MANAGEMENT OF SUCKING PESTS OF Bt. COTTON

THESIS

Submitted to
Dr. Panjabrao Deshmukh Krishi Vidyapeeth,Akola
In partial fulfilment of the requirements
for the degree of

MASTER OF SCIENCE
IN
AGRICULTURE
(AGRICULTURAL ENTOMOLOGY)

By
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(A) DECLARATION OF STUDENT

I hereby declare that, the experimental work and its interpretation of the thesis entitled, **"MANAGEMENT OF SUCKING PESTS OF Bt. COTTON"** or part thereof has neither been submitted for any other degree or diploma of any University, nor have the data been derived from any thesis / publication of any University or scientific organization. The source of materials used and all assistance received during the course of investigation have been duly acknowledged.

Place: Nagpur (Bharkade Pooja Shriram)

Date: 18/6/19 Enrolment No – PP-3259

(B) CERTIFICATE

This is to certify that thesis entitled, **"MANAGEMENT OF SUCKING PESTS OF Bt. COTTON"**submitted in partial fulfilment of the requirement for the degree of **"Master of Science in Agriculture(Agricultural Entomology)"** of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is a record of bonafide research work carried out by **BHARKADE POOJA SHRIRAM** under my guidance and supervision.

The subject of the thesis has been approved by the Student's Advisory Committee.

Place: Nagpur
Date: 18/06/19

(Shri. N. V. Lavhe**)**
Chairman,
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Associate Dean,
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THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE INCLUDING EXTERNAL EXAMINAR (AFTER VIVA-VOCE)

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Place: Nagpur **(Bharkade pooja shriram)**
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(G) Abbreviations

%	-	per cent
/	-	per
@	-	at the rate
^{0}C	-	Degree Celsius
a.i.	-	Active Ingredient
Bt	-	*Bacillus thuringiensis*
CD	-	Critical Difference
Cfu	-	Colony forming unit
Cm	-	Centimeter
CV	-	Coefficient of Variation
DAS	-	Days After Spraying
DAT	-	Days After Treatment
EC	-	Emulsifiable concentrate
et al.	-	et alia (And others)
etc	-	Etcetera
ETL	-	Economic Threshold Level
Fig.	-	Figure
G	-	Gram
Ha	-	Hectare
i.e.	-	id est. (that is)
kg	-	Kilogram
Max.	-	Maximum
Min.	-	Minimum
Ml	-	milliliter

No.	-	Number
Ns	-	Non- significant
Plate	-	Photographs
Q	-	Quintal
q/ha	-	Quintals per hactar
RBD	-	Randomized Block Design
SC	-	Soluble Concentration
SE(m)±	-	Standard Error Mean
SG	-	Soluble Granule
Sig.	-	Significant
SL	-	Soluble (liquid) concentrate
SMW	-	Standard Metrological Week
Sr. No.	-	Serial Number
Tr.	-	Treatment
Viz.,	-	Videlicent
WAE	-	Week After Emergence
WG	-	Water dispersible granules

(H) THESIS ABSTRACT

a)	Title of the thesis	:	**MANAGEMENT OF SUCKING PESTS OF Bt. COTTON**
b)	Full name of student	:	**Bharkade pooja shriram**
c)	Name and address of Major Advisor	:	**Shri. N. V. Lavhe** Assistant Professor, Entomology Section, College of Agriculture, Nagpur.
d)	Degree to be awarded	:	M.Sc. (Agriculture)
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g)	Total number of pages in the thesis	:	137
h)	Number of words in the abstract	:	435
i)	Signature of the student	:	
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ABSTRACT

The present study entitled, “ Management of sucking pests of Bt. cotton” was undertaken incorporating eight treatments consisting of

Lecanicillium lecanii @4g/l (T_1),Neem oil @ 2 % (T_2), Neem seed kernel extract (NSKE) @ 5% (T_3), Imidacloprid 17.8SL @ 0.008% (T_4), Flonicamid 50 WG@ 0.02% (T_5), Thiamethoxam 25 WG@ 0.005% (T_6), Acetamiprid 20 SP@ 0.004 % (T_7) and control (T_8:Water spray) against sucking pests on *Bt* Cotton *i.e.* aphids, jassids, thrips, whiteflies.The average population of sucking pests on cotton was observed at 3, 7 and 10 days after each spray application. The experiment was laid out in RBD during *Kharif,*2018.

