found to be the next most effective insecticides in minimizing the incidence of these sucking pests and maximizing the yield and net return in chilli production.

Yadav and Raghuraman, (2014) studied on bio-efficacy of certain newer insecticides against fruit and shoot borer, *leucinodes orbonalis* (Guen.), white fly, *Bemicia tabaci* (Genn.), and jassid, *Amrasca devastans* distant in brinjal and found In case of second spray, imidacloprid 17.8% SL recorded the highest reduction in whitefly population (31.2%) followed by fipronil 80 WG @ 100 g.*a.i*./ha with 45.4% , buprofezin and 46.5% reduction in whitefly population over control respectively.

CHAPTER 3
MATERIAL AND METHODS

The experiment entitled **"**Comparative bio-efficacy of *Metarhizium anisopliae* based bio-insecticide Met 52 OD in Chilli (*Capsicum annuum* L.) for the control of sucking insect pests."was conducted in *Kharif* season of 2014-15 at field of College of Agriculture, Indore (M.P.). The details of experimental materials and methods followed are described as below:

3.1 Experimental site

The present experiment was carried out on medium black cotton soil of the College of Agriculture Farm, Indore, having a uniform topography. Indore is situated in the "Malwa Plateau" which is an agro-climatic zone of Madhya Pradesh at the following geographical parameters:

- Latitude of $22^o43^'$N
- Longitude of $75^o56^'$E
- Altitude of 555.7 meters above the mean sea level

3.2 Layout of the experiments

The experiment was laid out in a Randomized Block Design (RBD) with eight treatments in three replications. Thus in all there were 24 plots. The layout plan of experiment is shown in Fig 3.1.

3.3 Climate and weather conditions

The climate of this region is semi-arid and sub-tropical having mild winter and summer with uncertain winter rains. The rainfall occurs mostly from mid-June to end of September. The meteorological data regarding temperature, relative humidity and rainfall was recorded during the cropping season from the meteorological observatory of All India Coordinated Dry land Agriculture Research Project, located at College of Agriculture Farm, Indore, presented in the Table 3.1 and depicted in Figure 3.2.

Table 3.1 Meteorological parameters recorded at Indore (M.P.) during crop season 2014-15.

SMW	R.H. %	Max.Tem. (^oC)	Min.Tem, (^oC)	Rainfall (mm)
29	84.00	27.64	23.57	139.6
30	83.43	23.71	20.43	172.2
31	81.57	28.71	21.00	12.0
32	81.86	27.00	21.79	12.6
33	80.14	28.71	22.29	6.1
34	79.29	31.5	23.43	18.2
35	81.57	30.14	22.79	72.4
36	81.57	26.93	23.00	129.8
37	83.57	25.93	22.64	12.8
38	82.43	29.64	22.57	8.4
39	81.14	31.71	18.36	12.0
40	80.71	32.93	20.64	14.0
41	81.71	32.64	18.29	10.4
42	78.86	31.79	18.79	7.0
43	81.71	31.21	15.71	0.0
44	80.43	31.29	14.5	0.0
45	79.00	31.07	14.21	0.0
46	81.14	30.21	17.71	0.0
47	82.14	29.36	12.07	0.0
48	80.43	29.86	11.71	0.0
49	77.86	27.71	08.50	0.0
50	82.14	25.71	06.71	5.8

51	75.57	21.71	04.50	0.0
52	76.63	22.75	05.38	0.0
1	***82.00***	***17.20***	***06.00***	***45.8***
2	***77.0***	***23.60***	***06.70***	***0.0***
3	***78.00***	***23.30***	***06.70***	***0.0***
4	***80.00***	***22.50***	***08.60***	***14.8***

Source: Observatory, All India Coordinated Dry land Agriculture Research Project, College of Agriculture, Indore.

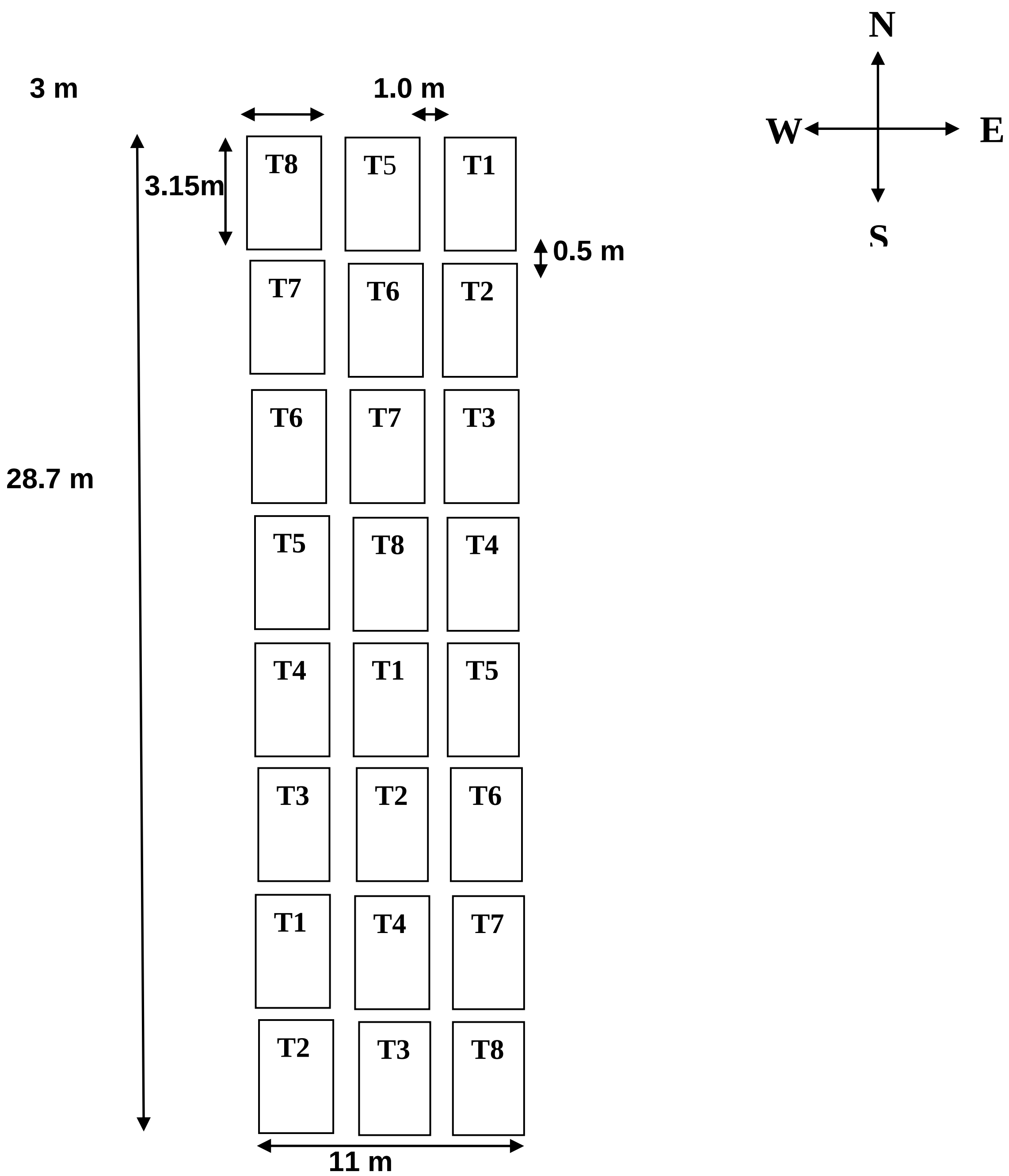


Fig 3.1 Layout plan of the experiment field

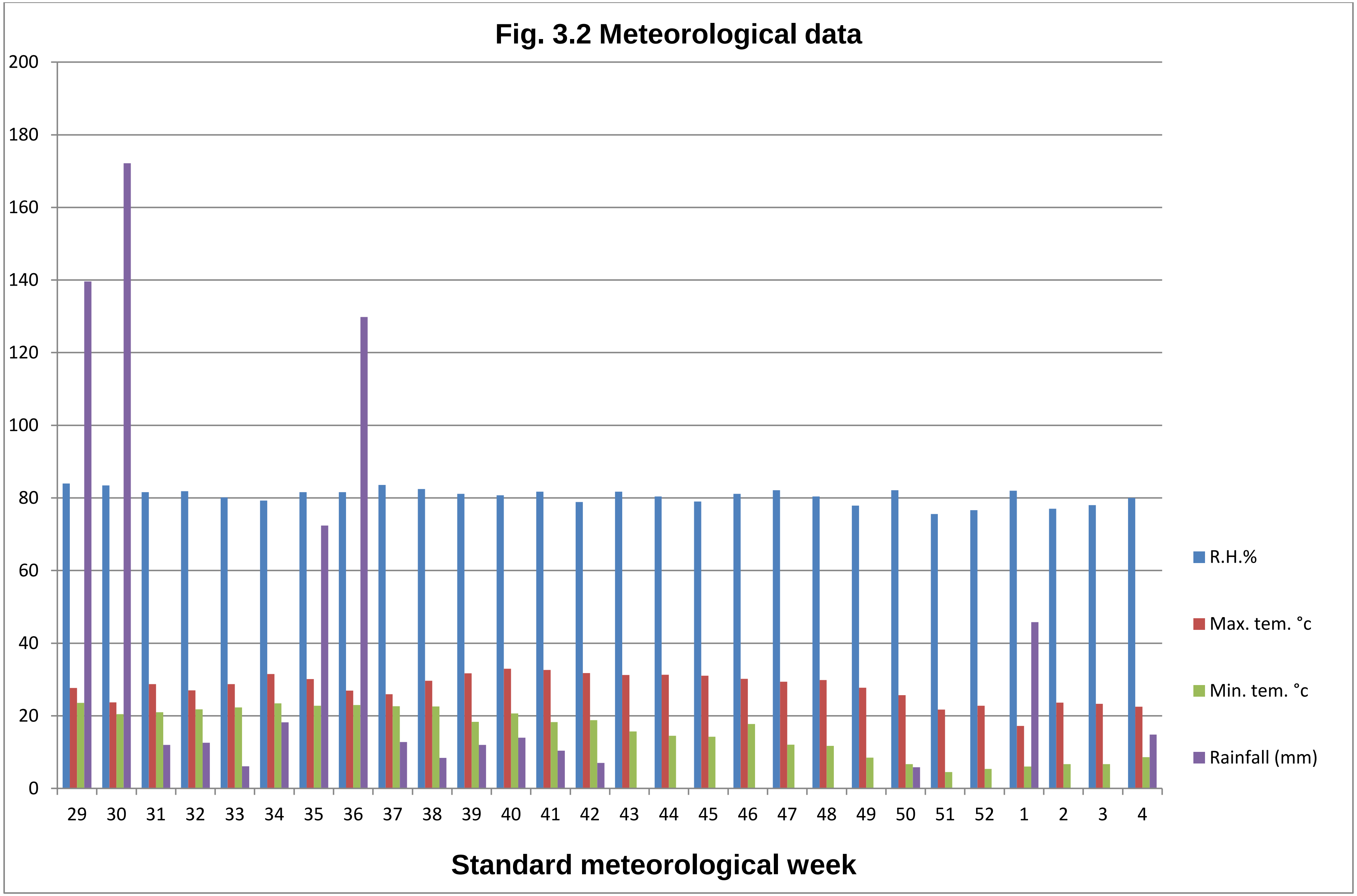


Fig. 3.2 Meteorological data
200
180
160
140
120
100
80
60
40
20
0
29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 1 2 3 4
Standard meteorological week
R.H.%
Max. tem. °c
Min. tem. °c
Rainfall (mm)

3.3 Experiment details

The experiment was carried out in Randomized Block Design (RBD) with 8 treatments and 3 replications at farm to evaluate the bioefficacy of Metarhizium anisopliae based bio-insecticide Met 52 OD with different insecticides against the sucking insect pest of chilli and the details of experiment are given below.

Table 3.2 Experiment details:

Crop	Chilli
Variety	Pusa jwala
Date of sowing in nursery	17/07/14
Date of Transplanting	19/08/14
Design	RBD (Randomized Block Design)
Replications	3
Treatments	8
Plots	24
Spacing between plant	45 cm.
Spacing between rows	60 cm.
Spacing between plots	0.5m.
Spacing between replication	1.0 m.
Gross area	315.7 m^2
Net area	226.8 m^2
Net plot size	3.15 m. × 3 m. = 9.45 m^2
Application timing	Crop sprayed when insect reached ETL.
No. of application	8 spraying at 10 days interval
Method of application	Foliar application with knapsack sprayer fitted with a duromist nozzle
Water volume	500 liter water per hectare.

Table 3.3 Treatments detail:

S.NO.	Treatments	
1	T_1	Untreated control (UTC)
2	T_2	Fipronil 5 SC @ 1000 ml/ha and alternated with Thiacloprid 21.7 SC @ 300 ml/ha.(4+4 application)
3	T_3	Met 52 @ 250ml/ha foliar spray x 8 application
4	T_4	Met 52 @ 500ml/ha foliar spray x 8 application
5	T_5	Met 52 @ 1000ml/ha foliar spray x 8 application
6	T_6	Met 52 @ 250ml/ha foliar spray alternated with Fipronil 5 SC @ 850 ml/ha (4+4 application)
7	T_7	Met 52 @ 500ml/ha foliar spray alternated with Fipronil 5 SC @ 900 ml/ha (4+4 application)
8	T_8	Met 52 @ 1000ml/ha foliar spray alternated with Fipronil 5 SC @ 950 ml/ha (4+4 application)

1. Management practices

(1) Fertilizer - N:P:K::100:50:50 kg/ha

Observations

Observations were recorded at different stages of plant growth.

1. To study the bio-efficacy of treatments, population of sucking pest like thrips, white fly, mites etc was planned to be counted on five tagged plants from each plot and five leaves from each plant i.e. two leaves from top, two from leaves middle and one leaf from lower portion of the plant. The aphid population was also planned to be counted on 10 cm long twig of each plant. The thrips was dislodged by jerking the twig on a white paper and the number of thrips (nymphs) counts was recorded. Bagle (1993)
2. Per cent insect mortality wascalculated for every 3, 7 and 10 days up to last application.
3. Five plants were selected randomly in each plot and scored for leaf curling visually following the standard scoring procedure as described by Niles (1980).
4. Symptoms of phytotoxicity were observed visually.
5. Dry fruit yield was recorded and converted into kg/ hectare.
6. Economics of different treatments was also computed.

Meteorological data (weekly wise) was recorded during the entire investigation.

Statistical analysis

The Per cent mortality (Henderson and Tilton, 1955) was worked out on the basis of sucking pests population recorded before and after each spray.

Per cent mortality = $1 - \frac{(\text{Ta}\times\text{Cb})}{\text{Tb}\times\text{Ca}} \times 100$

Where,

Ta = Number of insects on treated plots after insecticidal application

Tb = Number of insects in treated plots before insecticidal application

Ca = Number of insects in untreated plots after insecticidal application

Cb = Number of insects in untreated plots before insecticidal application

The data on percentage mortality of thrips population were transformed into angular values (Bliss, 1937) and subjected to analysis of variance.

Yield

The yield of dry chilli received from different treatments (kg/plot) along with control, recorded during each picking. The total yield of dry chilli (kg/plot) was converted on hectare basis and subjected to statistical analysis.

The data obtained from a set of observations for each character were tabulated and analyzed by the method of “Analysis of variance" as suggested by Fisher and Yates, (1963).

Table 3.4 Skeleton of ANOVA table

Source of variance	**Degree of freedom**	**Sum of square (SS)**	**Mean sum of square (MSS)**	**Calculated F value**	**Table value at 5%**
Replication	(r-1)	SSR	MSR	MSR/MSE	
Treatments	(t-1)	SSTr	MSTr	MSTr/MSE	
Error	(r-1)(t-1)	SSE	MSE		

Total	(rt-1)	TSS			

The significant differences between different treatments were judged by using critical differences (CD) which was calculated as follows:

S.Ed = $\sqrt{\frac{MSE}{r}} X \sqrt{2}$

S.Ed = Standard error of differences between two treatment means.

MSE (Ve) = Error mean sum of square (Error variance).

CD = For treatment at 5% = S.Ed.

X + (e.d.f) at 5% x $\sqrt{2}$

CD = Critical difference

Where,

r = Number of replication

t = Value for fishers table for error degree of Freedom at 5%

e.d.f. = Error degree of freedom.

CHAPTER 4

EXPERIMENTAL FINDINGS

The research findings of the experiment entitled "Comparative bio-efficacy of *Metarhizium anisopliae* based bio-insecticide Met 52 OD in Chilli (*Capsicum annuum* L.) for the control of sucking insect pests.'' was undertaken during the *kharif* 2014-15 at the experimental site of farm of College of Agriculture, Indore, are described in this chapter under following headings:

1. Bioefficacy of *Metarhizium anisopliae* against sucking insect pests of chilli.
2. Phytotoxic effect of *Metarhizium anisopliae* on chilli.
3. Yield performance in different treatments.
4. Economics of treatments.

During the experimentation period except thrips, no insect pests occurred hence only thrips population was counted. Negligible whitefly population was seen in the field.

4.1 Bioefficacy of *Metarhizium anisopliae* against sucking insect pests of Chilli.

The efficacy of various treatments was observed on the basis of-

-Thrips population count and

-per cent mortality.

Population count of chillithrips (*Scirtothrips dorsalis* Hood)

The first appearance of chilli thrips was found 25 days after transplanting and reached its ETL before first spraying.

Pre-treatment

The thrips population exhibited non-significant difference in all the experimental plots before spraying. The lowest population was recorded as 4.49 and highest as 6.45/ leaf.

Post treatment

4.1.1 After first spray

3 days after

Population

The lowest thrips population was recorded in T2 (0.89) which was significantly minimum as compared to all other treatments including untreated check. Among rest of the treatments lowest population was noted in T5 (4.20) followed by T3 (4.24) and other treatment. The maximum thrips population was recorded in untreated check T1 (5.48) followed by T7 (5.00).(table 4.1 and fig 4.1).

Mortality

The maximum per cent mortality of thrips was noted in treatment T2 (80.17%) which was significantly higher overall other treatments. Rest of the treatments showed non-significant difference with each other excluding untreated check.(table 4.2 and fig 4.2).

7 days after

Population

All the treatment exhibited significant difference with untreated check. The least thrips population was noted in T2 (1.50) which again showed significant difference with rest of the treatments. Further the next best treatment was observed T5 (1.89) which was found at par with remaining treatments. The highest population was recorded in untreated check T1 (5.75). (table 4.1 and fig 4.1).

Mortality

The lowest mortality of thrips was recorded in treatment T3 (39.75%) which was at par with all other treatments except T8 (46.06%) which showed significant difference. The highest mortality was recorded in T2 (68.16%)**.**(table 4.2 and fig 4.2).

10 days after

Population

All the treatments exhibited significant difference with untreated check. The lowest population of thrips was recorded in treatment T5 (2.20) which was at par with all other treatment except T2 (3.20) The highest population was noted in untreated check T1 (5.80).(table 4.1 and fig 4.1).

Mortality

The minimum mortality was noted in T2 (34.66%) which showed significant difference with rest of the treatments. Further the best treatment was observed as T5 (61.93%) which was found at par with all the treatments. The maximum mortality was recorded in untreated check T5 (61.93).(table 4.2 and fig 4.2).