The results on the bio-efficacy of pesticides used for sucking pests of *Bt* cotton shows that the chemical pesticides caused higher per cent reduction, while biopesticides caused moderate to lower per cent reduction.Among the insecticidal treatments, Flonicamid 0.02 per cent, Acetamiprid 0.004 per cent and Imidacloprid 0.008 per cent were found more effective against aphids, jassids, thrips and whiteflies on *Bt* cotton followed by thiamethoxam 0.005 per cent. Among the biopesticides, Neem oil 2.0 per cent and NSKE 5.0 per cent were found moderate effective and *Lecanicillium lecanii* 4g/l found least effective against sucking pests of *Bt* cotton.

Effect of various insecticides on field population of natural enemies of cotton sucking pests revealed that, the treatment with biopesticides *viz,*.Neem oil 2.00 per cent, NSKE 5.0, *Lecanicillium lecanii* 4g/lwere found safer against Coccinellids, *Chrysoperla* and Spider predator after their application in the cotton field.

The treatments with chemical pesticides Flonicamid 0.02 per cent, Imidacloprid 0.008 per cent and Acetamiprid 0.004 per cent were found moderately safer against population of natural enemies.While,Thiamethoxam 0.005 per cent was found toxic against Coccinellids,*Chrysoperla* and spider predator.

The study revealed that, incidence of aphids and whiteflies initiated from 29th MWand its peak incidence was in 39thMW. Incidence

of jassidsand thrips initiated 29th MW, respectively and its peak period was in 37th MW.

The correlation analysis results revealed that, incidence of aphids was significant and positively correlated with maximum temperature (0.781**) and minimum temperature (0.614**)and highly significant and negatively correlated with morning humidity(-0.525**) and evening humidity(-0.514**). Jassids correlated significant and positively with maximum temperature (0.583**) and minimum temperature (0.710**).Thrips positive significant with maximum temperature (0.458*) and minimum temperature (750**).Whiteflies positive significant with maximum temperature (0.736**) and minimum temperature (0.596**) and highly significant negatively correlated with morning humidity (-0.497*).

Among the different treatments higher yield of cotton was recorded in plot treated with Flonicamid 0.02 per cent followed by Acetamiprid 0.004 per cent, Imidacloprid 0.008 per cent and Thiamethoxam 0.005 per cent.*Lecanicillium lecanii* 4 g/l gave the lowest yield among the different treatments.

Chapter I

INTRODUCTION

1.1 Background information

Cotton, (*Gossypium spp*.) is the leading oil seed crop and natural fibre and which plays a key role in Indian economy with global position of second in production after China and offering livelihood security for the Indian farming community. It also plays a dominant role in the industrial and agricultural economy of the nation and has a unique place in social affairs. Many allied activities like textile processing, ginning, fabric production, garment manufacture and their marketing etc. provides employment about 6 million people. It also provides 65 percent raw material to textile industry and contributed 1/3rd of total foreign exchange earning of India (Mayee and Rao, 2002).

Cotton is a perennial semi-shrub grown as an annual crop in both tropical and warm temperate regions. In addition to textile manufacturing, it produces seeds with a potential multi product base such as hulls, oil, lint and food for animals (Ozyigit*et al*. 2007).

Cotton is one of the most important cash crop and accounts for around 25 per cent of the total global fibre production. In the raw material consumption basket of the Indian textile industry,the proportion of cotton is around 59per cent.The consumption of cotton is more than 300 lakh bales(170kg each)per year. India occupies first position in the world in cotton acreage with around 105 lakh ha under cotton cultivation which around 35% of the world area. Cotton plays a major role in sustaining the livelihoods of an estimated 5.8 million farmers and 40-50 million people engaged in related activities such as cotton processing and trade (Anonymous,2017-18).

In India, cotton production during 2017-18 is expected to produce 377 lakh bales of 170 kg from 122 lakh hectares with a productivity of 524 kg lint/ha during the current year 2017-18. Gujarat,

Maharashtra and Telangana were the major cotton growing states covering around 71 per cent (86.4 lakh hectare) in area under cotton cultivation and 65 per cent (246 lakh bales) of cotton production in India. An area of around 15.44 lakh ha (Punjab -3.85, Haryana, 6.56 and Rajasthan -5.03) was sown under cotton during 2017-18 in North zone. With 16.44 per cent increase in area under cotton, the cotton production increased from 46 to 59 lakh bales with enhancement of 28 per cent as compared to last year in North Zone (Anonymous, 2017-18).

The most important parts of the cotton are the cotton seed and fiber or lint (Sarwar *et al.,* 2013). It also contributes 69.5 per cent share in country wide oil production (Awan, 1994). In India, 160 species of insect pests have been reported to attack the cotton crop right from the time of germination till the final harvesting of cotton (Agrawal, 1978)

India accounts for approximately 25 per cent of worlds total cotton area and 18 per cent of global cotton production. For Maharashtra state positive trend is observed in case of the area, production and productivity. (Kulkarni*et al*. 2017). Important insect pests are aphid, (*Aphis gossypii* Glover; Aphididae: Hemiptera) (Leclant and Degnine,1994;) green leaf hopper, (*Amrasca biguttula biguttula* Ishida; jassidae: Hemiptera) (Mathews, 1994); whitefly, (*Bemisia tabaci* Gennadius; Aleyrodidae: Hemiptera) (Butler and Hennerberry, 1994); cotton thrips, (*Thrips tabaci* Linnman, Thripidae: Thysanoptera) (Bournier,1994); red cotton bug, (*Dysdercus koenigii* Fabricius, Pyrrhocoreidae: Hemiptera); dusky cotton bug, (*Oxycarenus laetus* Kirby, Lygaeidae: hemiptera);

The sucking insect pests thrips (*Thrips tabaci* Lind),whitefly (*Bemisia tabaci* Genn) and jassid (*Amrasca biguttula*) are more injurious to the cotton which cause 40-50 percent damage in the crop (Naqvi, 1976).Whitefly causes great damage by sucking the cell sap, secreting the honey dews and transmitting the leaf curl viral disease to cotton (Ahmad *et al*. 2002). More than 10 percent of the world’s

pesticides and nearly 25 percent of world's insecticides are used in cotton farming (Khadi, 2003)

Cotton is a very delicate crop in terms of pest complex being attacked by different insect pests from germination to harvesting (Sarwar *et al.* 2013).

1.2 Importance of study

The chemical control is the one of the most rapid methods to reduce the losses caused by sucking insect pests to the cotton crop (Gogi *et al.* 2006).Entomopathogenic fungi have specific biological characteristics that influence their activity in the environment (Parker *et al.* 2003).

The other most effective method in managing cotton insect pests is chemical control, but should only be used as last report (Korejo *et al.* 2000). Pesticides are to be used judiciously in combination with proper spray technology. Economic threshold levels have been recommended to reduce pesticide loads (Bakhetia *et al.* 1996). Acetamiprid, Thiamethoxam,Imidacloprid, and Dinotefuran are new type of necotinoid insecticides which act by binding to nicotionic acetylcholine receptors and provide an excellent control as seed and foliar treatments against a broad range of commercially important sucking insect pests, such as aphids, jassids whiteflies, thrips, and others (Prasanna *et al*. 2004; Abd-Ella, 2014).

Main losses in cotton production are due to its susceptibility to about 162 species of insect pests and a number of diseases (Dhawan and Sidhu, 1986).Conservation of natural enemies through using selective pesticides has been one of the main criterions for establishing an integrated pest management program (El-Zahi, 2012).With effective control of cotton pests, yield of cotton can be increased by 200-300 kg ha-1 (Khan *et al.* 1987).