Table 4.1 Effect of treatments on thrips population after 1st spray

Treatments	Pre-treatment count	Thrips Population/leaf		
		After 1st Spray		
		3 DAS	7 DAS	10 DAS
T1- Untreated control	5.48 (2.44)	5.48 (2.44)	5.75 (2.50)	5.80 (2.51)
T2- Fipronil 5 SC @ 1000 ml/ha and alternated with Thiacloprid 21.7 SC @ 300 ml/ha	4.49 (2.23)	0.89 (1.17)	1.50 (1.41)	3.20 (1.92)
T3- Met 52 @ 250ml/ha	5.22 (2.39)	4.24 (2.17)	3.30 (1.94)	2.30 (1.67)
T4- Met 52 @ 500ml/ha	5.53 (2.45)	4.40 (2.21)	3.25 (1.93)	2.30 (1.67)
T5- Met 52 @ 1000ml/ha	5.46 (2.44)	4.20 (2.16)	3.10 (1.89)	2.20 (1.64)
T6-Met 52 @ 250 ml/ha alternated with Fipronil 5 SC @ 850 ml/ha	5.96 (2.54)	4.89 (2.32)	3.70 (2.04)	2.70 (1.78)
T7- Met 52 @ 500 ml/ha alternated with Fipronil 5 SC @ 900 ml/ha	6.21 (2.59)	5.00 (2.34)	3.65 (2.03)	2.60 (1.76)
T8- Met 52 @ 1000 ml/ha alternated with Fipronil 5 SC @ 950 ml/ha	6.45 (2.63)	4.98 (2.34)	3.65 (2.03)	2.66 (1.77)
S Em±		0.10	0.07	0.09
CD at 5 %(p=0.05)	**N.S.**	**0.32**	**0.22**	**0.26**

CV %		8.48	6.31	8.24

The values in parentheses are square root transformed values,
DAS = Days after spray

Fig. 4.1 Effect of treatments on thrips population after 1st spray

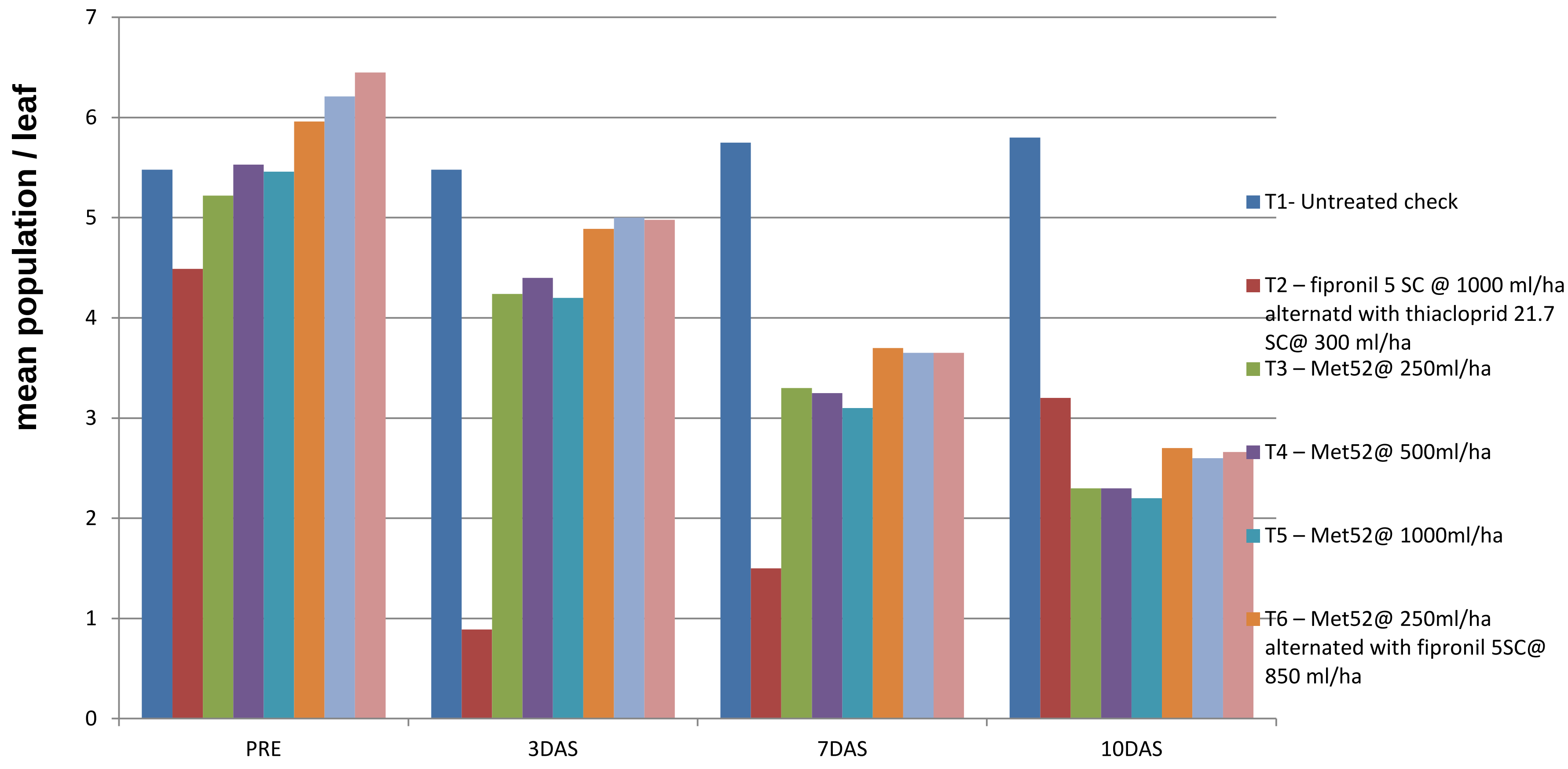


Table 4.2 Effect of treatments on thrips mortality after 1st spray

Treatments	Per cent mortality		
	After 1st Spray		
	3 DAS	7 DAS	10 DAS
T1- Untreated control			
T2- Fipronil 5 SC @ 1000 ml/ha and alternated with Thiacloprid 21.7 SC @ 300 ml/ha	80.17 (63.51)	68.16 (55.16)	32.66 (34.88)
T3- Met 52 @ 250ml/ha	18.77 (25.70)	39.75 (39.05)	58.36 (49.78)
T4- Met 52 @ 500ml/ha	20.43 (26.85)	43.98 (41.50)	60.70 (51.18)
T5- Met 52 @ 1000ml/ha	23.07 (28.73)	45.88 (42.65)	61.93 (51.88)
T6-Met 52 @ 250 ml/ha alternated with Fipronil 5 SC @ 850 ml/ha	17.95 (25.03)	40.83 (39.70)	57.19 (49.14)
T7- Met 52 @ 500 ml/ha alternated with Fipronil 5 SC @ 900 ml/ha	19.48 (26.21)	43.98 (41.50)	60.44 (51.00)
T8- Met 52 @ 1000 ml/ha alternated with Fipronil 5 SC @ 950 ml/ha	22.79 (28.52)	46.06 (42.76)	61.03 (51.35)
S Em±	1.24	1.94	1.91
CD at 5 %(p=0.05)	**3.82**	**5.98**	**5.90**
CV %	7.17	6.57	6.85

The values in parentheses are angular transformed (arc sin) values
DAS = Days after spray.

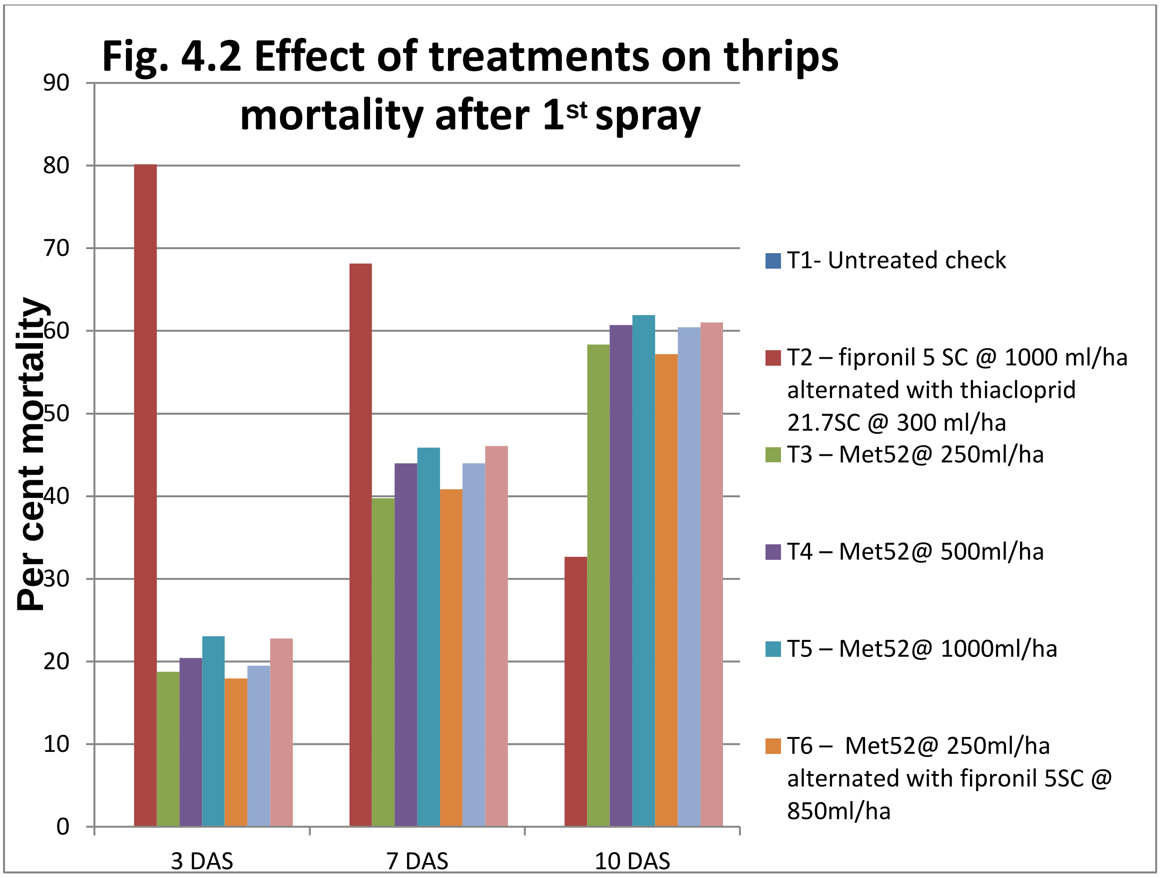


Fig. 4.2 Effect of treatments on thrips mortality after 1st spray
Per cent mortality
90
80
70
60
50
40
30
20
10
0
3 DAS
7 DAS
10 DAS
T1- Untreated check
T2 – fipronil 5 SC @ 1000 ml/ha alternated with thiacloprid 21.7SC @ 300 ml/ha
T3 – Met52@ 250ml/ha
T4 – Met52@ 500ml/ha
T5 – Met52@ 1000ml/ha
T6 – Met52@ 250ml/ha alternated with fipronil 5SC @ 850ml/ha

4.1.2 After second spray

3 days after

Population

The thrips population recorded in the range of 0.70 to 5.83. The lowest population was observed in treatment T8 (0.70) and found to be at par with T2 (0.80), T7 (0.80), and T6 (0.85). Treatment T5 (1.60), T4 (1.80) and T3 (1.90) were not so effective but were significantly better than untreated check. The highest population was noted in untreated check T1 (5.83). (table 4.3 and fig 4.3).

Mortality

The maximum mortality of thrips was noted in treatment T2 (75.12%) which was on par with T8 (73.81%), T7 (69.38%) and T6 (68.68%) but showed significant difference with rest of the treatments. The minimum pest mortality was noted in T3 (17.81%). (table 4.4 and fig 4.4).

7 days after

Population

The maximum thrips population was recorded in untreated check T1 (5.87) which differed significantly with all the treatments. The minimum thrips population was recorded in T8 (0.77) which was on par with treatments T5 (0.80), T7 (0.82), T6 (0.88), T2 (0.92) and T4 (1.00) but showed significant difference with T3 (1.20).(table 4.3 and fig 4.3).

Mortality

The highest mortality was recorded in T2 (71.59%) and found to be at par with T8 (71.39%), T7 (68.83%), T6 (67.79%) and T5 (64.07%). Remaining treatments showed poor mortality. (table 4.4 and fig 4.4).

10 days after

Population

The thrips population was noted in the range of 0.7 to 5.91. It was recorded maximum in the untreated check T1 (5.91), which differed significantly with all the treatments. The minimum insect population was recorded in treatment T5 (0.70) which was at par with T4 (0.90) and T3 (1.10) and followed with T7 and T8 (1.80), T6 (1.90) and T2 (2.00).(table 4.3 and fig 4.3).

Mortality

The maximum mortality of thrips was noted in treatment T5 (68.77%) and found to be at par with T4 (61.59%) followed by T3 (53.06%). Rest of the treatments exhibited comparatively poor insect mortality.(table 4.4 and fig 4.4).

Table 4.3 Effect of treatments on thrips population after 2nd spray

Treatments	Pre-treatment count	Thrips Population		
		After 2nd Spray		
		3 DAS	7 DAS	10 DAS
T1- Untreated control	5.80 (2.5)	5.83 (2.51)	5.87 (2.52)	5.91 (2.53)
T2- Fipronil 5 SC @ 1000 ml/ha and alternated with Thiacloprid 21.7 SC @ 300 ml/ha	3.20 (1.92)	0.80 (1.14)	0.92 (1.19)	2.00 (1.58)
T3- Met 52 @ 250ml/ha	2.30 (1.67)	1.90 (1.54)	1.20 (1.30)	1.10 (1.26)
T4- Met 52 @ 500ml/ha	2.30 (1.67)	1.80 (1.51)	1.00 (1.22)	0.90 (1.18)
T5- Met 52 @ 1000ml/ha	2.20 (1.64)	1.60 (1.44)	0.80 (1.14)	0.70 (1.09)
T6-Met 52 @ 250 ml/ha alternated with Fipronil 5 SC @ 850 ml/ha	2.70 (1.78)	0.85 (1.16)	0.88 (1.17)	1.90 (1.55)
T7- Met 52 @ 500 ml/ha alternated with Fipronil 5 SC @ 900 ml/ha	2.60 (1.76)	0.80 (1.14)	0.82 (1.15)	1.80 (1.51)
T8- Met 52@ 1000 ml/ha alternated with Fipronil 5 SC @ 950 ml/ha	2.60 (1.77)	0.70 (1.09)	0.77 (1.13)	1.80 (1.51)
S Em±	0.09	0.06	0.05	0.06
CD at 5 %(p=0.05)	**0.26**	**0.19**	**0.15**	**0.20**
CV %	8.24	7.69	6.24	7.34

The values in parentheses are square root transformed values

DAS = Days after spray

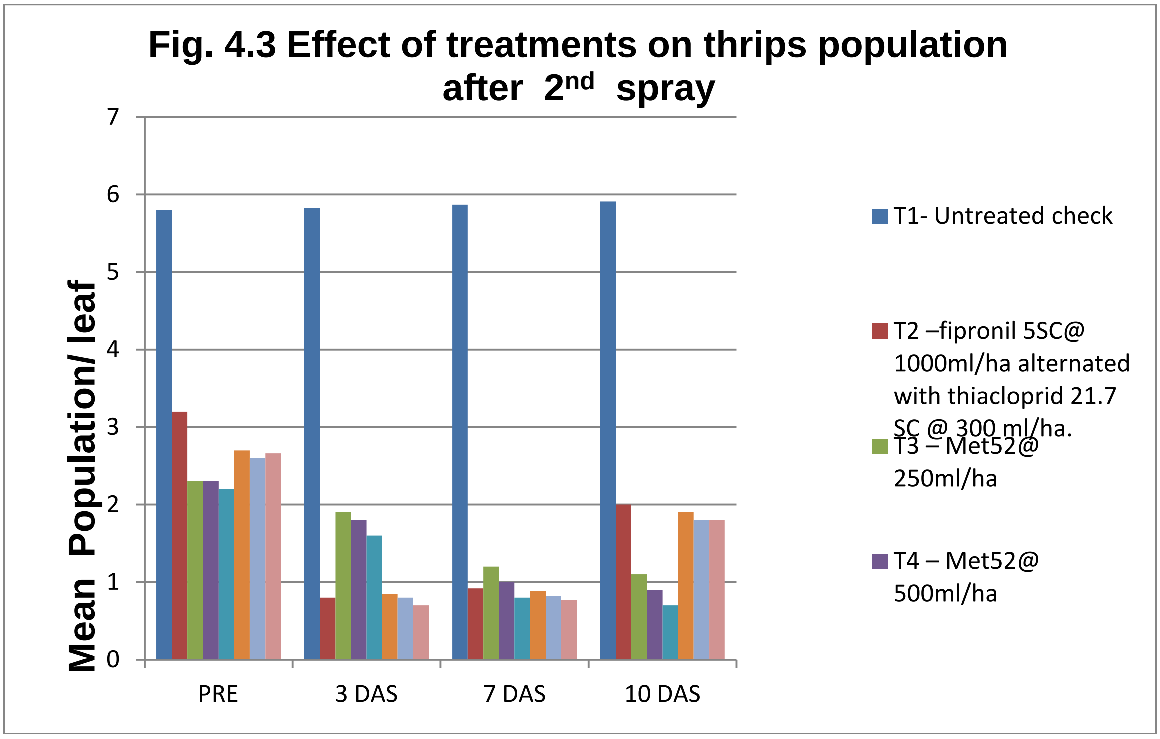


Fig. 4.3 Effect of treatments on thrips population after 2nd spray
Mean Population/ leaf
7
6
5
4
3
2
1
0
PRE
3 DAS
7 DAS
10 DAS
T1- Untreated check
T2 –fipronil 5SC@ 1000ml/ha alternated with thiacloprid 21.7 SC @ 300 ml/ha.
T3 – Met52@ 250ml/ha
T4 – Met52@ 500ml/ha

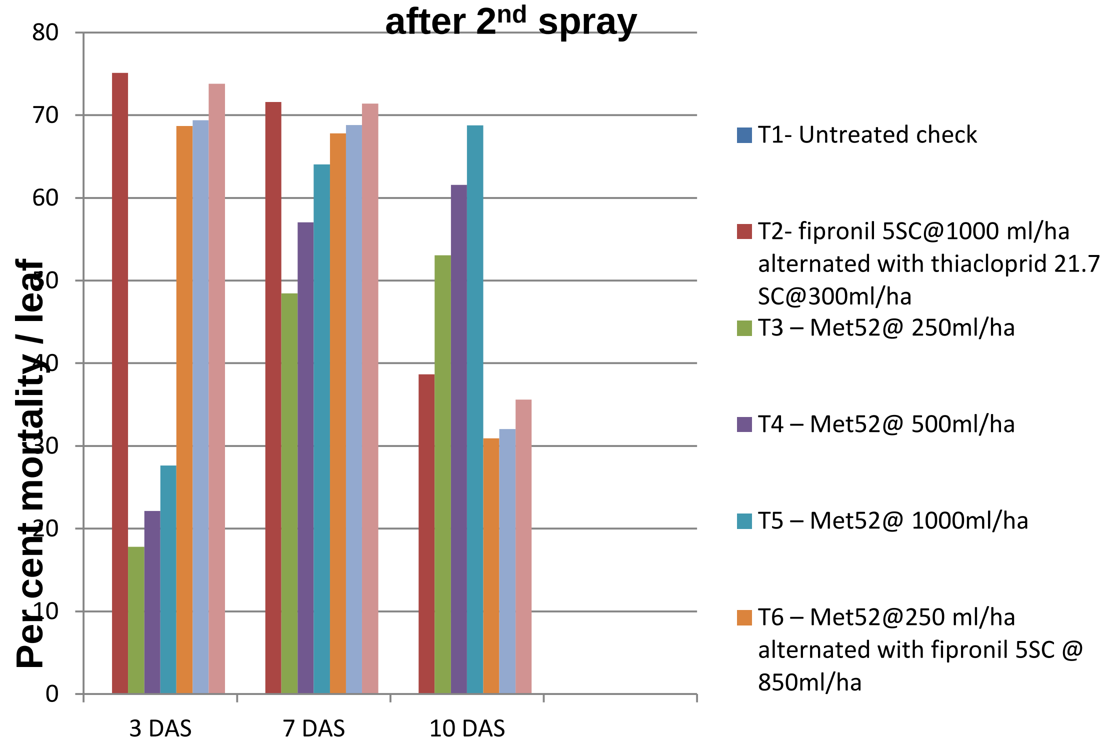
Table 4.4 Effect of treatments on thrips mortality after 2nd spray

Treatments	Per cent mortality		
	After 2nd Spray		
	3 DAS	7 DAS	10 DAS
T1- Untreated control			
T2- Fipronil 5 SC @ 1000 ml/ha and alternated with Thiacloprid 21.7 SC @ 300 ml/ha	75.12 (60.07)	71.59 (57.80)	38.66 (38.41)
T3- Met 52 @ 250ml/ha	17.81 (24.95)	48.44 (44.08)	53.06 (46.78)
T4- Met 52 @ 500ml/ha	22.14 (28.04)	57.04 (49.02)	61.59 (51.71)
T5- Met 52 @ 1000ml/ha	27.64 (31.69)	64.07 (53.19)	68.77 (56.04)
T6-Met 52 @ 250 ml/ha alternated with Fipronil 5 SC @ 850 ml/ha	68.68 (55.37)	67.79 (55.43)	30.93 (33.77)
T7- Met 52 @ 500 ml/ha alternated with Fipronil 5 SC @ 900 ml/ha	69.38 (56.42)	68.83 (56.04)	32.05 (34.45)
T8- Met 52 @ 1000 ml/ha alternated with Fipronil 5 SC @ 950 ml/ha	73.81 (59.21)	71.39 (57.67)	35.59 (36.63)
S Em±	2.15	2.23	2.10
CD at 5 %(p=0.05)	**6.39**	**6.89**	**6.47**
CV %	7.9	7.10	8.50

The values in parentheses are angular transformed (arc sin) values

DAS = Days after spray.

Fig. 4.4 Effect of treatments on thrips mortality after 2nd spray



4.1.3 After third spray

3 days after

Population

The least insect count was observed in T2 (0.50), which was found to be at par with T5 (0.60), T4 (0.80) and T3 (1.00) and showed significant difference with T7 (1.43), T6 (1.48) and T8 (1.50). The highest count was recorded in untreated check T1 (5.90).(table 4.5 and fig 4.5).

Mortality

The maximum mortality was noticed in T2 (75.12%) and exhibited highly significant difference with rest of the treatments which showed the insect mortality in the range of 9.55-17.09 %.(table 4.6 and fig 4.6).

7 days after

Population

The maximum population was noted in T1 (5.92) which was significantly higher over all the treatments. The minimum population was noted in T5 (0.32) which was at par with treatment T4 (0.44) and T3 (0.60) and followed with treatments T2 (0.75), T8 (0.80), T7 (0.85) and T6 (1.05). (table 4.5 and fig 4.5).

Mortality

The mortality was found in the range of 45.2-62.81%. The highest mortality was noted in T2 (62.81%) and exhibited non-significant difference with T8 (55.93%), T5 (54.67%) and T7 (53.17%) followed by), T4 (51.52%), T3 (45.91%) andT6 (45.20%).(table 4.6 and fig 4.6).

10 days after

Population

The Thrips count was found in the range of 0.28 to 5.95 per leaf. It was recorded maximum in T1 (5.95) which was significantly higher over all the treatments. The least number was noted in T5 (0.28) which was at par with T4 (0.40) and T3 (0.53). Treatments T8 (0.75), T7 (0.77), T6 (0.90) and T2 (1.50) gave poor performance but were significantly superior over untreated check.(table 4.5 and fig 4.5).

Mortality

The maximum mortality of insect population was noted in treatment T5 (60.53%) which showed non-significant difference with all the treatments except T2 (26.00%) which expressed least insect mortality.(table 4.6 and fig 4.6).

Table 4.5 Effect of treatments on thrips population after 3rd spray

Treatments	Pre-treatment count	Thrips Population		
		After 3rd Spray		
		3 DAS	7 DAS	10 DAS
T1- Untreated control	5.91 (2.53)	5.90 (2.52)	5.92 (2.53)	5.95 (2.54)
T2- Fipronil 5 SC @ 1000 ml/ha and alternated with Thiacloprid 21.7 SC @ 300 ml/ha	2.00 (1.58)	0.50 (1.00)	0.75 (1.11)	1.50 (1.41)
T3- Met 52 @ 250ml/ha	1.10 (1.26)	1.00 (1.22)	0.60 (1.04)	0.53 (1.01)
T4- Met 52 @ 500ml/ha	0.90 (1.18)	0.80 (1.14)	0.44 (0.96)	0.40 (0.95)
T5- Met 52 @ 1000ml/ha	0.70 (1.09)	0.60 (1.04)	0.32 (0.90)	0.28 (0.88)
T6-Met 52 @ 250 ml/ha alternated with Fipronil 5 SC @ 850 ml/ha	1.90 (1.55)	1.70 (1.48)	1.05 (1.24)	0.90 (1.18)
T7- Met 52 @ 500 ml/ha alternated with Fipronil 5 SC @ 900 ml/ha	1.80 (1.51)	1.55 (1.43)	0.85 (1.16)	0.77 (1.13)
T8- Met 52 @ 1000 ml/ha alternated with Fipronil 5 SC @ 950 ml/ha	1.80 (1.51)	1.50 (1.41)	0.80 (1.14)	0.75 (1.12)
S Em±	0.06	0.07	0.06	0.06
CD at 5 %(p=0.05)	**0.19**	**0.22**	**0.20**	**0.18**
CV %	7.34	8.83	8.90	7.88

The values in parentheses are square root transformed values
DAS = Days after spray

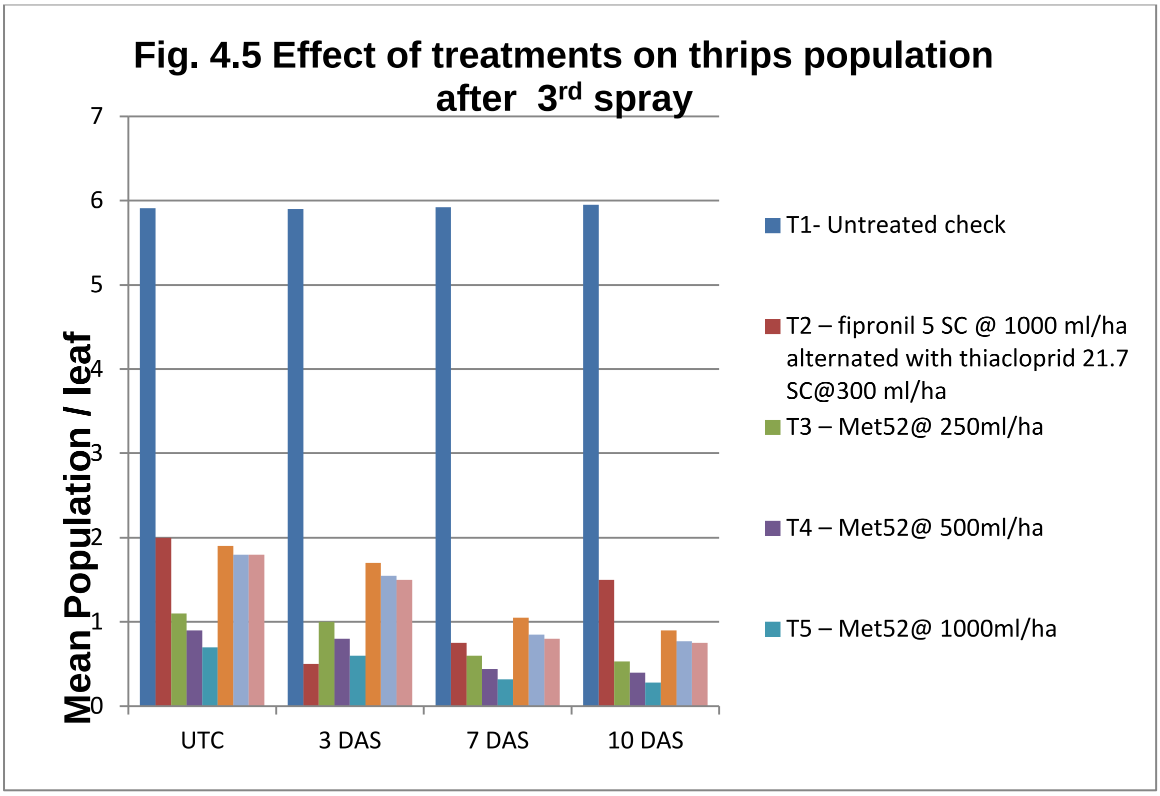


Fig. 4.5 Effect of treatments on thrips population after 3rd spray
Mean Population / leaf
7
6
5
4
3
2
1
0
UTC
3 DAS
7 DAS
10 DAS
T1- Untreated check
T2 – fipronil 5 SC @ 1000 ml/ha alternated with thiacloprid 21.7 SC@300 ml/ha
T3 – Met52@ 250ml/ha
T4 – Met52@ 500ml/ha
T5 – Met52@ 1000ml/ha

Table 4.6 Effect of treatments on thrips mortality after 3rd spray

Treatments	Per cent mortality		
	After 3rd Spray		
	3 DAS	7 DAS	10 DAS
T1- Untreated control			
T2- Fipronil 5 SC @ 1000 ml/ha and alternated with Thiacloprid 21.7 SC @ 300 ml/ha	75.12 (60.07)	62.81 (52.42)	26.00 (30.66)
T3- Met 52 @ 250ml/ha	09.55 (17.95)	45.91 (42.65)	51.46 (45.86)
T4- Met 52 @ 500ml/ha	11.56 (19.91)	51.52 (45.86)	56.15 (48.5)
T5- Met 52 @ 1000ml/ha	14.72 (22.55)	54.67 (47.7)	60.53 (51.06)
T6-Met 52 @ 250 ml/ha alternated with Fipronil 5 SC @ 850 ml/ha	10.98 (19.37)	45.20 (42.27)	53.26 (46.89)
T7- Met 52 @ 500 ml/ha alternated with Fipronil 5 SC @ 900 ml/ha	14.32 (22.22)	53.17 (46.83)	57.79 (49.49)
T8- Met 52 @ 1000 ml/ha alternated with Fipronil 5 SC @ 950 ml/ha	17.09 (24.43)	55.93 (48.39)	58.89 (50.13)
S Em±	1.04	1.92	2.05
CD at 5 %(p=0.05)	**3.20**	**5.90**	**6.31**
CV %	6.75	7.12	7.72

The values in parentheses are angular transformed (arc sin) values
DAS = Days after spray.

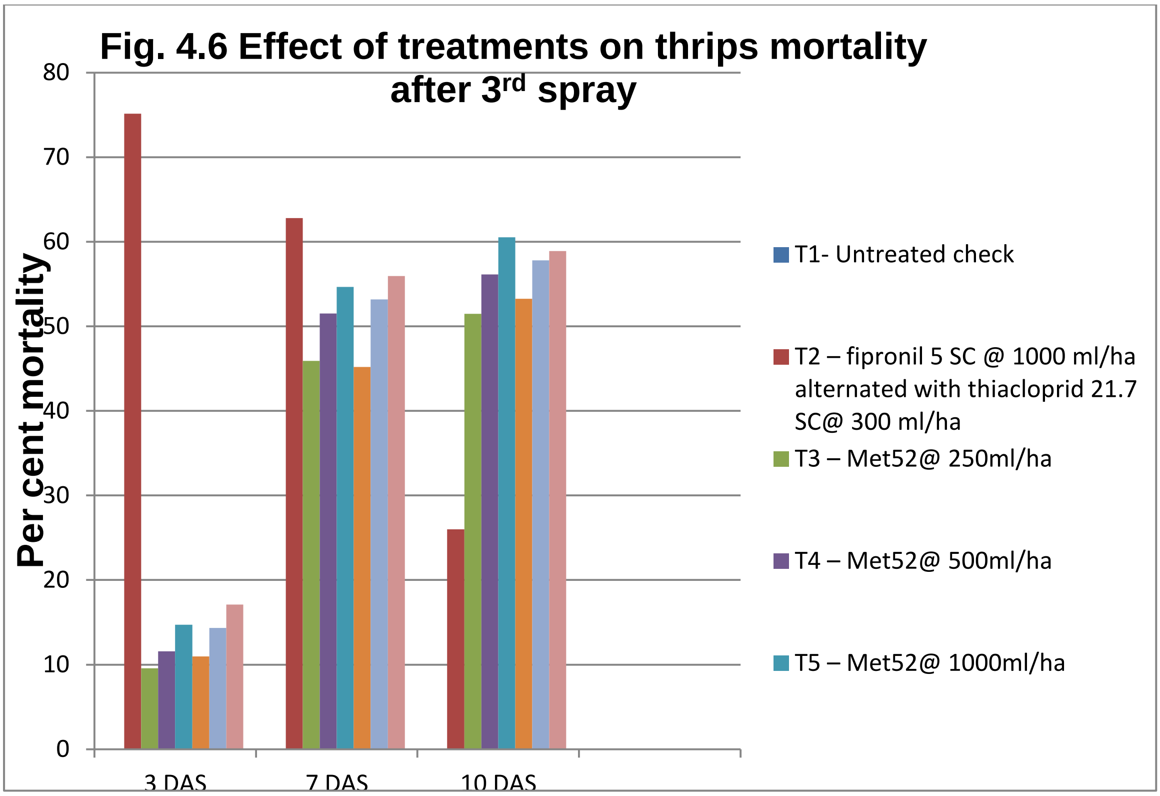


Fig. 4.6 Effect of treatments on thrips mortality after 3rd spray
Per cent mortality
0
10
20
30
40
50
60
70
80
3 DAS
7 DAS
10 DAS
T1- Untreated check
T2 – fipronil 5 SC @ 1000 ml/ha alternated with thiacloprid 21.7 SC@ 300 ml/ha
T3 – Met52@ 250ml/ha
T4 – Met52@ 500ml/ha
T5 – Met52@ 1000ml/ha

4.1.4 After fourth spray

3 days after

Population

The highest population was noticed in untreated check T1 (5.99) which was significantly different from all the treatments. The lowest population was counted in T8 (0.22) which was at par with T7 (0.25), T5 (0.25), T6 (0.32) T4 (0.36), T2 (0.45) and T3 (0.50). (table 4.7 and fig 4.7).

Mortality

The maximum mortality was found in T8 (70.86%) which was at par with T2 (70.20%), T7 (67.74%), and T6 (64.68%). Rest of the treatments exhibited very poor insect mortality.(table 4.8 and fig 4.8).

7 days after

Population

All the treatment exhibited significant difference over untreated check. The minimum thrips count was observed in T5 (0.14) which was found to be at par with all the treatments except T2 (0.50).(table 4.7 and fig 4.7).

Mortality

The mortality was recorded in the range of 43.54 to 69.63%. The maximum population reduction was calculated in treatment T8 (69.63%) which was at par with T2 (66.99%) and T7 (65.28%) followed by T6 (60.40%), T5 (50.49%), T4 (45.54%) and T3 (43.54%). (table 4.8 and fig 4.8).

10 days after

Population

The minimum number was recorded in T5 (0.13) which was at par with T4 (0.20) and T3 (0.27).The next best treatments was T8 (0.55) followed by T7 (0.59) and T6 (0.70). The maximum population was observed in untreated check T1 (6.07) which showed significant difference with all the treatments.(table 4.7 and fig 4.7).

Mortality

The maximum mortality was noted in treatment T5 (54.48%) which did not differ significantly T4 (50.98%) and T3 (50.06%). Rest of the treatments showed insect mortality in the range of 23.75% to 28.11% which is comparatively very poor. (table 4.8 and fig 4.8).

Table 4.7 Effect of treatments on thrips population after 4th spray

Treatments	Pre-treatment count	Thrips Population		
		After 4th Spray		
		3 DAS	7 DAS	10 DAS
T1- Untreated control	5.95 (2.54)	5.99 (2.54)	6.01 (2.55)	6.07 (2.56)
T2- Fipronil 5 SC @ 1000 ml/ha and alternated with Thiacloprid 21.7 SC @ 300 ml/ha	1.50 (1.41)	0.45 (0.97)	0.50 (1.00)	1.10 (1.26)
T3- Met 52 @ 250ml/ha	0.53 (1.01)	0.50 (1.00)	0.30 (0.89)	0.27 (0.87)
T4- Met 52 @ 500ml/ha	0.40 (0.95)	0.36 (0.92)	0.22 (0.84)	0.20 (0.83)
T5- Met 52 @ 1000ml/ha	0.28 (0.88)	0.25 (0.87)	0.14 (0.80)	0.13 (0.79)
T6-Met 52 @ 250 ml/ha alternated with Fipronil 5 SC @ 850 ml/ha	0.90 (1.18)	0.32 (0.91)	0.36 (0.93)	0.70 (1.09)
T7- Met 52 @ 500 ml/ha alternated with Fipronil 5 SC @ 900 ml/ha	0.77 (1.13)	0.25 (0.87)	0.27 (0.88)	0.59 (1.04)
T8- Met 52 @ 1000 ml/ha alternated with Fipronil 5 SC @ 950 ml/ha	0.75 (1.12)	0.22 (0.85)	0.23 (0.85)	0.55 (1.02)
S Em±	0.06	0.05	0.05	0.06
CD at 5 %(p=0.05)	**0.18**	**0.15**	**0.17**	**0.18**
CV %	7.88	7.87	8.90	8.72

The values in parentheses are square root transformed values

DAS = Days after spray

Fig. 4.7 Effect of treatments on thrips population after 4th spray

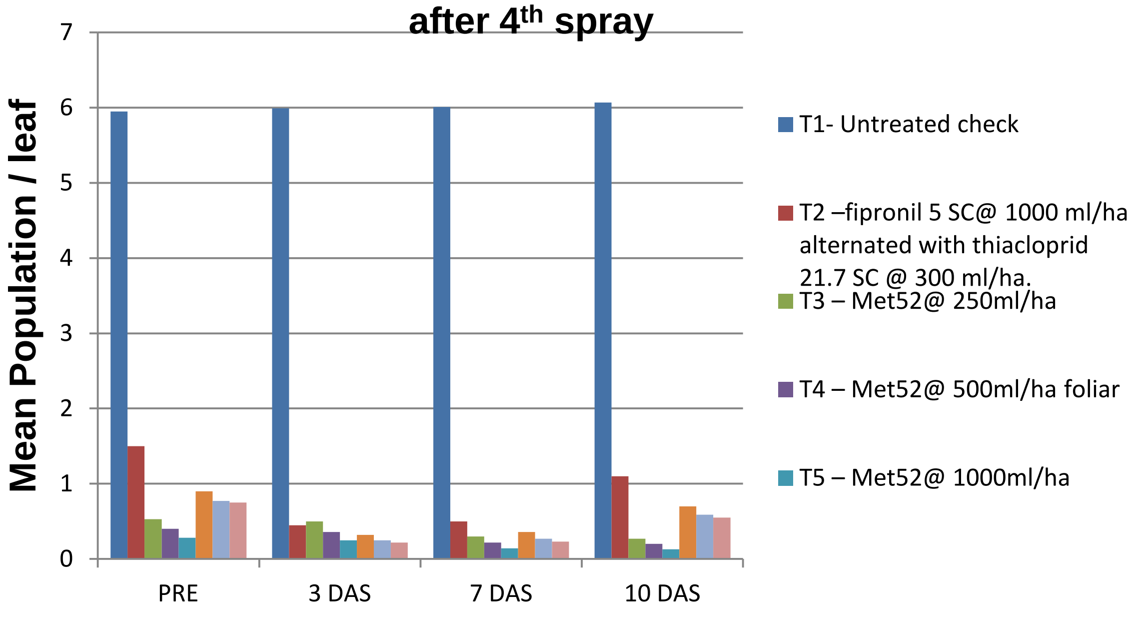


Table 4.8 Effect of treatments on thrips mortality after 4th spray

Treatments	Per cent mortality		
	After 4th Spray		
	3 DAS	7 DAS	10 DAS
T1- Untreated control			
T2- Fipronil 5 SC @ 1000 ml/ha and alternated with Thiacloprid 21.7 SC @ 300 ml/ha	70.20 (56.91)	66.99 (54.94)	28.11 (32.01)
T3- Met 52 @ 250ml/ha	6.29 (14.54)	43.54 (41.27)	50.06 (45.06)
T4- Met 52 @ 500ml/ha	10.60 (19.00)	45.54 (42.42)	50.98 (45.67)
T5- Met 52 @ 1000ml/ha	11.31 (19.64)	50.49 (45.29)	54.48 (47.58)
T6-Met 52 @ 250 ml/ha alternated with Fipronil 5 SC @ 850 ml/ha	64.68 (53.55)	60.40 (51.00)	23.75 (29.13)
T7- Met 52 @ 500 ml/ha alternated with Fipronil 5 SC @ 900 ml/ha	67.74 (55.37)	65.28 (53.91)	24.89 (29.93)
T8- Met 52 @ 1000 ml/ha alternated with Fipronil 5 SC @ 950 ml/ha	70.86 (57.29)	69.63 (56.64)	28.11 (32.01)
S Em±	1.27	1.48	1.14
CD at 5 %(p=0.05)	**3.91**	**4.56**	**3.52**
CV %	9.13	8.07	7.67

The values in parentheses are angular transformed (arc sin) values
DAS = Days after spray.