The effectiveness of imidacloprid and thiamethoxam applied separately, against sucking insects on cotton was studied by several

authors (Zidan *et al*. 2008). Flomicamide 50 WG is one such new molecule belong to the class Pyridin Carbaxamid with systemic and translaminar action in plant and has no least impact on beneficial fauna (Anonymous, 2011).

At present, synthetic insecticides have been used extensively to overcome the pest problem but indiscriminate use resulted in number of problems *viz.*, the development of insect resistance to insecticide, induced resurgence of pests and adverse effect on non-target organisms such as natural enemies of insect pests (Dodia *et al.* 2008). Plant products are one of the eco-safe tools of the IPM. Botanical pesticides have less side effects and more insect control properties. Farmers should use these ecofriendly pest management tactics.

Last few decades bollworm attack on cotton was a serious problem but, with the introduction of Bt varieties of cotton this problem has been solved to some extent and a significant change in cropping scheme in the cotton growing areas has been observed But the problem of sucking insect pests attack is remained unsolved still now(Ahsan & Altaf, 2009).

The low yield per unit area could be because of the lack of quality seed, non technical approach of farmers and the attack of insect pest's complex which cause 15-20% loss in cotton yield (Zahidullah, 1992).

The sucking pests are injurious; they cause damage by sucking the sap and transmit viral diseases. That losses about 30-40% yield and infestation also caused deterioration in lint than 10-40% losses in crop production seedling and vegetative phase (sahito *et al.*2011)

The generally used chemical pesticides to control the pest problem having heavy cost. Therefore, promotion and development of botanicals with chemical insecticides are economical method of pest management which helps to minimize the pest attack and use of excessive pesticides.

1.3 Objectives of the study

Considering research gaps, it was envisaged to carry out investigation on thrips diversity by using the molecular techniques with the following objectives:

1. To study the bio-efficacy of pesticides used for sucking pests of *Bt* Cotton.

2. To study the effects of pesticides on natural enemies.

1.4 Scope and limitation of study

There is large scope for developing eco-friendly safe and effective pest management approach because the indiscriminate use of chemical insecticides which disturbs the natural balance of pests, leading to resurgence of pests and pollution in crop ecosystem. From this point of view, botanicals have become more attractive and provide an eco-friendly alternative (Dodia *et al.* 2008).

Use of specific chemical insecticides gives help in result within definite period and results in decrease of heavy losses due to insect pest.

Botanical pesticides have less rise of developing resistance. They generally have features of strong selectivity, low toxicity to human, livestock and natural enemies. Control of insect pests with insecticides is widely used because it is highly effective and rapid one. Hence, it is an effective component for IPM of crops.

The use of chemical pesticides is widespread due to their relatively low cost. Application of insecticide provide effective reduction of insect pest, particularly when the infestation reaches up to economic threshold level or weather remained continuously cloudy, insecticide become necessary.Easy availability of chemical insecticides helps in quick management of insect pests. Therefore, management of pests becomes possible within a short period of time.

Limitations are

There is low adoption of botanical insecticides by farmers as it takes more time for management of pests. Seasonal availability of plant products indicates the need for their storage.

Chemical control is a vital component of crop protection in modern agriculture although over-reliance on insecticides has caused resistance problem, ecological problem and higher costs to the grower.

Effect of the botanical pesticides are slow and they are generally aqueous solution and are liable to be decomposed in the action of sunlight or microbes with a short half life quick degradation.Biopesticides application must coincide with the presence of susceptible stages of pest, high humidity and evening hour for effective control.

1.5Hypothesis

Bt cotton has been found successful in the management of bollworms, however, it has invited other insect pests especially sucking pests due to reduction in pesticide sprays at early stage.There is a need to monitor and take up control measures for the management sucking pests in *Bt* cotton. By utilizing botanical and chemical insecticide, we can identify which chemical or botanical is effective against sucking pests and which is superior.

Keeping this in view these studies were taken up to monitor the population of sucking pests in commercially released *Bt*cotton.