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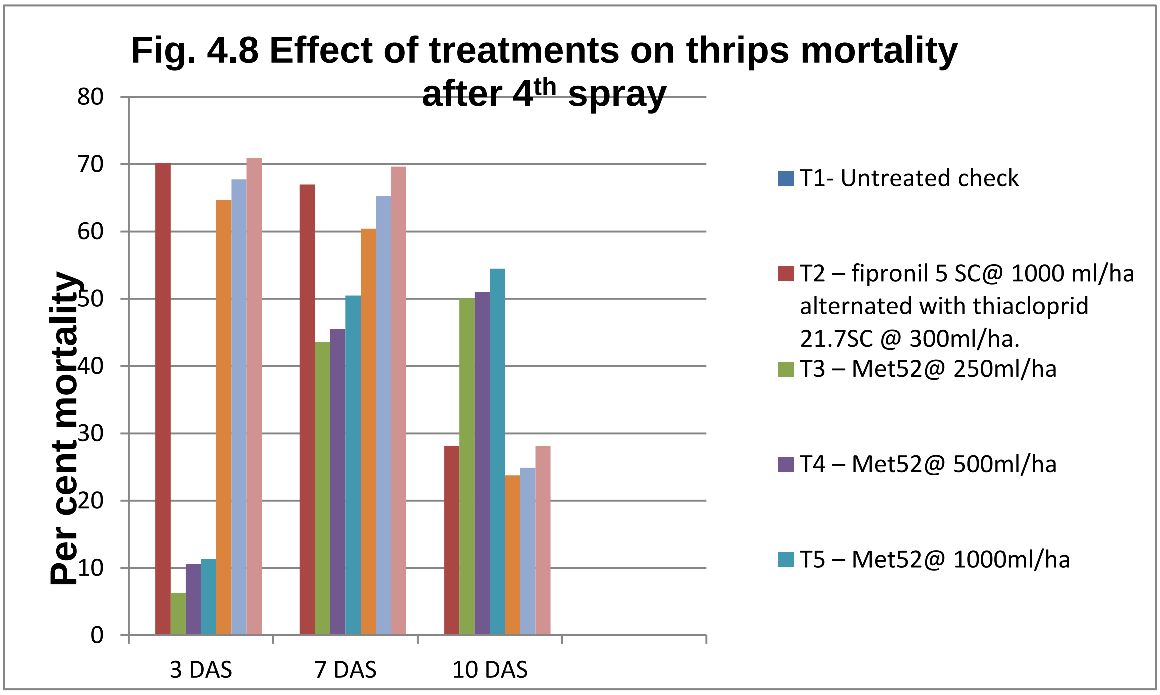
Fig. 4.8 Effect of treatments on thrips mortality after 4th spray
Per cent mortality
0
10
20
30
40
50
60
70
80
3 DAS
7 DAS
10 DAS
T1- Untreated check
T2 – fipronil 5 SC@ 1000 ml/ha alternated with thiacloprid 21.7SC @ 300ml/ha.
T3 – Met52@ 250ml/ha
T4 – Met52@ 500ml/ha
T5 – Met52@ 1000ml/ha

4.1.5 After fifth spray

3 days after

Population

The least population count was observed in treatment T5 (0.11) which was at par with T4 (0.17), T3 (0.24) and T2 (0.30) followed with T8 (0.46), T7 (0.50), and T6 (0.62). The maximum population was recorded in untreated check T1 (6.10).(table 4.9 and fig. 4.9).

Mortality

The highest mortality was recorded in T2 (72.68%) and showed highly significant difference with rest of the treatments where they exhibited mortality in the range of 11.54% to 16.77% which was very poor. (table 4.10 and fig. 4.10).

7 days after

Population

The maximum thrips population was recorded in untreated check T1 (6.14) which differed significantly with all the treatments. The minimum insect count was recorded in T5 (0.06) which was on par with T4 (0.10), T3 (0.15) and T8 (0.25) and followed with T7 (0.30), T2 (0.35) and T6 (0.40).(table 4.9 and fig. 4.9).

Mortality

Maximum pest mortality was calculated in T2 (68.54%) which differed significantly with all the treatments. Further the better treatment was T8 (55.06%) and showed non-significant difference with rest of the treatments. (table 4.10 and fig. 4.10).

10 days after

Population

The thrips population was noted in the range of 0.05 to 6.18. It was recorded maximum in the untreated check T1 (6.18) which was significantly higher over all the treatments. The minimum insect population was recorded in treatment T5 (0.05) which was at par with T4 (0.09), T3 (0.13) and T2 (0.80).(table 4.9 and fig. 4.9).

Mortality

The insect killing was recorded in the range of 28.56% to 62.22%. It was recorded maximum in the treatment T5 (62.22%) which was on par with T8 (60.71%), T4 (55.80%) and T7 (55.05%) and followed with T3 (52.70%) and T6 (50.88%). The minimum mortality was recorded in treatment T2 (28.56%). (table 4.10 and fig. 4.10).

Table 4.9 Effect of treatments on thrips population after 5th spray

Treatments	Pre-treatment count	Thrips Population		
		After 5th Spray		
		3 DAS	7 DAS	10 DAS
T1- Untreated control	6.07 (2.56)	6.10 (2.57)	6.14 (2.58)	6.18 (2.58)
T2- Fipronil 5 SC @ 1000 ml/ha and alternated with Thiacloprid 21.7 SC @ 300 ml/ha	1.10 (1.26)	0.30 (0.89)	0.35 (0.92)	0.80 (1.14)
T3- Met 52 @ 250ml/ha	0.27 (0.87)	0.24 (0.86)	0.15 (0.80)	0.13 (0.79)
T4- Met 52 @ 500ml/ha	0.20 (0.83)	0.17 (0.81)	0.10 (0.77)	0.09 (0.76)
T5- Met 52 @ 1000ml/ha	0.13 (0.79)	0.11 (0.78)	0.06 (0.74)	0.05 (0.74)
T6-Met 52 @ 250 ml/ha alternated with fipronil 5 SC @ 850 ml/ha	0.70 (1.09)	0.62 (1.05)	0.40 (0.94)	0.35 (0.92)
T7- Met 52 @ 500 ml/ha alternated with fipronil 5 SC @ 900 ml/ha	0.59 (1.04)	0.50 (1.00)	0.30 (0.89)	0.27 (0.87)
T8- Met 52 @ 1000 ml/ha alternated with fipronil 5 SC @ 950 ml/ha	0.55 (1.02)	0.46 (0.97)	0.25 (0.86)	0.22 (0.84)
S Em±	0.06	0.05	0.04	0.04
CD at 5 %(p=0.05)	**0.18**	**0.15**	**0.13**	**0.12**
CV %	8.72	7.53	6.93	6.24

The values in parentheses are square root transformed values
DAS = Days after spray

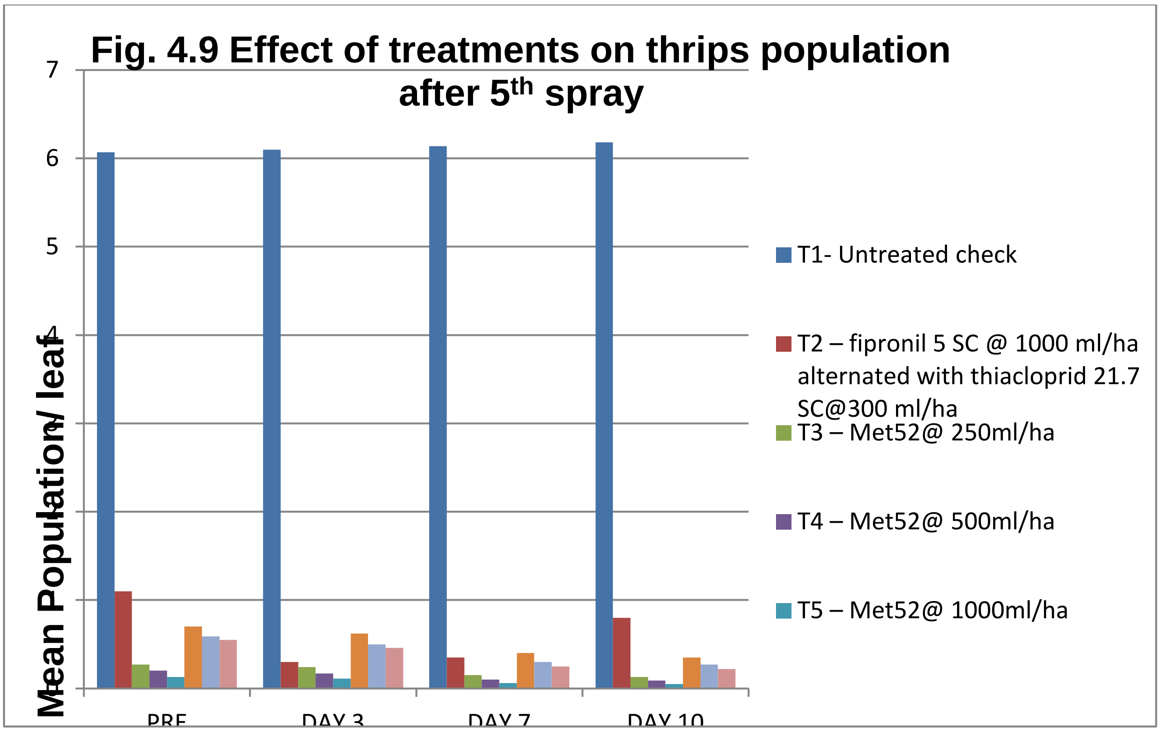
Fig. 4.9 Effect of treatments on thrips population after 5th spray
Mean Population/ leaf
7
6
5
4
PRE
DAY 3
DAY 7
DAY 10
T1- Untreated check
T2 – fipronil 5 SC @ 1000 ml/ha alternated with thiacloprid 21.7 SC@300 ml/ha
T3 – Met52@ 250ml/ha
T4 – Met52@ 500ml/ha
T5 – Met52@ 1000ml/ha

Table 4.10 Effect of treatments on thrips mortality after 5th spray

Treatments	Per cent mortality		
	After 5th Spray		
	3 DAS	7 DAS	10 DAS
T1- Untreated control			
T2- Fipronil 5 SC @ 1000 ml/ha and alternated with Thiacloprid 21.7 SC @ 300 ml/ha	72.86 (58.63)	68.54 (55.86)	28.56 (32.27)
T3- Met 52 @ 250ml/ha	11.54 (19.82)	45.07 (42.19)	52.7 (46.55)
T4- Met 52 @ 500ml/ha	15.41 (23.11)	50.57 (45.34)	55.8 (48.33)
T5- Met 52 @ 1000ml/ha	15.80 (23.42)	54.37 (47.52)	62.22 (52.06)
T6-Met 52 @ 250 ml/ha alternated with Fipronil 5 SC @ 850 ml/ha	11.86 (20.18)	43.50 (41.27)	50.88 (45.52)
T7- Met 52 @ 500 ml/ha alternated with Fipronil 5 SC @ 900 ml/ha	15.67 (23.34)	49.73 (44.83)	55.05 (47.87)
T8- Met52@1000 ml/ha alternated with Fipronil 5 SC @ 950 ml/ha	16.77 (24.20)	55.06 (47.93)	60.71 (51.18)
S Em±	0.85	2.21	1.59
CD at 5 %(p=0.05)	**2.62**	**6.82**	**4.90**
CV %	8.89	8.34	6.76

The values in parentheses are angular transformed (arc sin) values
DAS = Days after spray.

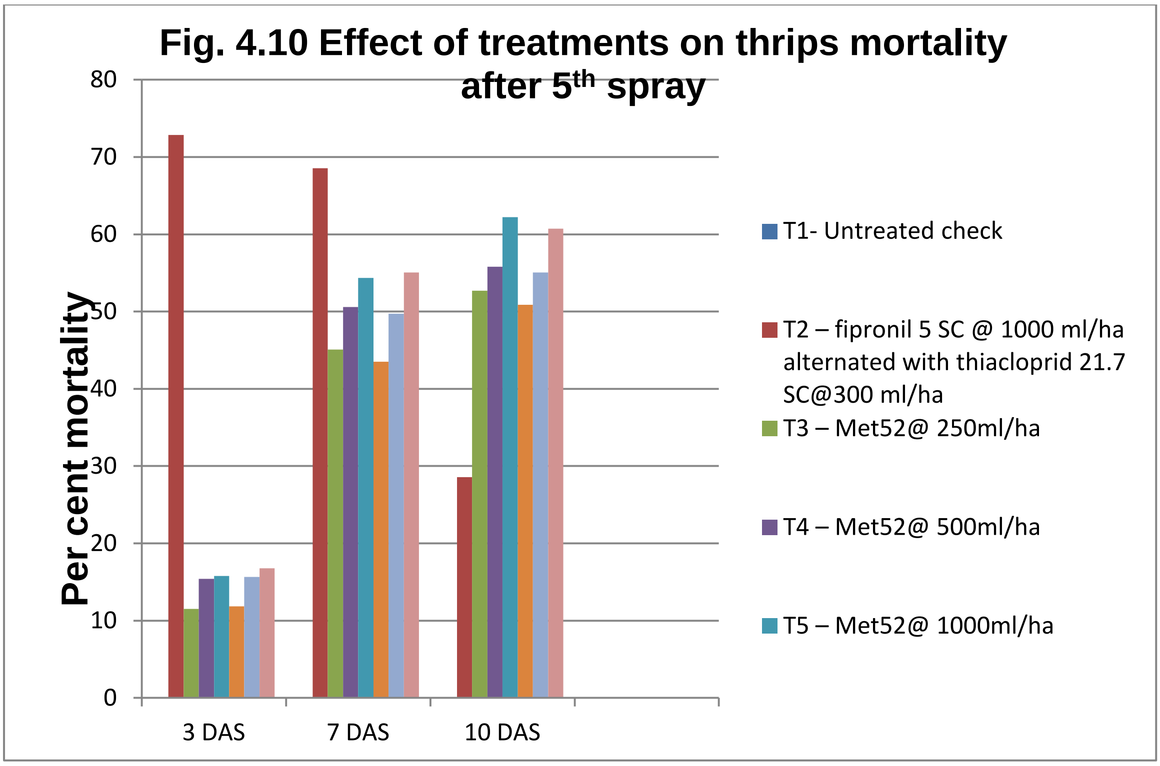
Fig. 4.10 Effect of treatments on thrips mortality after 5th spray
Per cent mortality
0
10
20
30
40
50
60
70
80
3 DAS
7 DAS
10 DAS
T1- Untreated check
T2 – fipronil 5 SC @ 1000 ml/ha alternated with thiacloprid 21.7 SC@300 ml/ha
T3 – Met52@ 250ml/ha
T4 – Met52@ 500ml/ha
T5 – Met52@ 1000ml/ha

4.1.6 After sixth spray

3 days after

Population

The minimum thrips population was noted in treatment T5 (0.04) and it was at par with T8 (0.07), T4 (0.08), T7 (0.09), T6 (0.12) and T3 (0.12) followed by T2 (0.24). The maximum population was recorded in untreated check T1 (6.2) and exhibited significant difference with all the treatments.(table 4.11 and fig. 4.11).

Mortality

The maximum insect mortality was noted in treatment T2 (70.09%) which was on par with T8 (68.28%), T7 (66.77%) and T6 (65.82%).Treatments T3 (7.99%), T4 (11.39%) and T5 (20.25%) gave poor performance. (table 4.12 and fig. 4.12).

7 days after

Population

The maximum thrips population was recorded in untreated check T1 (6.25) which differed significantly with all the treatments. The minimum insect population was recorded in T5 (0.02) which was on par with T4 (0.05), T8 (0.07), T7 (0.09), T6 (0.13) and T3 (0.08) followed by T2 (0.25).(table 4.11 and fig. 4.11).

Mortality

The highest mortality was recorded in treatment T2 (69.10%) and exhibited non-significant difference with T8 (67.63%), T7 (65.57%) and T6 (63.27%) and followed withT5 (50.56), T4 (45.06) and T3 (39.15%). (table 4.12 and fig. 4.12).

10 days after

Population

The thrips population was noted in the range of 0.02 to 6.31. It was recorded maximum in the untreated check T1 (6.31), which was significantly higher over all the treatments. The minimum insect population was recorded in treatment T5 (0.02) which was at par with T4 (0.04), T3 (0.07), and T8 (0.17). Rest of the treatments as T7 (0.22), T6 (0.29) and T2 (0.65) did not perform much better.(table 4.11 and fig. 4.11).

Mortality

The maximum mortality of thrips was noted in treatment T5 (60.82%) and found at par with T4 (56.47%) followed by T3 (47.26%).Rest of the treatments exhibited less than 25% insect killing. (table 4.12 and fig. 4.12).

Table 4.11 Effect of treatments on thrips population after 6th spray

Treatments	Pre-treatment count	Thrips Population		
		After 6th Spray		
		3 DAS	7 DAS	10 DAS
T1- Untreated control	6.18 (2.58)	6.20 (2.58)	6.25 (2.59)	6.31 (2.6)
T2- Fipronil 5 SC @ 1000 ml/ha and alternated with Thiacloprid 21.7 SC @ 300 ml/ha	0.80 (1.14)	0.24 (0.86)	0.25 (0.86)	0.65 (1.07)
T3- Met 52 @ 250ml/ha	0.13 (0.79)	0.12 (0.78)	0.08 (0.76)	0.07 (0.75)
T4- Met 52 @ 500ml/ha	0.09 (0.76)	0.08 (0.76)	0.05 (0.74)	0.04 (0.73)
T5- Met 52 @ 1000ml/ha	0.05 (0.74)	0.04 (0.73)	0.03 (0.72)	0.02 (0.72)
T6-Met 52 @ 250 ml/ha alternated with Fipronil 5 SC @ 850 ml/ha	0.35 (0.92)	0.12 (0.78)	0.13 (0.79)	0.29 (0.88)
T7- Met 52 @ 500 ml/ha alternated with Fipronil 5 SC @ 900 ml/ha	0.27 (0.87)	0.09 (0.76)	0.09 (0.77)	0.22 (0.84)
T8- Met 52 @ 1000 ml/ha alternated with Fipronil 5 SC @ 950 ml/ha	0.22 (0.84)	0.07 (0.75)	0.07 (0.76)	0.17 (0.81)
S Em±	0.04	0.04	0.04	0.05
CD at 5 %(p=0.05)	**0.12**	**0.13**	**0.13**	**0.16**
CV %	6.24	7.08	7.38	8.86

The values in parentheses are square root transformed values,
DAS = Days after spray

.

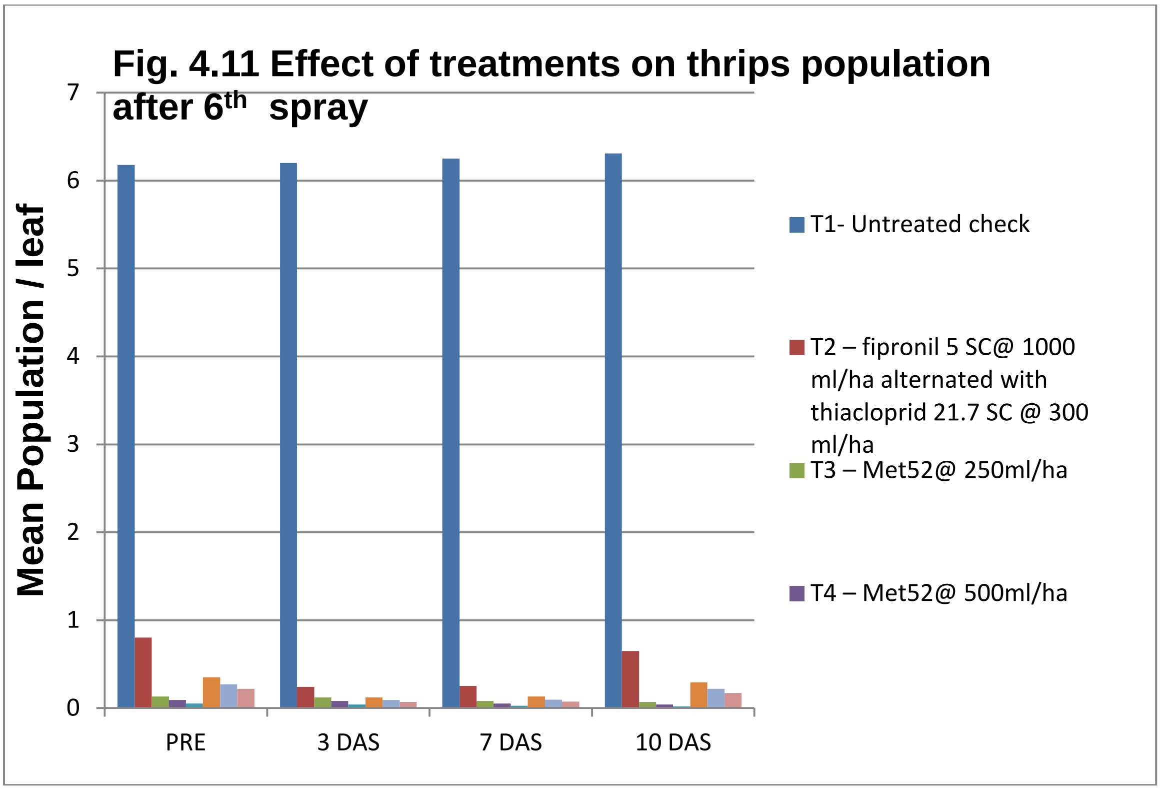
Fig. 4.11 Effect of treatments on thrips population after 6th spray
Mean Population / leaf
0
1
2
3
4
5
6
7
PRE
3 DAS
7 DAS
10 DAS
T1- Untreated check
T2 – fipronil 5 SC@ 1000 ml/ha alternated with thiacloprid 21.7 SC @ 300 ml/ha
T3 – Met52@ 250ml/ha
T4 – Met52@ 500ml/ha

Table 4.12 Effect of treatments on thrips mortality after 6th spray

Treatments	Per cent mortality After 6th Spray		
	3 DAS	7 DAS	10 DAS
T1- Untreated control			
T2- Fipronil 5 SC @ 1000 ml/ha and alternated with Thiacloprid 21.7 SC @ 300 ml/ha	70.09 (56.85)	69.10 (56.23)	20.42 (26.85)
T3- Met 52 @ 250ml/ha	7.99 (16.43)	39.15 (38.70)	47.26 (43.45)
T4- Met 52 @ 500ml/ha	11.39 (19.73)	45.06 (42.19)	56.47 (48.73)
T5- Met 52 @ 1000ml/ha	20.25 (26.71)	50.56 (45.34)	60.82 (51.24)
T6-Met 52 @ 250 ml/ha alternated with Fipronil 5 SC @ 850 ml/ha	65.82 (54.21)	63.27 (52.71)	18.84 (25.70)
T7- Met 52 @ 500 ml/ha alternated with Fipronil 5 SC @ 900 ml/ha	66.77 (54.82)	65.57 (54.09)	20.19 (26.64)
T8- Met 52 @ 1000 ml/ha alternated with Fipronil 5 SC @ 950 ml/ha	68.28 (55.73)	67.63 (55.30)	24.31 (29.53)
S Em±	1.76	2.30	1.40
CD at 5 %(p=0.05)	**5.43**	**7.08**	**4.32**
CV %	7.20	8.09	6.74

The values in parentheses are angular transformed (arc sin) values
DAS = Days after spray.

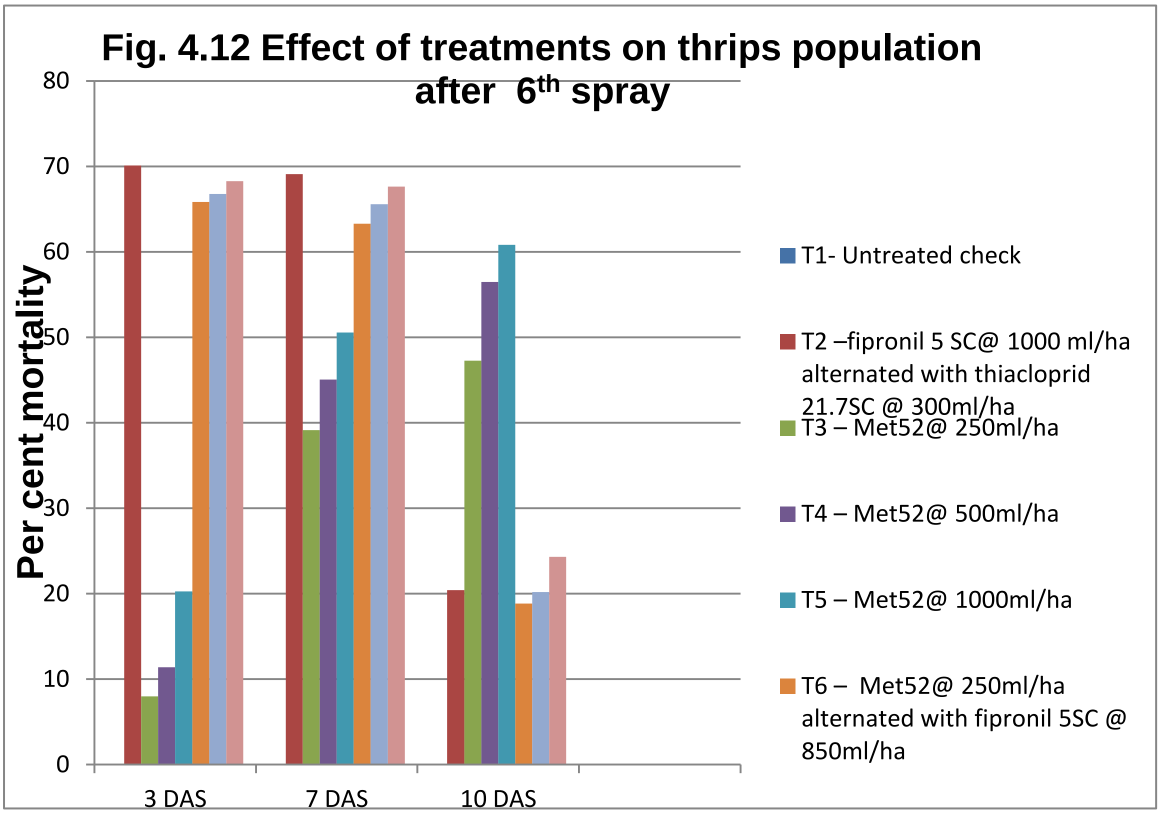

Fig. 4.12 Effect of treatments on thrips population after 6th spray

4.1.7 After Seventh spray

3 day after

Population

The least thrips count was noted in treatment T5 (0.01) which was at par with treatment T4 (0.03), T3 (0.06), T8 (0.13), T7 (0.17) and T2 (0.20) followed by T6 (0.25). Untreated check T1 (6.45) showed maximum thrips population.(table 4.13 and fig. 4.13).

Mortality

The maximum mortality was shown in treatment T2 (69.89%) which was significantly higher than all the treatments. Rest of the treatments performed less than 27% insect mortality.(table 4.14 and fig. 4.14).

7 day after

Population

The minimum thrips population was noted in T5 (0.01) which was found at par with treatment T4 (0.02), T3 (0.04), T8 (0.08) and T7 (0.12). The next best treatment was T6 (0.17) followed by T2 (0.22). The maximum thrips population was recorded in untreated check T1 (6.49) which differed significantly with all the treatments.(table 4.13 and fig. 4.13).

Mortality

The highest insect mortality was calculated in treatment T2 (67.09%) and exhibited significant difference with all the treatments and followed with T8 (54.24%), T5 (51.38%), T7 (46.96%), T4 (46.52%), T3 (44.44%) and T6 (43.00%). (table 4.14 and fig. 4.14).

10 day after

Population

The thrips population was recorded in the range of 0.00 to 6.53. It was recorded maximum in the untreated check T1 (6.53), which was significantly higher over all the treatments. The minimum insect population was recorded in treatment T5

(0.00) which was at par with T4 (0.01), T3 (0.03), T8 (0.06) and T7 (0.09) followed by T6 (0.15) and treatment T2 (0.50).(table 4.13 and fig. 4.13).

Mortality

The mortality was recorded in the range of 25.66% to 65.89%. It was recorded maximum in T8 (65.89%), which was at par with T5 (61.34%), T7 (60.46%) and T4 (58.93%) and followed with T3 (51.68%), T6 (50.01) and T2 (25.66%).(table 4.14 and fig. 4.14).

Table 4.13 Effect of treatments on thrips population after 7th spray

Treatments	Pre-treatment count	Thrips Population		
		After 7thSpray		
		3 DAS	7 DAS	10 DAS
T1- Untreated control	6.31 (2.6)	6.45 (2.63)	6.49 (2.64)	6.53 (2.65)
T2- Fipronil 5 SC @ 1000 ml/ha and alternated with Thiacloprid 21.7 SC @ 300 ml/ha	0.65 (1.07)	0.20 (0.83)	0.22 (0.84)	0.50 (1.00)
T3- Met 52 @ 250ml/ha	0.07 (0.75)	0.06 (0.74)	0.04 (0.73)	0.04 (0.70)
T4- Met 52 @ 500ml/ha	0.04 (0.73)	0.03 (0.72)	0.02 (0.72)	0.02 (0.71)
T5- Met 52 @ 1000ml/ha	0.02 (0.72)	0.01 (0.71)	0.01 (0.71)	0.00 (0.71)
T6-Met 52 @ 250 ml/ha alternated with Fipronil 5 SC @ 850 ml/ha	0.29 (0.88)	0.25 (0.86)	0.17 (0.81)	0.15 (0.80)
T7- Met 52 @ 500 ml/ha alternated with Fipronil 5 SC @ 900 ml/ha	0.22 (0.84)	0.17 (0.81)	0.12 (0.78)	0.09 (0.76)
T8- Met 52 @ 1000 ml/ha alternated with Fipronil 5 SC @ 950 ml/ha	0.17 (0.81)	0.13 (0.79)	0.08 (0.76)	0.06 (0.74)
S Em±	0.05	0.05	0.04	0.04
CD at 5 %(p=0.05)	**0.16**	**0.14**	**0.13**	**0.13**
CV %	8.86	7.98	7.16	7.13

The values in parentheses are square root transformed values
DAS = Days after spray

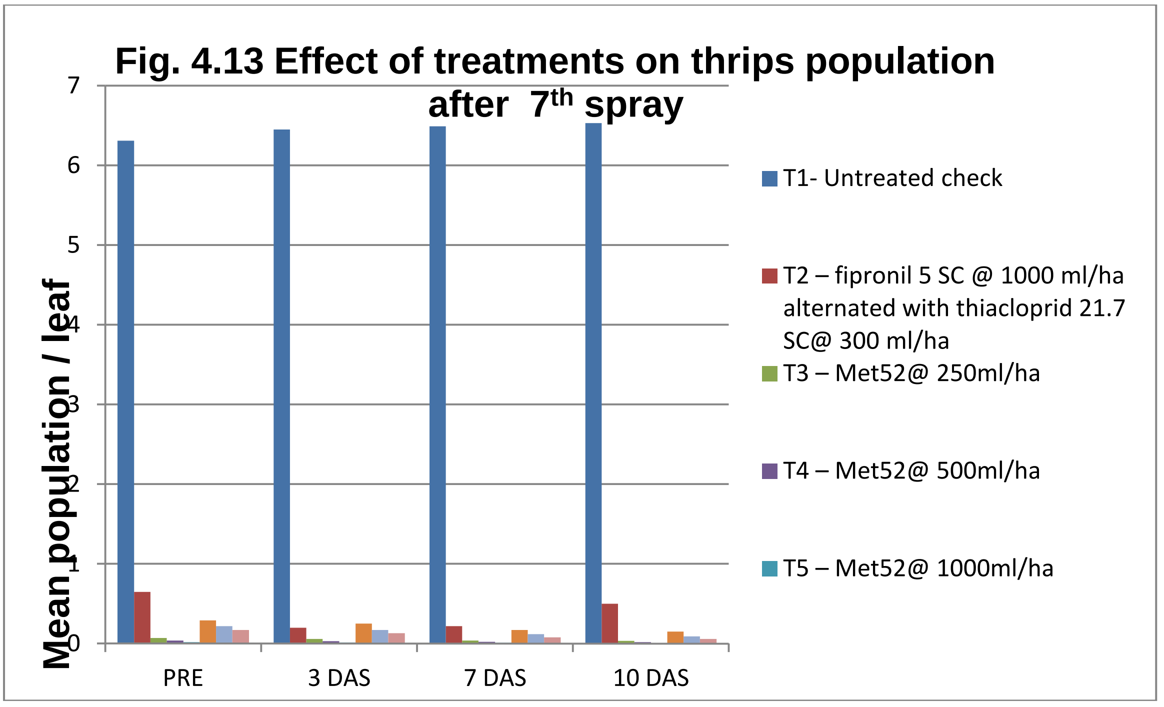
Fig. 4.13 Effect of treatments on thrips population after 7th spray
Mean population / leaf
0
1
2
3
4
5
6
7
PRE
3 DAS
7 DAS
10 DAS
T1- Untreated check
T2 – fipronil 5 SC @ 1000 ml/ha alternated with thiacloprid 21.7 SC@ 300 ml/ha
T3 – Met52@ 250ml/ha
T4 – Met52@ 500ml/ha
T5 – Met52@ 1000ml/ha

Table 4.14 Effect of treatments on thrips mortality after 7th spray

Treatments	Per cent mortality		
	After 7th Spray		
	3 DAS	7 DAS	10 DAS
T1- Untreated control			
T2- Fipronil 5 SC @ 1000 ml/ha and alternated with Thiacloprid 21.7 SC @ 300 ml/ha	69.89 (56.73)	67.09 (55.00)	25.66 (30.46)
T3- Met 52 @ 250ml/ha	16.14 (23.73)	44.44 (41.73)	51.68 (45.97)
T4- Met 52 @ 500ml/ha	24.18 (29.47)	46.52 (42.99)	58.93 (50.13)
T5- Met 52 @ 1000ml/ha	26.62 (31.05)	51.38 (45.80)	61.34 (51.53)
T6-Met 52 @ 250 ml/ha alternated with Fipronil 5 SC @ 850 ml/ha	15.66 (23.34)	43.00 (40.98)	50.01 (45.00)
T7- Met 52 @ 500 ml/ha alternated with Fipronil 5 SC @ 900 ml/ha	24.40 (29.60)	46.96 (43.28)	60.46 (51.06)
T8- Met 52 @ 1000 ml/ha alternated with Fipronil 5 SC @ 950 ml/ha	25.18 (30.13)	54.24 (47.41)	65.89 (54.27)
S Em±	1.15	1.53	1.88
CD at 5 %(p=0.05)	**3.53**	**4.72**	**5.79**
CV %	6.31	5.47	7.51

The values in parentheses are angular transformed (arc sin) values
DAS = Days after spray.

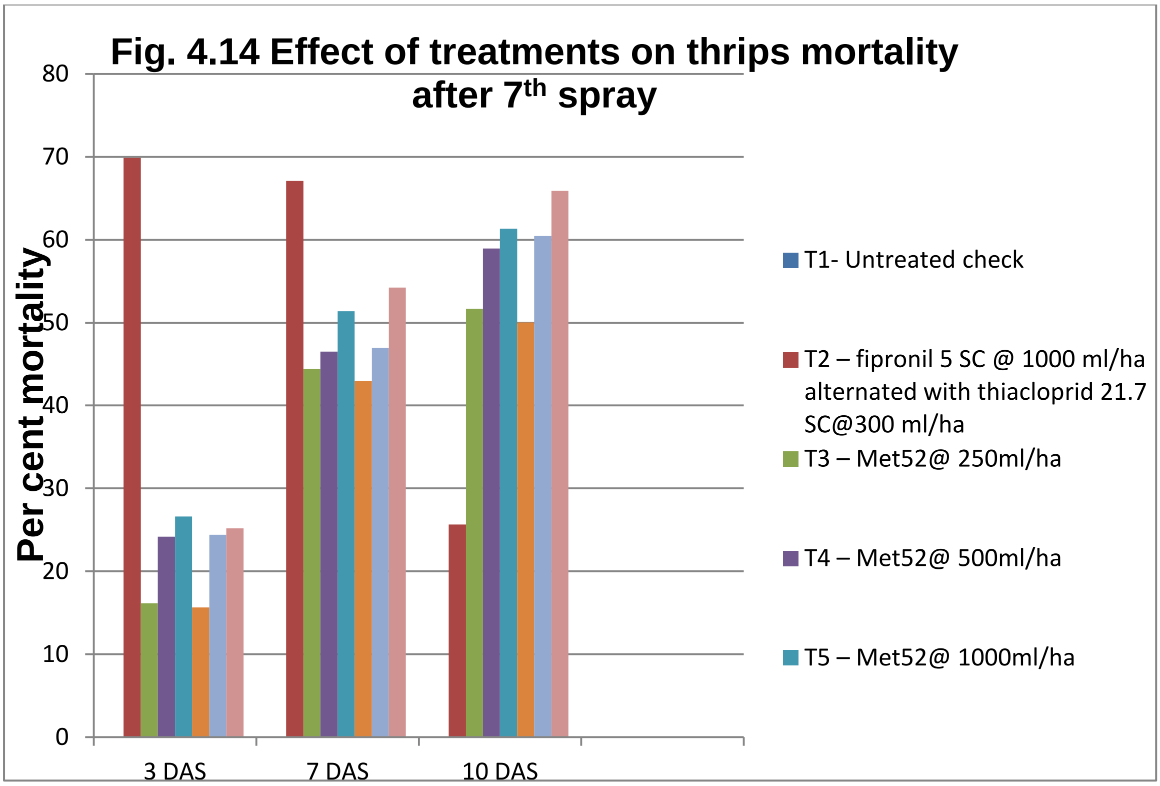

Fig. 4.14 Effect of treatments on thrips mortality after 7th spray
Per cent mortality
0
10
20
30
40
50
60
70
80
3 DAS
7 DAS
10 DAS
T1- Untreated check
T2 – fipronil 5 SC @ 1000 ml/ha alternated with thiacloprid 21.7 SC@300 ml/ha
T3 – Met52@ 250ml/ha
T4 – Met52@ 500ml/ha
T5 – Met52@ 1000ml/ha

4.1.8 After Eighth spray

3 days after

Population

The maximum thrips population was noted in untreated check T1 (6.62) and showed significant difference with all the treatments. Treatment T5 (0.00) performed zero population but due to very less population remaining treatments exhibited no significant difference. (table 4.15 and fig. 4.15).