Chapter II

REVIEW OF LITERATURE

Several researchers have attempted through their research work from time to time to explore the various aspects of insect pests of cotton and its management. The literature available from India and abroad on different aspect of the present studies have been reviewed under the following heads:

2.1To study the bio-efficacy of pesticides used for sucking pests of *Bt* cotton

Mohan and Katiyar (2000) studied that, Imidacloprid was found to be the most effective insecticide in suppressing jassid population up to next spray, whereas, its continuous use invited more whitefly population.

Afzal *et al*. (2001) studied that, the insecticides *viz.,* Diafenthiuron (polo 50%SC), Thiamethoxam (actara 25%WG), Acetamiprid (diamond 20%SP), Imidacloprid (confidor 20%SL) and Thiacloprid (calypso 24% OD) at the rate of 200 ml, 24gm, 125gm, 250ml and 250ml/ acre respectively, were sprayed when population of whitefly and jassid reached to economic threshold level (ETL) *i.e.* jassid 1-1.5/ leaf and whitefly 4–5/ leaf. Imidacloprid, Diafenthiuron, Acetamiprid and Thiamethoxam proved to be the most effective insecticides against whitefly up to seven days after application. While, Imidacloprid, Diafenthiuron and Acetamiprid proved to be the most effective against jassid up to seven days after application.

Aslam *et al.*(2004) found that, the most effective insecticides for jassid, up to seven days were Confidor and Mospilan, while Advantage was ineffective to control jassid population. Most effective insecticides were Mospilan and Actara against whitefly while Mospilan, Confidor and Tamaron were highly effective against thrips.

Razaq *et al.*(2005) conducted in his study that, Diafenthiuron, Acetamiprid, Imidacloprid and Thiamethoxam proved to be the most effective in reducing jassid population below ETL (1-1.5/leaf) up to seven days after application during both the years. All the insecticides could not reduce the population of whitefly below ETL (5/leaf), seven days after application. Population of whitefly was below ETL in plots treated with acetamiprid (3.38/leaf) and diafenthiuran (2.69/leaf) seven days after application.

Kolhe *et al.* (2009) evaluated the bio-efficacy of Imidacloprid 17.8 SL (at 0.004, 0.006, 0.008 and 0.01%), Thiamethoxam 25 WG (at 0.005 and 0.01%) and Acetamiprid 20 SP (at 0.003 and 0.006%) along with recommended insecticides, Oxydemeton-Methyl 25 EC (at 0.02%), Dimethoate 30 EC (at 0.03%) and Imidacloprid 70 WS at 10 g/kg seed was evaluated against early season sucking pests (such as *Aphis gossypii, Amrasca biguttulabiguttula* and *Scirtothrips dorsalis*) of cotton. The Imidacloprid seed treatment (at 10 g/kg seed) and both concentrations of acetamiprid and thiamethoxam were the most and equally effective against the aphid. Imidacloprid, Acetamiprid and Thiamethoxam at all the concentrations recorded equal efficacy against the jassid. Imidacloprid (at 0.0040.01%) and Acetamiprid (at 0.003 and 0.006%) were the most effective against the thrips.

Boricha *et al*. (2010) revealed that, the Thiamethoxam (0.008 per cent) and Acetamiprid (0.005 per cent) were found most effective against the pest. While, the combination of biopesticides with Thiamethoxam (0.008 per cent) and Acetamiprid (0.005 per cent) were superior over biopesticides alone against the cotton thrips.

Kedar *et al*.(2010) an experiment conducted at the Research Farm, Department of Agronomy, Marathwada Agriculture University, Parbhani during Kharif 1999-2000 and 2000-2001. The plant protection with carbosultan 25 STD @ 60 g/kg as seed treatment and foliar application of dimethoate, NSKE and Endosulfan 35 EC a month after

sowing showed significantly lower incidence of sucking pests as well as bollworm complex successfully over untreated check.

Zhang *et al*.(2010) studied that, Use of Imidacloprid andThiamethoxam treated seeds canbeanimportantalternative for management of whiteflies on cotton.