Mortality

Treatment T2 and T8 (70.40%) performed maximum insect mortality and expressed no significant difference with T7 (69.31%) and T6 (67.11%).The remaining treatments showed less than 27% mortality of insect. (table 4.16 and fig. 4.16).

7 days after

Population

No thrips population was observed in treatment T4 (0.00) and T5 (0.00) and found at par with all the remaining treatments. Untreated check T1 (6.67) gave maximum pest population with significant difference to all the treatments.(table 4.15 and fig. 4.15).

Mortality

The maximum insect mortality was noted in treatment T8 (67.36%) which was on par with T2 (66.71), T7 (66.27%), T6 (66.06%), T5 (63.28%) and T4 (59.68%) followed by T3 (46.85%). (table 4.16 and fig. 4.16).

10 days after

Population

The thrips population was noted in the range of 0.00 to 6.76. It was recorded maximum in the untreated check T1 (6.76), which was significantly higher over all the treatments. All the treatments exhibited negligible population.(table 4.15 and fig. 4.15).

Mortality

The maximum mortality was noted in treatment T5 (75.85%) which was significantly higher over all treatment. The next best treatment was T4 (65.90%) and found at par with T3 (58.60%) and followed with T2 (28.51%), T8 (27.55%),T7 (24.86%) and T6 (22.75%).(table 4.16 and fig. 4.16).

4.1.9 Average thrips mortality of all the sprays

The average lowest thrips count was observed in T5 (1.29) followed with T2 (1.33), T4 (1.38), T3 (1.41), T6 91.63) and T7 (1.64) with difference it the population of untreated check (6.81). Based on the average of eight sprays, the average insect mortality was calculated and it was noticed that highest thrips mortality was observed T2 (54.08%) and followed with T8 (50.60%), T7 (47.61%), T5 (46.09%), T6 (44.10%), T4 (41.33%) and T3 (36.66%). (table 4.17).

Table 4.15 Effect of treatments on thrips population after 8th spray

Treatments	Pre-treatment count	Thrips Population		
		After 8[th] Spray		
		3 DAS	7 DAS	10 DAS
T1- Untreated control	6.53 (2.65)	6.62 (2.66)	6.67 (2.67)	6.76 (2.69)
T2- Fipronil 5 SC @ 1000 ml/ha and alternated with Thiacloprid 21.7 SC @ 300 ml/ha	0.50 (1.00)	0.15 (0.80)	0.17 (0.82)	0.37 (0.93)
T3- Met 52 @ 250ml/ha	0.04 (0.70)	0.03 (0.72)	0.02 (0.72)	0.01 (0.71)
T4- Met 52 @ 500ml/ha	0.02 (0.71)	0.01 (0.71)	0.00 (0.71)	0.00 (0.71)
T5- Met 52 @ 1000ml/ha	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T6-Met 52 @ 250 ml/ha alternated with Fipronil 5 SC @ 850 ml/ha	0.15 (0.80)	0.05 (0.74)	0.05 (0.74)	0.12 (0.78)
T7- Met 52 @ 500 ml/ha alternated with Fipronil 5 SC @ 900 ml/ha	0.09 (0.76)	0.03 (0.72)	0.03 (0.72)	0.07 (0.75)
T8- Met 52 @ 1000 ml/ha alternated with Fipronil 5 SC @ 950 ml/ha	0.06 (0.74)	0.01 (0.71)	0.02 (0.72)	0.04 (0.73)
S Em±	0.04	0.04	0.04	0.05
CD at 5 %(p=0.05)	**0.13**	**0.14**	**0.12**	**0.16**
CV %	7.13	7.97	6.75	8.87

The values in parentheses are square root transformed values

DAS = Days after spray

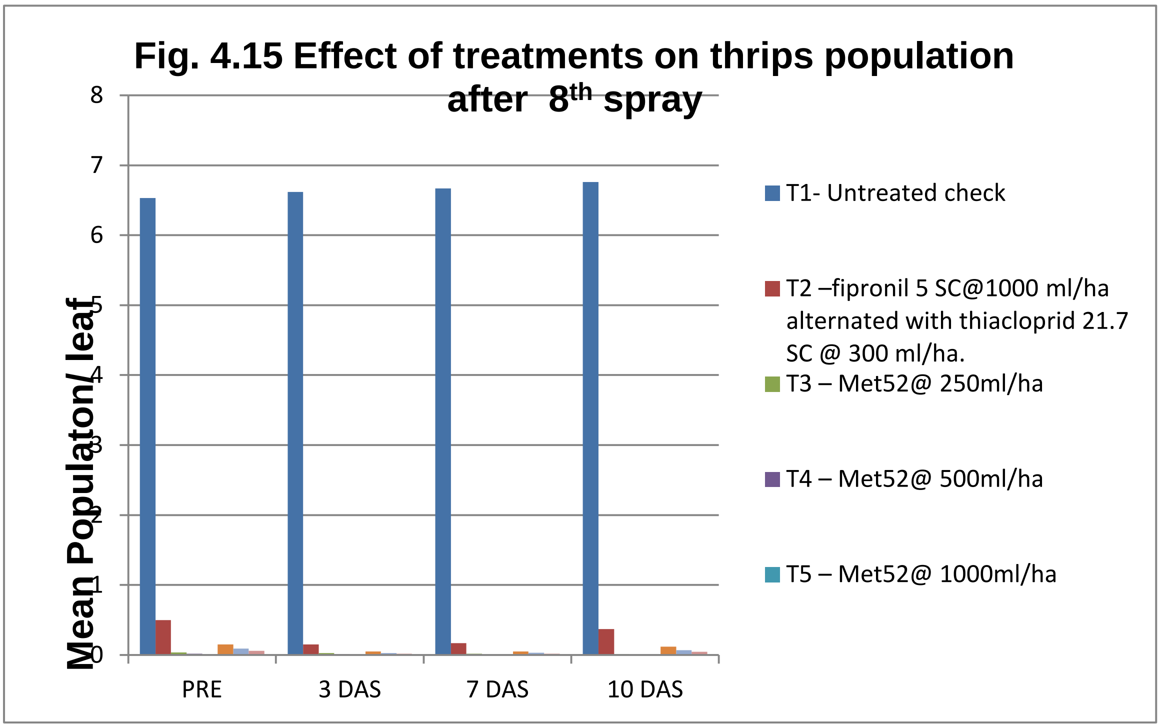
Fig. 4.15 Effect of treatments on thrips population after 8th spray
Mean Populaton/ leaf
0
1
2
3
4
5
6
7
8
PRE
3 DAS
7 DAS
10 DAS
T1- Untreated check
T2 –fipronil 5 SC@1000 ml/ha alternated with thiacloprid 21.7 SC @ 300 ml/ha.
T3 – Met52@ 250ml/ha
T4 – Met52@ 500ml/ha
T5 – Met52@ 1000ml/ha

Table 4.16 Effect of treatments on thrips mortality after 8th spray

Treatments	Per cent mortality		
	After 8th Spray		
	3 DAS	7 DAS	10 DAS
T1- Untreated control			
T2- Fipronil 5 SC @ 1000 ml/ha and alternated with Thiacloprid 21.7 SC @ 300 ml/ha	70.40 (57.04)	66.71 (54.76)	28.51 (32.27)
T3- Met 52 @ 250ml/ha	15.45 (23.11)	46.85 (43.17)	58.60 (49.95)
T4- Met 52 @ 500ml/ha	18.76 (25.70)	59.68 (50.59)	65.90 (54.27)
T5- Met 52 @ 1000ml/ha	26.01 (30.66)	63.28 (52.71)	75.85 (60.53)
T6-Met 52 @ 250 ml/ha alternated with Fipronil 5 SC @ 850 ml/ha	67.11 (55.00)	66.06 (54.39)	22.72 (28.45)
T7- Met 52 @ 500 ml/ha alternated with Fipronil 5 SC @ 900 ml/ha	69.31 (56.35)	66.27 (54.57)	24.86 (29.93)
T8- Met 52 @ 1000 ml/ha alternated with Fipronil 5 SC @ 950 ml/ha	70.40 (57.04)	67.36 (55.18)	27.55 (31.63)
S Em±	1.87	2.51	2.10
CD at 5 %(p=0.05)	**5.77**	**7.73**	**6.47**
CV %	7.45	8.33	8.83

The values in parentheses are angular transformed (arc sin) values,
DAS = Days after spray.

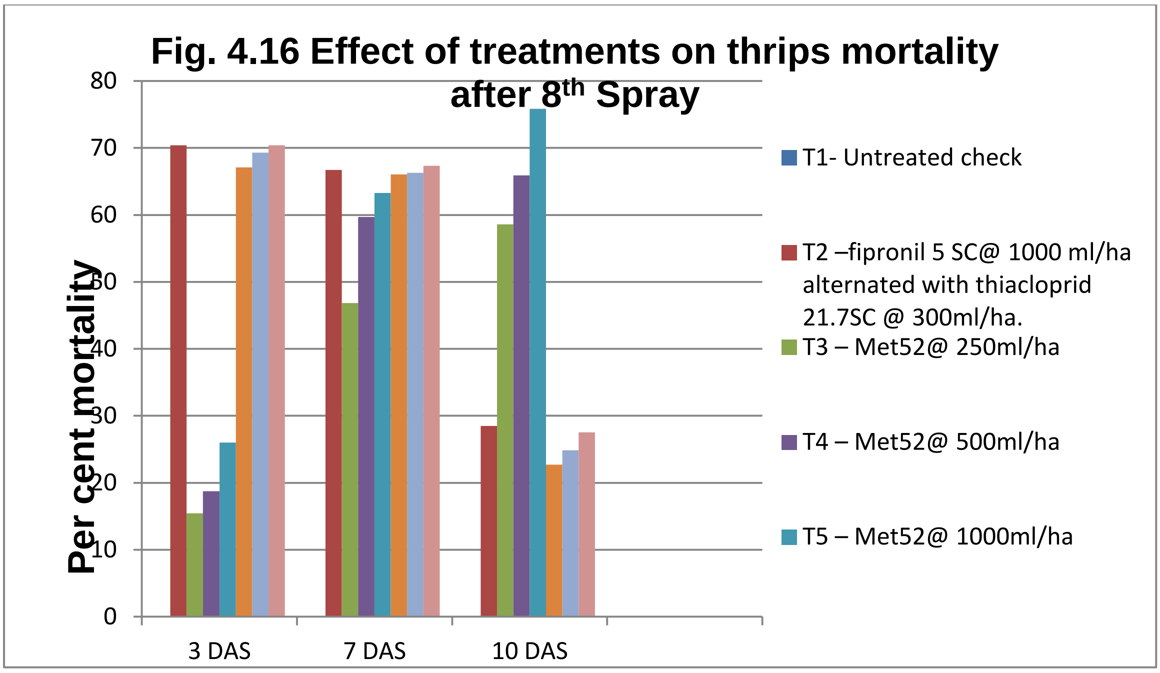

Fig. 4.16 Effect of treatments on thrips mortality after 8th Spray
Per cent mortality
80
70
60
50
40
30
20
10
0
3 DAS
7 DAS
10 DAS
T1- Untreated check
T2 –fipronil 5 SC@ 1000 ml/ha alternated with thiacloprid 21.7SC @ 300ml/ha.
T3 – Met52@ 250ml/ha
T4 – Met52@ 500ml/ha
T5 – Met52@ 1000ml/ha

Table 4.17 Average thrips population and mortality after sprays

Mean thrips population and mortality(%) after sprays											
Treatment	**Pre**	**1st spray**	**2nd spray**	**3rd spray**	**4th spray**	**5th spray**	**6th spray**	**7th spray**	**8th spray**	**Av. Population**	**Av. Mortality**
T1- Untreated check	5.48	5.67	5.87	5.92	6.02	6.14	6.25	6.49	6.68	**6.81**	
T2 – Fipronil 5 SC @ 1000 ml/ha alternated with thiacloprid 21.7SC @ 300ml/ha.	4.49	1.86* (60.33)**	1.24 (43.29)	0.92 (54.64)	0.68 (55.1)	0.48 (56.65)	0.38 (53.20)	0.31 (54.21)	0.23 (55.21)	**1.33**	**54.08**
T3 – Met 52 @ 250ml/ha	5.22	3.28 (38.96)	1.40 (39.77)	0.71 (35.64)	0.36 (33.30)	0.17 (36.44)	0.09 (31.46)	0.04 (37.42)	0.02 (40.3)	1.41	36.66
T4 – Met 52 @ 500ml/ha	5.53	3.32 (41.70)	1.23 (46.92)	0.55 (39.74)	0.26 (35.71)	0.12 (40.59)	0.06 (37.64)	0.02 (43.21)	0.00 (48.11)	1.38	41.33
T5 – Met 52 @ 1000ml/ha	5.46	3.17 (43.63)	1.03 (53.49)	0.40 (43.31)	0.17 (38.76)	0.07 (44.13)	0.03 (43.87)	0.01 (46.45)	0.00 (55.05)	**1.29**	**46.09**
T6 – Met 52 @ 250ml/ha alternated with fipronil 5SC @ 850ml/ha	5.96	3.76 (38.66)	1.21 (55.80)	1.22 (36.48)	0.46 (49.61)	0.46 (35.61)	0.18 (49.31)	0.19 (35.41)	0.07 (51.96)	1.63	44.10
T7 – Met 52 @ 500ml/ha alternated with fipronil 5SC @	6.21	3.75 (41.30)	1.14 (56.75)	1.05 (41.76)	0.37 (52.64)	0.36 (40.15)	0.13 (50.84)	0.13 (43.94)	0.04 (53.48)	1.64	**47.61**

900ml/ha											
T8 – Met 52 @ **1000ml/ha alternated with fipronil 5SC** @ **950ml/ha**	6.45	3.76 (43.29)	1.09 (60.26)	1.02 (43.97)	0.33 (56.20)	0.31 (44.18)	0.10 (53.40)	0.09 (48.44)	0.03 (55.10)	1.64	**50.60**

*Thrips population

** Thrips mortality

4.2 Phytotoxic effect of *Metarhiziumanisopliae* Met 52 OD on chillicrop

No phytotoxic symptoms like yellowing, necrosis, scorching, epinasty and hyponasty were observed on crop after spray with all the doses of *Metarhiziumanisopliae*Met52 OD @ 250,500 and 1000 ml.ha^{-1}

Table 4.18 Phytotoxicityof*Metarhiziumanisopliae* Met 52 ODon chilli crop after all spray

Treatments	Yellowing	Necrosis	Scorching	Epinasty	Hyponasty
Untreated check	0	0	0	0	0
Met 52 OD @ 250 ml.ha^{-1}	0	0	0	0	0
Met 52 OD @ 500 ml.ha^{-1}	0	0	0	0	0
Met 52 OD @ 1000 ml.ha^{-1}	0	0	0	0	0

4.3 Effect of treatment on chilli yield

All the treatments exhibited the significant difference with untreated check. The maximum yield was recorded in T2 (2256 Kg/ha) which was significantly higher over all the treatments. Further the next best treatment was T8 (2114 Kg/ha) followed by T5 (1905 Kg/ha), T7 (1895 Kg/ha) and T4 (1784 kg/ha). The minimum yield was noted in untreated check T1 (1178 Kg/ha).

(table 4.19 and fig. 4.17)

Table 4.19 Effect of treatments on chilli yield

Treatments	Yield kg/ha
T1- Untreated check	1178
T2 – Fipronil 5 SC @ 1000 ml/ha and alternated Thiacloprid 21.7 SC @ 300 ml/ha.(4+4 application)	2256
T3 – Met 52 @ 250ml/ha foliar spray x 8 application	1589
T4 – Met 52 @ 500ml/ha foliar spray x 8 application	1784
T5 –Met 52 @ 1000ml/ha foliar spray x 8 application	1905
T6 –Met 52 @ 250ml/ha foliar spray alternated with Fipronil 5 SC @ 850 ml/ha (4+4 application)	1745
T7 – Met 52 @ 500ml/ha foliar spray alternated with Fipronil 5 SC @ 900 ml/ha (4+4 application)	1895
T8 – Met 52 @ 1000ml/ha foliar spray alternated with Fipronil 5 SC @ 950 ml/ha (4+4 application)	2114
S Em±	29.494
CD at 5 %(p=0.05)	89.47
CV %	8.477

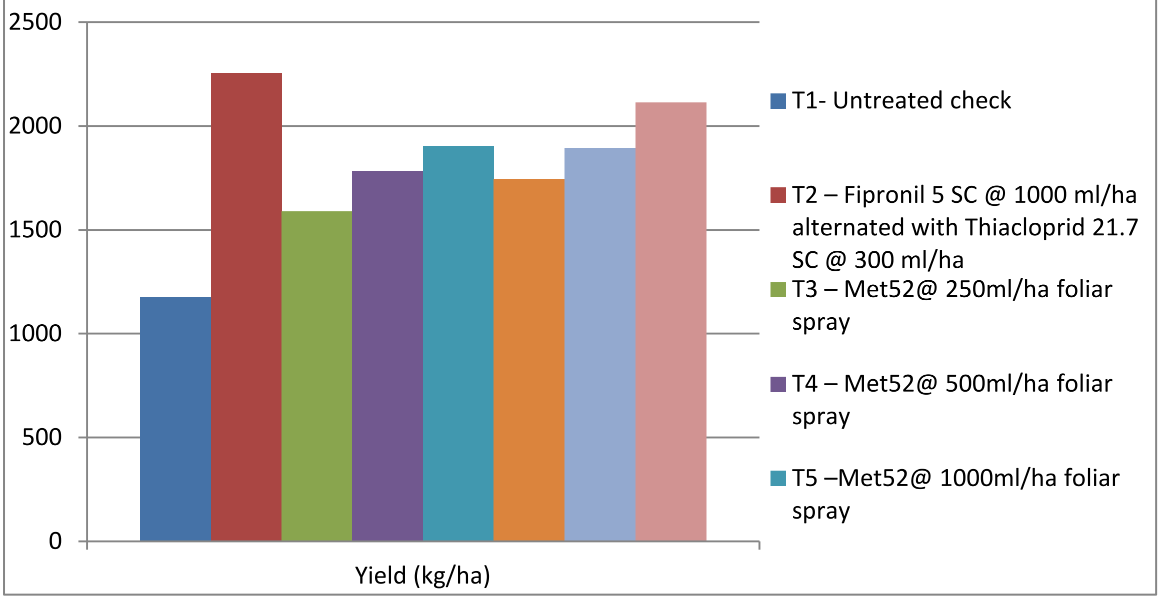

Fig. 4.17 Effect of treatments on chilli yield

4.4 Economic assessment of chilli yield

Among the treatments highest fruit yield was observed in T2 (2256 kg/ha) and received maximum net return (Rs.1,61,560) with maximum cost benefit ratio (2.88) followed by T8 (2.31), T5 (1.91), T7 (1.85), and T4 (1.78).The minimum fruit yield was observed in untreated check T1 (1178 kg/ha) and exhibited minimum net return (Rs.55,918). (Table 4.20)

4.20 Economic assessment of different treatments on chilli yield

Treatments	Nursery + Field prepa-ration cost (Rs)	Seed cost (1.5Kg/ha) (Rs)	Fertilizer + 5labour cost (Rs)	Trans-planting cost (12labour (Rs)	Weeding cost (2 weeding) (36 labour) (Rs)	Irrigation cost (8irrigation) (Rs)	Harve-sting cost (45 labour) (Rs)	Cost of insecticide (Rs)	Total cost (Rs)	Yield kg/ha	Gross income (Rs)	Net income (Rs)	Cost benefit ratio
T1-Untreated check	4500	1800	3532	2400	7200	4000	9000	--	32,432	1178	88,350	55918	
T2- Fip.5 SC @ 1000ml/ha and Thia.21.7 SC @ 300ml/ha	4500	1800	3532	2400	7200	4000	9000	7640	40072	**2256**	1,69,200	161560	1:2.88
T3- Met 52 @ 250ml/ha	4500	1800	3532	2400	7200	4000	9000	800	33232	1589	1,19175	85943	1:1.53
T4- Met 52 @ 500ml/ha	4500	1800	3532	2400	7200	4000	9000	1600	34032	1784	1,33,800	99768	1:1.78
T5- Met 52 @ 1000ml/ha	4500	1800	3532	2400	7200	4000	9000	3200	35632	**1905**	1,42,875	107243	1:91
T6 –Met 52 @ 250ml/ha f.b.Fip.5SC@ 850ml/ha	4500	1800	3532	2400	7200	4000	9000	5400	37832	1745	1,30,875	93042	1:1.66
T7 —Met 52 @ 500ml/ha f.b.Fip.5SC @ 900ml/ha	4500	1800	3532	2400	7200	4000	9000	5800	38232	1895	1,42,125	103893	1:1.85
T8 —Met 52 @ 1000ml/ha f.b.Fip.5SC @ 950ml/ha	4500	1800	3532	2400	7200	4000	9000	6600	39032	**2114**	1,58550	119518	1:2.31

Remark: 1. Market rate of dry chilli fruit was @ Rs 7500/ Q.
2. Labour charge @ Rs 200/labour/day.
3. Seed cost @ Rs 1200/kg.
4. Irrigation cost @ 500/irrigation.

Overall performance of treatments after all sprays

Average thrips population/leaf

The least thrips count was observed in T5 (1.29) followed with T2 (1.33), T4 (1.38), T3 (1.41), T6 (91.63) and T7 (1.64) with difference it the population of untreated check (6.81).(table 4.21)

Mortality

The highest insect mortality was recorded in T2 (54.08%) and followed with T8 (50.60%), T7 (47.61%), T5 (46.09%), T6 (44.10%), T4 (41.33%) and T3 (36.66%).(table 4.21)

Fruit Yield

All the treatments exhibited the significant difference with untreated check. The maximum yield was recorded in T2 (2256 Kg/ha) which was significantly higher over all the treatments. Further the next best treatment was T8 (2114 Kg/ha) followed by T5 (1905 Kg/ha), T7 (1895 Kg/ha) and T4 (1784 kg/ha). The minimum yield was noted in untreated check T1 (1178 Kg/ha).(table 4.21)

Cost benefit ratio

The highest cost benefit ratio was calculated in treatment T2 (1:2.88) followed by T8 (1:2.31), T5 (1:1.91), T7 (1:1.85), T4 (1:1.78), T6 (1:1.66) and T3 (1:1.53).(table 4.21)

Table 4.21 Overall performance of treatments after all sprays

Treatments	Average thrips Population /leaf	Average Mortality (%)	Yield (Kg/ha)	C:B Ratio
T1- Untreated check	6.81		1178	
T2 – Fipronil 5 SC @ 1000 ml/ha alternated with Thiacloprid 21.7SC @ 300ml/ha.	1.33	54.08	2256	1:2.88
T3 – Met 52 @ 250ml/ha	1.41	36.66	1589	1:1.53
T4 – Met 52 @ 500ml/ha	1.38	41.33	1784	1:1.78
T5 – Met 52 @ 1000ml/ha	1.29	46.09	1905	1:1.91
T6 – Met 52 @ 250ml/ha alternated with Fipronil 5SC @ 850ml/ha	1.63	44.10	1745	1:1.66
T7 – Met 52 @ 500ml/ha alternated with Fipronil 5SC @ 900ml/ha	1.64	47.61	1895	1:1.85
T8 – Met 52 @ 1000ml/ha alternated with Fipronil 5SC @ 950ml/ha	1.64	50.60	2114	1:2.31

CHAPTER 5

DISCUSSION

The present investigation entitled “Comparative bioefficacy of *Metarhizium anisopliae* based bio-insecticide MET 52 OD in chilli for the control of sucking insect pest” was undertaken to study the efficacy of treatments under irrigated condition for the major insect pests during the *Kharif* season of 2014-15 at College of Agriculture, Indore.

The various findings of the present experiment have been discussed in this chapter under the light of past work done on the same and related topics. The chapter has been divided under following sub-headings:

5.1. Bio-efficacy of *Metarhizium anisopliae* against sucking insect pests of chilli.

5.2 Phytotoxicity of *Metarhizium anisopliae*

5.3 Yield performance of the different treatments.

5.4 Economic assessment of treatments

5.1. Bio-efficacy of *Metarhizium anisopliae* against sucking insect pests of chilli

Comparative bio-efficacy of *Metarhizium anisopliae* was assessed with different doses and alternation of insecticides like fipronil and thiacloprid with the marked treatments as **T1**- Untreated control, **T2**- fipronil 5 SC @ 1000 ml/ha alternated with thiacloprid 21.7 SC @ 300 ml/ha., **T3**- Met 52 @ 250ml/ha,**T4**- Met 52 @ 500ml/ha, **T5**-Met 52 @ 1000ml/ha, **T6**-Met 52 @ 250ml/ha foliar spray alternated with fipronil 5 SC @ 850 ml/ha ,**T7**- Met 52 @ 500ml/ha foliar spray alternated with fipronil 5 SC @ 900ml/ha and **T8**-Met 52 @ 1000ml/ha foliar spray alternated with fipronil 5 SC @ 950 ml/ha.

From overall findings, it was revealed that T5-Met 52 @ 1000ml/ha(1.29/leaf) reduced maximum thrips population and, followed with T2- fipronil 5 SC @ 1000 ml/ha alternated with thiacloprid 21.7 SC @ 300 ml/ha (1.33/leaf),T4- Met 52 @ 500ml/ha (1.38/leaf) and T3- Met 52 @ 250ml/ha (1.45/leaf). Rest of the treatments poorly reduced insect population. In relation to insect mortality, it was noted highest in T2- fipronil 5 SC @ 1000 ml/ha alternated with thiacloprid 21.7 SC @ 300 ml/ha (54.08%) followed by T8-Met 52 @ 1000ml/ha foliar spray alternated with fipronil 5 SC @ 950 ml/ha. (50.60%), T7- Met 52 @ 500ml/ha foliar spray alternated with fipronil 5 SC @ 900ml/ha (47.61%) and T5-Met 52 @ 1000ml/ha (46.09%). From these observations the highest effectiveness was observed with the application of T2- fipronil 5 SC @ 1000 ml/ha alternated with thiacloprid 21.7 SC @ 300 ml/ha followed by independent and alternated use of *Metarhizium anisopliae* with their highest dose.

Reddy *et al*., (2005) evaluated certain new insecticides against chilli thrips (*Scirtothrips dorsalis*) and mites (*Polyphagotarsonemus latus*) and found that fipronil, followed by thiamethoxam, acetamiprid and dimethoate, was the most effective against the thrips.Again Reddy *et al.,* (2007) found that fipronil 5% SC @ 2 ml was the best treatment against thrips followed by spinosad 45% SC @ 0.3 and 0.2 ml/litre in chilli (*Capsicum annum* L.). In another study again Reddy *et al.*, (2007) against chilli thrips (*Scirtothrips dorsalis*) and mites (*Polyphagotarsonemus latus*) found that fipronil 5% SC at 0.01% more effective against thrips, as they reduced thrips population. Mahalingappa *et al*., (2008) studied the bio-efficacy of fipronil with certain insecticides against thrips (*Scirtothrips dorsalis* Hood) and mite (*Polyphagotarsonemus latus* Banks) infesting chilli (*Capsicum annuum* L.) and results indicated that fipronil 0.01 was the most effective against thrips in chilli. Reddy and Sreehari (2009) found that fipronil 80 WG @ 50 g.*a.i*./ha recorded lowest number of thrips and is on par with fipronil 80 WG @ 40 g.*a.i*./ha against chilli thrips. None of the treatments had shown any phytotoxicity symptoms on chilli crop. Ghosh *et al.* (2009) reported that fipronil @ 100 g.*a.i../*ha recorded lowest population of chilli thrips (*Scirtothrips dorsalis* Hood) on chilli. Nayak *et al.,* (2014) reported that acetamiprid and fipronil were found to be effective insecticides in minimizing the incidence of thrips and aphid and maximizing the yield and net return in chilli production.The findings of these researchers are in the line of agreement as they reported the effectiveness of fipronil with their different doses in relation to population reduction and mortality.

Patil *et al.,* (*2009)* revealed that fipronil 5% SC @ 800 g/ ha registered least number of thrips (8.47 / 3 leaves) in *Bt* cotton and significantly highest seed cotton was harvested with higher dose of fipronil 5% SC @ 800 g/ha. Rohini *et al.,*(2012) studied on management of major sucking pests in cotton by insecticides and found that fipronil 5 SC @ 2ml/L and acephate 75 SP @ 1.5g/L were found to be effective against thrips in cotton. Mahla *et al*.,(2013) evaluated bio-efficacy of fipronil 200 SC against thrips, *Thrips tabaci* (Lindeman) infesting cotton and found that fipronil 200 SC at 375 ml/ha caused the highest percent reduction of thrips at 3, 7 and 10 days after first and second spray with the highest seed cotton yield of 29.90 q/ha. Dhawan and Singh (2013) reported that population of cotton thrips per 3 leaves was significantly lower in fipronil @ 50 g.*a.i*./ha and 60 g.*a.i*./ha (5.13 and 3.63) as compared to all other treatment after 3 days of spray. After 12 days of spray thrips population per 3 leaves was significantly lower in fipronil @ 60 g.*a.i*./ha (2.49) which was on par with its lower dose fipronil @ 50 g.*a.i*./ha (5.06).Shreekanth and Reddy (2011) reported cotton thrips AT 3 DAS, that the mortality of thrips was high in thiamethoxam (78.52%) and fipronil (75.23%).

Kandekar *et al*., (2010) evaluated efficacy of fipronil 5% SC at different doses against aphids and leaf hopper in cotton and found fipronil @ 200 & 400 g.*a. i*./ha was found the most effective against aphids and leaf hopper. Kalyan *et al*.,(2012) studied against jassids and whitefly in cotton and reported that spinosad, imidacloprid, acephate and fipronil effectively controlled the population of jassids and whiteflies and gave significantly higher seed cotton yield over to untreated check and standard check.

Pandey *et al.* (2013) found that the lowest mean thrips population (8.0 nymphs/plant) and the highest marketable yield (362 Q/ha) were achieved by applying fipronil @ 1.5 ml/lt. resulting in the highest cost benefit ratio (1:11.55) leading to an arbitration of spraying fipronil @ 1.5 ml/lt. at fifteen days interval minimize the thrips population and increase the yield of *Rabi* onion.Hosamani *et al*., (2012) evaluated fipronil 80 WG against thrips in onion and found to be effective up to ten days, recording minimum population of 0.83 thrips/plant at three days, and 0.58 thrips per plant at ten days after spray with the highest yield of 29.16 t/ha. These researchers found the efficacy of fipronil on onion and cotton against thrips hence the findings of these workers are in close association with the present study.

Chaudhary and Jaipal (2006) reported new insecticides *i.e*. regent 5 SC (fipronil) and confidor 200 SL (imidacloprid) applied on sugarcane foliage at 0.05% each were most effective and caused 85.1 and 83.1% reduction in whitefly population. Das and Tarikul (2014) evaluated the efficacy of some new generation insecticides against two important sucking insects, *Amrasca devastans* (jassid or leafhopper) and *Bemicia tabaci* (white fly) in brinjal and found that fipronil, imidacloprid and buprofezin were most effective. Yadav and Raghuraman, (2014) recorded the higher reduction in whitefly population in brinjal by fipronil 80 WG @ 100 g a.i./ha with 45.4% mortality. The findings of these workers are also in partial agreement due to variation in crop and pests.

In present investigation thiacloprid was also tested in the alternation with fipronil which also exhibited the lowest insect population and highest thrips mortality. Walunj and Pawar (2004) observed that thiacloprid at 36, 54 and 72 g a.i./ha was equally effective against aphids,in chilli at 3, 7 and 14 days after each spray. All insecticidal treatments decreased the numbers of aphids and whiteflies at 14 days after spraying. Ahmed *et al*., (2014)tested efficacy of four neonicotinoids viz; nitenpyram 10SL, thiacloprid 480SC, imidacloprid 200SL, acetamiprid 20SL and four traditional insecticides at their recommended field doses against sucking insect pests of cotton and reported that minimum number of whitefly was recorded in thiacloprid treated plots. The results of these research workers are in partial support with present study as they reported the efficacy of thiacloprid against other sucking pests.

The efficacy of *Metarhizium anisopliae* was also noted after fipronil and thiacloprid with little difference in present study. Thungrabeab *et al.,* (2006) studied on onion thrips *Thrips tabaci* Lindeman (Thys., Thripidae) using different entomopathogenic fungi and showed that mortalities caused by *Metarhizium spp*. ranged from 23.5% to 97.3%, in which *Metarhizium* sp. isolates were more pathogenic than *M. anisopliae*. *M. anisopliae* isolates were also more pathogenic than *Metarhizium flavoviride.* Naik *et al.,* (2009) showed that *Metarhizium anisopliae* oil and their WP formulations recorded 96.67% mortality of okra leafhoppers at 10 DAT. The efficacy against mite was 96.67 and 94.67 per cent in *M. anisopliae* oil and WP formulations respectively. The yield of okra was significantly higher in oil based formulation of *M. anisopliae* (38.80 q/ha) with monetory returns of Rs. 14720 and Rs. 14480/ha, respectively.However, higher the benefit cost ratio of 16.68:1 was recorded with *M. anisopliae* wettable powder formulation. Arthurs *et al*., (2013) evaluated entomopathogenic fungi against chilli thrips, *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae), in laboratory assays. Four applications reduced thrips populations over 10 weeks: by *M. brunneum* F52 by an average of 81%. The data show that mycoinsecticides can be used in management strategies for low to moderate populations of *S. dorsalis* and provide resistance management tools for the limited number of insecticides that are effective against this pest .Visalakshy *et al*., (2012) found that *M. ansiopliae* at a concentration of 1x10^9 spores/ml with adjuvant (sunflower and Triton-X) recorded the lowest thrips/plant population contributing to 58% reduction and 49.12% increase in cotton yield over control. This study suggests that entomopathogens can substitute chemical pesticides in the management of *Thrips tabaci* in onion. Shanmugapriyan and Mathew Babu (2010) evaluated *Metarhizium anisopliae* (Kalichakra 1% W.P.) and Derimax against tea thrips under laboratory conditions and found *M. anisopliae* at 3.75 g/litre recorded 96.7% mortality after 96 h. The herbal product, Derimax recorded 100% mortality at 0.375 ml/litre within 72 h after treatment .Ansari *et al*., (2007) found that *Metarhizium anisopliae* V275 was more efficacious than chemical insecticides (imidacloprid, fipronil) in killing pupae of the western flower thrips. Gouli *et al.,* (2008) reported that formulations based on *Beauveria bassiana* (Balsamo) *Vuillemin*, *Metarhizium anisopliae* (Metschnikoff) Sorokin and *Lecanicillium lecanii* (Zimmermann) Zareet W. Gams, have reported to significantly reduce WFT populations in greenhouse vegetable and floral crops. Maketon *et al.,* (2008) found that *Metarhizium anisopliae* CKM-048 was the most virulent strain in controlling both larvae and adult broad mites in mulberry at the concentration of 2x10^8 conidia/ml. Sabbour (2009) observed on tomato under field conditions that the percentage of infested plants with *B. tabaci* and *A. gossypii* significantly decreased after treatments with *Metarhizium anisopliae*, as compared with the control. *Metarhizium anisopliae* also increased the tomato yield over control. Karkar *et al., (*2014) noted the bio-efficacy of microbial insecticides against insect pests of brinjal and found that application of *M. anisopliae* and *L. lecanii* applied at 40 g/10 litres of water was effective against sucking pests. These findings of previous workers exhibits that *Metarhizium anisopliae* is effective in reducing the population of thrips and other sucking insect pests which supports the present investigation.

The findings of Neelima *et al*., (2011) are also in consideration as they observed that fipronil 5% SC @ 50 g.a.i./ha was effective in bringing down the population of cotton leafhoppers up to 72.3% over control at 14 days after spraying. Per cent reduction in leafhopper population was less with bio-control agents viz., *V.*

lecanii @ 2500 g/ha (11.0), *M. anisopliae* @ 2500 g/ha (12.3), *B. bassiana* @ 2500 g/ha @ 2500 g/ha (14.9).

5.2 Phytotoxicity of *Metarhizium anisopliae*

During the experimentation no phytotoxic effect of any dose of *Metarhizium anisopliae* was reported at any interval of sprays either in alternate use with insecticides or independent highest dose. No phytotoxic symptoms like yellowing, necrosis, scorching, epinasty and hyponasty on chilli appeared during the crop period. Thungrabeab *et al*., (2006), Ansari *et al*., (2007), Gouli *et al.,* (2008), Maketon *et al.,* (2008), Naik *et al.,* (2009), Sabbour. (2009), Shanmugapriyan and Mathew Babu (2010), Visalakshy *et al*., (2012), Arthurs *et al*., (2013) and Karkar *et al., (*2014) observed the effectiveness of *Metarhizium anisopliae* against thrips and other sucking pest but did not report any phytotoxic effect of this fungus which support's the present investigation.

5.3 Yield performance of the different treatments.

The highest dried fruit yield was received from T2-Fipronil 5 SC@1000ml/ha alternated with thiacloprid 21.7 SC@300 ml/ha (2256 Kg/ha),which followed with T8-Met 52 @ 1000ml/ha alternated with fipronil 5 SC @ 950 ml/ha(2114 Kg/ha) and highest independent dose of *Metarhizium anisopliae* as T5- Met 52 @ 1000 ml/ha (1905 Kg/ha). The finding exhibits that application of fipronil 5 SC @ 1000ml/ha alternated with thiacloprid 21.7 SC @ 300 ml/ha showed the best response in relation to yield comparing with independent and alternated use of *Metarhizium anisopliae*. Although T8-Met 52 @ 1000ml/ha foliar spray alternated with fipronil 5 SC @ 950 ml/ha exhibited second best response and later the highest dose of *Metarhizium anisopliae* @ 1000 ml/ha.

Nayak *et al.,* (2014) reported that fipronil was effective insecticide in minimizing the incidence of sucking insect pest and maximizing the chilli yield. This finding is in close association with the present study.

Further Hosamani *et al*., (2012) observed the highest onion yield due to application of fipronil 80 WG @ 60 g.a.i./ha. Similarly Pandey *et al*., (2013) noted the highest onion yield with the application of fipronil @ 1.5 ml/l. Kalyan *et al*., (2012) studied that spinosad, imidacloprid, acephate and fipronil effectively control the population of jassids and whiteflies and gave significantly higher seed cotton yield over untreated check and standard check. Mahla *et al*., (2013) also reported that the application of fipronil 200 SC @ 375 ml/ha exhibited maximum seed cotton yield. Furthermore Dhawan and Singh (2013) recorded the significantly high seed cotton yield with higher dose of fipronil 80 WG @ 60 g.a.i/ha. The findings of these researchers are in the partial support of present study due to variation in crop.

5.4 Economic assessment of treatments.

Based on the lower insect population, mortality and dry chilli yield the maximum cost benefit ratio was recorded in T2- Fipronil 5 SC @ 1000ml/ha alternated with thiacloprid 21.7 SC @ 300 ml/ha (1:2.88) which followed with T8-Met 52 @ 1000ml/ha f.b. fipronil 5 SC @ 950 ml/ha (1:2.31) and T5-Met 52 @ 1000 ml/ha (1:1.91). The findings of Nayak *et al*.,(2014) are in the line of agreement as they noted the higher net return in chilli production due to application of fipronil against chilli thrips (*Scirtothrips dorsalis).*

Further Pandey *et al.,* (2013) reported the highest cost benefit ratio (1:11.55) leading to an arbitration of spraying fipronil 1.5ml/l at 15 days interval on onion. Mahla *et al*., (2014) reported the highest seed cotton yield due to application of fipronil 200 SC @ 375 ml/ha which showed the maximum return from the treatment. Dhawan and Singh (2014) also observed the similar results with the application of fipronil 80 WG @ 60 g.*a.i*./ha on cotton. Kalyan *et al*.,(2012) observed that in cotton the highest avoidable losses (52.65%) were recorded in spinosad followed by imidacloprid (42.38%), acephate (31.47%), fipronil (28.23%) and dimethoate (28.12%). These findings are also in close conformity with the present study.