Khan (2011) studied that, among insecticides, Rani 20 SL and Acetamiprid 20 SP were more effective against the sucking insect pests and in increasing seed cotton yield as compared to the other tested insecticides.

Nadeem *et al.* (2011) evaluated that, Acetamiprid was the most effective against adult population of whitefly (0.3 to 1.3/leaf post 72 h spray, as compared to control with 6.9 to 8.2/leaf) followed by Diafenthiuron and Imidaclopirid. Whereas, endosulfan was found to be the least effective on both populations as adult and nymph of whitefly. From the tested insecticides, acetamaprid gave effective control of both nymph and adult population of *B. tabaci.*

Shivanna *et al.*(2011) reported that, among the treatments one day after spraying Fenpropathrin showed superior efficacy in bringing down all the sucking pest population followed by Dimethoate, Imidacloprid and standard check Acetamiprid. Dimethoate and Imidacloprid were most effective against aphid and Dimethoate alone was most effective on leafhopper, whitefly and thrips at three days after spraying which were found to be superior over other treatments followed by Imidacloprid, Acetamiprid, Triazophos, Fenpropathrin, Eco neem and Spinosad. The similar trend was also observed even at seven days after spray.

Sreekanth and Reddy (2011) revealed in their result the most effective insecticides for aphids and leafhoppers up to seven days were Imidachloprid and Acetamaprid whereas the insecticide triazophos was ineffective in controlling aphids. Against thrips, Thiomethoxam and fipronilwere found to be most effective insecticides while Acetamaprid

Triazophos and Diafenthiuron provided better control of whitefly population.

Vinodhini and Malaikozhundan (2011) found that, In situ count of leafhopper (*Amrasca devastans*) and aphids (*Aphis gossypii*) were made prior to the pesticide application and on 1st, 3rd, and 7th day after application of pesticides. Out of the different botanicals used, neem seed kernel extract (5%) was found to be effective followed by Pongamia Glabra seed kernel extract (5%), Neem oil (3%) and Pongamia Glabra oil (3%) against the sucking pests (Leafhopper and Aphids) of cotton. Maximum population reduction was noticed on the 3rd day after treatment.

Patil *et al*. (2012) investigated that, *Verticel* @ 7.50 kg/ha registered least number of thrips, aphids and leafhoppers and found to be on par with Acetamiprid 20 SP @ 100 g/ha. At 5.00 kg/ha, it was also found effective. Significantly higher seed cotton yield of 27. 15q/ha (2008-2009) and 23.50 q/ha (2009-2010) was obtained through protection by Verticel @ 7.50 kg/ha respectively which was proved to be on par with Aetamiprid 20 SP.

Bhamare and Wadnerkar (2013) in the studies reported that,Acetamiprid 20 g a.i./ha was found to be superior for minimizing aphids, leafhoppers, thrips and whiteflies population.

Khan *et al*. (2013)conducted a study on the effect of different plant extracts (neem oil, garlic, eucalyptus and datura) on the population of jassid, *Amrasca devastans* (Dist.), whitefly, *Bemisia tabaci* (Genn.) and thrips, *Thrips tabaci* (Lind.) tested in *Bt* cotton under field conditions. All the plant products showed varying toxicity against sucking complex of Bt. cotton 24, 72, 168 and 240 hours after application. Datura proved to be the most effective bringing about significant reduction in the pest population followed by neem oil. Garlic and eucalyptus also produced significant results compared to untreated check.

Bharpoda *et al.* (2014) studied that, Imidacloprid 17.8 SL @ 0.008% (7.50 aphid and 1.47 whitefly/ leaf), Thiamethoxam 25 WG @ 0.0125% (1.22 leaf hopper/ leaf) and Diafenthiuron 50 WP @ 0.05% (1.43 thrips/ leaf) found more effective and safer to the natural enemies *viz.,Chrysoperla carnea* (adult), spiders and coccinellids (grubs and adult).

Kadam *et al.* (2014) stated that, the most effective treatments in reducing incidence of sucking pests on *Bt* cotton as compared to Acetamiprid 20 per cent SP @ 20 g a.i./ha, Imidacloprid 17.8 SL, Thiamethoxam 25 per cent WS @ 25 g a.i./ha and Thiacloprid 21.7 per cent SC @ 30 g a.i./ha.

Morita *et al*.(2014) in their research revealed that, Flonicamid shows no cross-resistance to conventional insecticides and exhibits excellent systemic and translaminar activity. It has no negative impact on beneficial insects and mites. Furthermore, it has a favorable toxicological, environmental and ecotoxicological profile. These characteristics make flonicamid well suited for resistant management strategies and integrated pest-management programs.

Gaurkhede *et al*. (2015) reveald that, after third spray the application of flonicamid 50 WG@ 0.02 per cent, dinotefuran 20 SG @ 0.008 per cent and imidacloprid 30.5 SC @ 0.005 per cent proved effective in recording minimum aphid population i.e. 1.27, 1.37 and 1.92 aphids per leaf, respectively. The treatment with Dinotefuran 20 SG @ 0.008 per cent and 0.006 per cent, fipronil 5 SC @ 0.015 per cent, Acetamiprid 20 SP @ 0.004 per cent and Flonicamid 50 WG @ 0.02 per cent successfully checked the incidence of leafhopper with in the range of0.63 to 0.9 leafhoppers/leaf at third spray. The application of fipronil 5 SC @ 0.015 per cent, Flonicamid 50 WG @ 0.02 per cent, Imidacloprid 30.5 SC @ 0.005 per cent, Dinotefuran 20 SG @ 0.008 per cent and Acetamiprid 20 SP @ 0.004 per cent effectively minimized the incidence of thrips population with in the range of 2.59 to 3.60 thrips per leaf at the end of third spray. Whereas, Acetamiprid 20 SP @

0.004 per cent proved effective in lowering down the whitefly population (0.99 whiteflies/leaf), which was closely followed by Flonicamid 50 WG @ 0.02 per cent (1.10 whiteflies/leaf), fipronil 5SC @ 0.015 per cent (1.11 whiteflies/leaf), Dinotefuran 20 SG @ 0.008 per cent (1.20 whiteflies/leaf), and Imidacloprid 30.5 SC @ 0.005 per cent (1.34 whiteflies/leaf).

Kaur *et al*. (2015)evaluated the bio-efficacy of different insecticides against cotton Whitfly (*B.tabaci*).Maximum percent reduction was observed with Trizophos 40 EC (63.22%) followed by the Acetamiprid 20% SP (55.61%) and these were statistically at par and significantly superior over rest of the treatment.

Abbas *et al.* (2016) investigated that the insecticide Ulala (Flonicamid 50 WG) @148.26 gmha-1 is best against all the sucking pest of cotton under arid condition. The yield 1963.60 kgha-1 was maximum in T3 (Ulala (Flonicamid 50 WG) @ 148.26gmha-1 that was significant to all other treatments yield

Babar *et al*. (2016) conducted a study under a field in Shujabad (Multan district) and concluded that maximum mortality of thrips was by Acephate 75SP *i.e.*86.91 per cent and 75.47 per cent after 24 and 72 hours of spray while Pirate 360 SC @ 250 ml/ha exhibited maximum percentage of mortality*i.e*. 58.18 per cent after 168 hours of insecticides application.

Sathyan *et al*. (2016) studied that, the insecticidal sprays reduced the aphid population from 20 (Flubendiamide 20 WG) to cent per cent (Diafenthiuron 50 WP, imidacloprid 17.8 SL, thiamethoxam 25 WG, triazophos 40 EC, carbosulfan 25 EC and chlorpyriphos 20 EC) over untreated check.

Sharma and Sharan (2016) in their studies revealed that, maximum reduction (56.00%) in thrips population was recorded with the treatment of Acephate 75 SP, followed by Imidacloprid 17.8 SL

(49.66%). Both the treatments were at par and significantly superior over the other treatments.