Furthermore Naik *et al*.,(2009) reported the higher cost benefit ratio of 1:1.68 due to application of *Metarhizium anisopliae* wettable powder formulation which is also in the line of agreement with the present findings.

CHAPTER 6

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

6.1 SUMMARY

The present investigation entitled “Comparative bioefficacy of *Metarhizium anisopliae* based bio-insecticide MET 52 OD in chilli for the control of sucking insect pest” was undertaken to study the efficacy of treatments under the irrigated condition for the major insect pests during the *kharif* season of 2014-15 at College of Agriculture, Indore. The experiment was laid out in the randomized block design with the 8 treatments including untreated check comprising of different doses of Met 52 OD and different other insecticides on Chilli variety Pusa Jwala with 3 replications. Thrips population was counted on five randomly selected plants of each plot in pre and post treatment observations of 3, 7 and 10 days after each spray. The salient findings of the experiment are summarized below:

6.1.1 Bio-efficacy of *Metarhizium anisopliae* against sucking insect of chilli.

1. Chilli thrips first appeared at the age of 25 days on the chilli crop.

2. The activity of thrips was observed increasing with the development of the crop. The pest multiplied during the active vegetative growth stage of the chilli crop. After last observation of eighth spray, minimum thrips population was noted in T5- Met 52 @ 1000 ml/ha (0.00) and T4- Met 52 @ 500 ml/ha (0.00), followed by T3-Met 52 *(*Metarhizium *anisopliae)* @ 250 ml /ha (0.02), T8-– Met 52 @ 1000ml/ha alternated with fipronil 5SC @ 950 ml/ha (0.03), T7 – Met 52 @ 500ml/ha alternated with fipronil 5SC @ 900 ml/ha (0.04),T6–Met 52 @ 250ml/ha alternated with fipronil 5 SC @ 850 ml/ha (0.07), and T2- Fipronil 5 SC @ 1000 ml /ha alternated with thiacloprid 21.7 SC @ 300 ml/ha (0.23). Although all the treatments were significantly superior over untreated check T1 (6.68).

3. As far as overall per cent mortality in thrips population was concerned, it was noted maximum in T2- fipronil 5 SC @ 1000 ml/ha alternated with thiacloprid 21.7

SC @ 300 ml/ha (54.08%) followed by T8-Met 52 @ 1000 ml/ha foliar spray alternated with fipronil 5 SC @ 950 ml/ha. (50.60%), T7- Met 52 @ 500 ml/ha foliar spray alternated with fipronil 5 SC @ 900 ml/ha (47.61%) and T5- Met 52 @ 1000 ml/ha (46.09%). Minimum mortality was recorded in T3-(36.66%).

6.1.2 Phytotoxicity

During the observation all the doses of *Metarhizium anisopliae* either in alternate use with insecticides or independent highest dose i.e. 1000 ml./ha, were sprayed and no phytotoxic symptoms on chilli plants were observed.

6.1.3 Yield performance of the different treatments.

The highest dried fruit yield was received from T2-Fipronil 5 SC @ 1000ml/ha alternated with thiacloprid 21.7 SC @ 300 ml/ha (2256 Kg/ha), which followed with T8- Met 52 @ 1000 ml/ha alternated with fipronil 5 SC @ 950 ml/ha (2114 Kg/ha) and highest independent dose of *Metarhizium anisopliae* as T5- Met 52 @ 1000 ml/ha (1905 Kg/ha).The minimum yield was observed in untreated check T1 (1178Kg/ha).

6.1.4 Economic assessment of treatments.

The maximum cost benefit ratio was recorded in T2- Fipronil 5 SC @ 1000ml/ha alternated with thiacloprid 21.7 SC @ 300 ml/ha (1:2.88) which followed with T8-Met 52 @ 1000 ml/ha f.b. fipronil 5 SC @ 950 ml/ha (1:2.31) and T5-Met 52 @ 1000 ml/ha (1:1.91).

6.2 Conclusion

After all spraying minimum thrips population was noted in T5-Met 52 @ 1000 ml/ha(1.29/leaf) reduced maximum thrips population and followed with T2- fipronil 5 SC @ 1000 ml/ha alternated with thiacloprid 21.7 SC @ 300 ml/ha (1.33/leaf).

From these observations it was concluded that highest effectiveness was observed with the application of T2- fipronil 5 SC @ 1000 ml/ha alternated with thiacloprid 21.7 SC @ 300 ml/ha followed by independent and alternated use of *Metarhizium anisopliae* with their highest dose.

During the observation not any symptoms of Phytotoxicity were observed. Further no beneficial insect were recorded during the crop period.

Among the treatments highest cost benefit ratio was observed in T2- fipronil 5 SC @ 1000ml/ha alternated with thiacloprid 21.7 SC @ 300 ml/ha (1:2.88).

1.3 Suggestions for further work

1. To get better and accurate result it is necessary to continue this experiment.

2. The efficacy of *Metarhizium anisopliae* Met 52 OD also to be judged on the sucking pests of other crops to find out the efficacy of *Metarhizium anisopliae* Met 52 OD, with different doses.

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APPENDIX 1: Thrips population in pre-treatment count

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.035	0.02	0.52
Treat	7	0.33	0.05	**1.37**
Error	14	0.48	0.03	2.42
Total	23	0.85		
S Em±	0.10			
CD at 5 %	0.33			
CV %	7.53			

APPENDIX 2: Thrips population 3 days after 1st spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.03	0.02	0.50
Treat	7	3.42	0.49	14.75
Error	14	0.46	0.03	2.08
Total	23	3.92		
S Em±	0.10			
CD at 5 %	0.32			
CV %	8.48			

APPENDIX 3: Thrips population 7 days after 1st spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.06	0.03	2.08
Treat	7	1.84	0.26	16.89
Error	14	0.22	0.02	1.96
Total	23	2.12		
S Em±	0.07			
CD at 5 %	0.22			
CV %	6.31			

APPENDIX 4: Thrips population 10 days after 1st spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.06	0.03	1.40
Treat	7	1.68	0.24	10.46
Error	14	0.32	0.02	1.87
Total	23	2.07		
S Em±	0.09			
CD at 5 %	0.26			
CV %	8.24			

APPENDIX 5: Thrips Mortality 3 days after 1st spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	3.59	1.79	0.39
Treat	6	4686.52	781.09	169.49
Error	12	55.30	4.61	30.66
Total	20	4745.41		
S Em±	1.24			
CD at 5 %	3.82			
CV %	7.17			

APPENDIX 6: Thrips Mortality 7 days after 1st spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	36.99	18.50	1.64
Treat	6	2189.47	364.91	32.26
Error	12	135.75	11.31	50.72
Total	20	2362.22		
S Em±	1.94			
CD at 5 %	5.98			
CV %	6.57			

APPENDIX 7: Thrips Mortality 10 days after 1st spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	27.21	13.60	1.24
Treat	6	661.56	110.26	10.02
Error	12	132.06	11.01	47.98
Total	20	820.83		
S Em±	1.91			
CD at 5 %	5.90			
CV %	6.85			

APPENDIX 8: Thrips population 3 days after 2nd spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.04	0.02	1.78
Treat	7	4.64	0.66	53.74
Error	14	0.17	0.01	1.55
Total	23	4.86		
S Em±	0.06			
CD at 5 %	0.19			
CV %	7.69			

APPENDIX 9: Thrips population 7 days after 2nd spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.01	0.01	0.98
Treat	7	4.77	0.68	95.81
Error	14	0.10	0.01	1.43
Total	23	4.89		
S Em±	0.05			
CD at 5 %	0.15			
CV %	6.24			

APPENDIX 10: Thrips population 10 days after 2^{nd} spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.02	0.01	0.75
Treat	7	4.16	0.59	47.24
Error	14	0.18	0.01	1.53
Total	23	4.36		
S Em±	0.06			
CD at 5 %	0.20			
CV %	7.34			

APPENDIX 11: Thrips Mortality 3 days after 2^{nd} spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	34.19	17.09	1.23
Treat	6	6385.56	1064.26	76.47
Error	12	167.00	13.92	42.76
Total	20	6586.75		
S Em±	2.15			
CD at 5 %	6.39			
CV %	7.90			

APPENDIX 12: Thrips Mortality 7 days after 2^{nd} spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	63.32	31.66	2.11
Treat	6	664.18	110.70	7.38
Error	12	179.98	15.00	53.61
Total	20	907.47		
S Em±	2.23			
CD at 5 %	6.89			
CV %	7.10			

APPENDIX 13: Thrips Mortality 10 days after 2nd spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	43.74	21.87	1.66
Treat	6	1435.99	239.33	18.09
Error	12	158.76	13.23	43.53
Total	20	1638.49		
S Em±	2.10			
CD at 5 %	6.47			
CV %	8.50			

APPENDIX 14: Thrips population 3 days after 3rd spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.03	0.01	0.84
Treat	7	4.98	0.71	46.1
Error	14	0.22	0.02	1.40
Total	23	5.22		
S Em±	0.07			
CD at 5 %	0.22			
CV %	8.83			

APPENDIX 15: Thrips population 7 days after 3rd spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.00	0.00	0.11
Treat	7	5.77	0.83	65.12
Error	14	0.18	0.01	1.30
Total	23	5.96		
S Em±	0.06			
CD at 5 %	0.20			
CV %	8.90			

APPENDIX 16: Thrips population 10 days after 3rd spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.04	0.02	2.18
Treat	7	5.99	0.86	84.69
Error	14	0.14	0.01	1.33
Total	23	6.18		
S Em±	0.06			
CD at 5 %	0.18			
CV %	7.88			

APPENDIX 17: Thrips Mortality3 days after 3rd spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	1.45	0.73	0.22
Treat	6	3997.12	666.19	205.80
Error	12	38.84	3.24	27.01
Total	20	4037.43		
S Em±	1.04			
CD at 5 %	3.20			
CV %	6.75			

APPENDIX 18: Thrips Mortality 7 days after 3rd spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	46.62	23.31	2.12
Treat	6	219.71	36.62	3.33
Error	12	131.99	11.00	46.29
Total	20	398.32		
S Em±	1.92			
CD at 5 %	5.90			
CV %	7.12			

APPENDIX 19: Thrips Mortality 10 days after 3rd spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	1.27	0.64	0.05
Treat	6	891.50	148.58	11.74
Error	12	151.93	12.66	45.41
Total	20	1044.71		
S Em±	2.05			
CD at 5 %	6.31			
CV %	7.72			

APPENDIX 20: Thrips population 3 days after 4th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.02	0.01	1.76
Treat	7	7.08	1.01	131.42
Error	14	0.11	0.01	1.20
Total	23	7.22		
S Em±	0.05			
CD at 5 %	0.15			
CV %	7.87			

APPENDIX 21: Thrips population 7 days after 4th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.00	0.00	0.28
Treat	7	7.34	1.05	110.8
Error	14	0.13	0.01	1.17
Total	23	7.49		
S Em±	0.05			
CD at 5 %	0.17			
CV %	8.90			

APPENDIX 22: Thrips population 10 days after 4th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.02	0.01	1.04
Treat	7	6.97	1.00	93.06
Error	14	0.15	0.01	1.24
Total	23	7.14		
S Em±	0.06			
CD at 5 %	0.18			
CV %	8.72			

APPENDIX 23: Thrips Mortality 3 days after 4th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	14.68	7.34	1.52
Treat	6	2600.74	433.46	89.84
Error	12	57.90	4.82	21.67
Total	20	2673.32		
S Em±	1.27			
CD at 5 %	3.91			
CV %	9.13			

APPENDIX 24: Thrips Mortality 7 days after 4th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	6.77	3.38	0.52
Treat	6	5563.25	927.21	141.37
Error	12	78.70	6.56	28.27
Total	20	5648.72		
S Em±	1.48			
CD at 5 %	4.56			
CV %	8.07			

APPENDIX 25: Thrips Mortality 10 days after 4th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	6.81	3.40	0.87
Treat	6	4427.14	737.86	188.08
Error	12	47.08	3.92	29.22
Total	20	4481.02		
S Em±	1.14			
CD at 5 %	3.52			
CV %	7.67			

APPENDIX 26: Thrips population 3 days after 5th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.03	0.01	1.85
Treat	7	7.375129	1.05	148.38
Error	14	0.10	0.01	1.16
Total	23	7.50		
S Em±	0.05			
CD at 5 %	0.15			
CV %	7.53			

APPENDIX 27: Thrips population 7 days after 5th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.02	0.01	1.39
Treat	7	7.94	1.13	207.85
Error	14	0.08	0.01	1.13
Total	23	8.03		
S Em±	0.04			
CD at 5 %	0.13			
CV %	6.93			

APPENDIX 28: Thrips population 10 days after 5th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.02	0.01	2.23
Treat	7	8.04	1.15	251.43
Error	14	0.06	0.00	1.16
Total	23	8.13		
S Em±	0.04			
CD at 5 %	0.12			
CV %	6.24			

APPENDIX 29: Thrips Mortality 3 days after 5th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.43	0.22	0.09
Treat	6	1651.24	275.21	126.5
Error	12	26.10	2.17	18.46
Total	20	1677.78		
S Em±	0.85			
CD at 5 %	2.62			
CV %	8.89			

APPENDIX 30: Thrips Mortality 7 days after 5th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	73.45	36.72	2.50
Treat	6	550.49	91.75	6.25
Error	12	176.25	14.69	45.87
Total	20	800.20		
S Em±	2.21			
CD at 5 %	6.82			
CV %	8.34			

APPENDIX 31: Thrips Mortality 10 days after 5th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.58	0.29	0.04
Treat	6	5497.69	916.28	120.91
Error	12	90.93	7.58	38.53
Total	20	5589.21		
S Em±	1.59			
CD at 5 %	4.90			
CV %	6.76			

APPENDIX 32: Thrips population 3 days after 6th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.011	0.01	1.13
Treat	7	8.62	1.23	243.50
Error	14	0.07	0.01	1.09
Total	23	8.70		
S Em±	0.04			
CD at 5 %	0.13			
CV %	7.08			

APPENDIX 33: Thrips population 7 days after 6th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.00	0.00	0.17
Treat	7	8.78	1.25	230.09
Error	14	0.08	0.01	1.08
Total	23	8.86		
S Em±	0.04			
CD at 5 %	0.13			
CV %	7.38			

APPENDIX 34: Thrips population 10 days after 6th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.03	0.01	1.52
Treat	7	8.53	1.22	139.60
Error	14	0.12	0.01	1.13
Total	23	8.68		
S Em±	0.05			
CD at 5 %	0.16			
CV %	8.86			

APPENDIX 35: Thrips Mortality 3 days after 6th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	26.48	13.24	1.42
Treat	6	7820.54	1303.42	139.75
Error	12	111.92	9.33	38.13
Total	20	7958.95		
S Em±	1.76			
CD at 5 %	5.43			
CV %	7.20			

APPENDIX 36: Thrips Mortality 7 days after 6th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	10.68	5.34	0.34
Treat	6	891.4474	148.57	9.38
Error	12	190.14	15.84	48.21
Total	20	1092.27		
S Em±	2.30			
CD at 5 %	7.08			
CV %	8.09			

APPENDIX 37: Thrips Mortality 10 days after 6th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	27.9	13.95	2.37
Treat	6	2307.28	384.55	65.30
Error	12	70.66	5.89	37.10
Total	20	2405.84		
S Em±	1.40			
CD at 5 %	4.32			
CV %	6.74			

APPENDIX 38: Thrips population 3 days after 7th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.01	0.00	0.49
Treat	7	9.02	1.29	196.0
Error	14	0.09	0.01	1.09
Total	23	9.12		
S Em±	0.05			
CD at 5 %	0.14			
CV %	7.98			

APPENDIX 39: Thrips population 7 days after 7th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.00	0.00	0.12
Treat	7	9.28	1.33	257.08
Error	14	0.07	0.01	1.08
Total	23	9.35		
S Em±	0.04			
CD at 5 %	0.13			
CV %	7.16			

APPENDIX 40: Thrips population 10 days after 7th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.01	0.01	1.18
Treat	7	9.34	1.34	254.96
Error	14	0.07	0.01	1.10
Total	23	9.43		
S Em±	0.04			
CD at 5 %	0.13			
CV %	7.13			

APPENDIX 41: Thrips Mortality 3 days after 7th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	12.56	6.28	1.59
Treat	6	308.96	51.49	13.06
Error	12	47.31	3.94	31.69
Total	20	368.82		
S Em±	1.15			
CD at 5 %	3.53			
CV %	6.31			

APPENDIX 42: Thrips Mortality 7 days after 7th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	8.1	4.05	0.58
Treat	6	2596.77	432.79	61.48
Error	12	84.47	7.04	46.28
Total	20	2689.33		
S Em±	1.53			
CD at 5 %	4.72			
CV %	5.47			

APPENDIX 43: Thrips Mortality 10 days after 7th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	7.26	3.63	0.34
Treat	6	608.40	101.40	9.57
Error	12	127.10	10.59	43.52
Total	20	742.77		
S Em±	1.88			
CD at 5 %	5.79			
CV %	7.51			

APPENDIX 44: Thrips population 3 days after 8th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.00	0.00	0.09
Treat	7	9.82	1.40	232.03
Error	14	0.08	0.01	1.06
Total	23	9.91		
S Em±	0.04			
CD at 5 %	0.14			
CV %	7.97			

APPENDIX 45: Thrips population 7 days after 8th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.01	0.01	1.46
Treat	7	9.78	1.40	302.20
Error	14	0.06	0.00	1.10
Total	23	9.86		
S Em±	0.04			
CD at 5 %	0.12			
CV %	6.75			

APPENDIX 46: Thrips population 10 days after 8th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	0.00	0.00	0.50
Treat	7	9.97	1.42	180.42
Error	14	0.11	0.01	1.09
Total	23	10.09		
S Em±	0.05			
CD at 5 %	0.16			
CV %	8.87			

APPENDIX 47: Thrips Mortality3 days after 8th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	35.39	17.70	1.68
Treat	6	4684.4	780.74	74.22
Error	12	126.22	10.52	41.31
Total	20	4846.03		
S Em±	1.87			
CD at 5 %	5.77			
CV %	7.45			

APPENDIX 48: Thrips Mortality 7 days after 8th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	40.52	20.26	1.072
Treat	6	332.32	55.39	2.93
Error	12	226.74	18.89	51.72
Total	20	599.59		
S Em±	2.51			
CD at 5 %	7.73			
CV %	8.33			

APPENDIX 49: Thrips Mortality10 days after 8th spray

Source of Variance	DF	SS	MSS	F cal
Rep	2	62.18	31.09	2.34
Treat	6	3152.12	525.35	39.68
Error	12	158.86	13.24	42.81
Total	20	3373.16		
S Em±	2.10			
CD at 5 %	6.47			
CV %	8.83			

APPENDIX 50: Effect of treatments on Chilli yield (Kg/ha)

Source of Variance	DF	SS	MSS	F cal
Rep	2	75.25	37.63	0.01
Treat	7	254015.63	36287.95	13.90
Error	14	36536.75	2609.77	580.78
Total	23	290627.63		
S Em±	29.49			
CD at 5 %	89.47			
CV %	8.48			

VITA

The author of this thesis **Mr. Nilesh Raghuvanshi** S/o Shri Hikmat Singh Raghuvanshi was born on 8th October 1989 at Chhindwara district in Madhya Pradesh. He completed his schooling from Govt. Multi. HSS, in Indore district, securing first division in Higher Secondary Certificate Examinations.

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