Noonari *et al*. (2016) conducted studies consecutively for two years, 2006 and 2007 for management of cotton insect pests through eco-friendly measures. Bio-pesticides Neem seed extract, Neem oil, Asafoetida (Hing) and Tobacco leaf extract were evaluated against sucking complex. The experiment regarding evaluation botanical pesticides showed that among all bio-pesticides, the highest percent reduction of thrip (67.65%) was recorded in Neem seed extract followed by Neem oil (60.00%), Tobacco (63.59%) and Hing (Asafoetida) (52.68%) after 96 h. of application.

Indirakumar *et al.* (2017) stated that,an evaluation of new molecules compatible with IPM shows the most significant treatment in controlling the leafhopper were Imidacloprid@ 60 g a.i. ha-1 which has reduced the population to about 64 per cent; Thiomethoxam @ 450 g a.i. ha-1 hreduced the whiteflies to 75% and Acetamaprid45 g a.i. ha-1 reduced the aphids to 89 per cent.

Kalyan *et al.*(2017) observed that,seven days after spray, the maximum per cent reduction in jassids and whitefly population with a mean of 77.80; 79.13 and 81.71; 83.27 was recorded in Difenthiuron 50 WP during both the years, respectively and it was statistically at par with Flonicamid 50 WP@ 100g a.i. and Fipronil 5 EC @ 100g a.i.ha-1. Among biopesicides, NSKE 5 per cent gave comparatively higher per cent reduction in population of jassids and whiteflies in compare to entomopathogenic fungals.

Mahale *et al.*(2017) an experiment conducted on stem application of Acephate at 3,7 and 14 days after insecticide application and on the basis of overall efficacy proved most effective against aphids (4.18), jassid (1.48/leaf), thrips (2.63/leaf) and whitefly (2.63/leaf).

Naik *et al.* (2017) found that, Flonicamid 50 WG and Acephate 75 SP were the most effective treatments which were significantly superior to all the other treatments was 2.19 Jassid nymphs/ 3 leaves/ plant and 2.59 nymphs/ 3 leaves/ plant respectively. The lowest whitefly population was recorded in the flonicamid 50 WG (0.42 whitefly/ 3 leaves/ plant), Verticillium lecanii (0.50 whitefly/ 3 leaves/ plant) and Spiromesifen (0.64 whitefly/ 3 leaves/ plant) as compared to other treatments. Further, these insecticides were found to be eco friendly and safe to the natural enemies.

Nemade *et al.* (2017) revealed that, newer molecule flonicamid 50% WG @ 100 g a.i./ha was found promising to managed the major sucking pests of Bt cotton followed by Flonicamid 50% WG @ 75 g a.i./ha, Buprofezin 25% SC @ 250 g a.i./ha and Diafenthiuron 50% WP 300 g a.i./ha. Highest seed cotton yield (1681.02 Kg/ha.) was obtained from Flonicamid 50% WG @ 75 g a.i./ha followed by Flonicamid 50% WG @ 100 g a.i./ha (1627.31 Kg/ha.).

Sharma and Summarwar (2017a) evaluated that, bio-efficacy of some newer insecticides *viz.,* Acephate 75% SP, Thiomethoxam 25% WG, Acetamiprid 20% SP, Diafenthiuron 50% SP, Calypso 24% OD, Sulfoxaflor 24% SC, Triazophos 40% EC, Imidacloprid 17.8% SL and Pyriproxyfen 10% EC at field recommended doses against jassid on Bt cotton. These insecticides were sprayed when population of jassid reached to Economic Threshold Level (ETL) *i.e*. jassid 1-1.5/ leaf. The population of jassid was recorded 24 hours before and after 1, 3, 5 and 10 days of treatment and percent reduction in population was calculated. Among these insecticides, Acephate75 SP% was found most effective with 76.10 per cent reduction in jassid population.

Sharma and summawar (2017b) found that, maximum reduction in jassid population was offered by NSKE 5% (37.61%) and was superior to rest of the treatments. The treatment of Neem oil +liquid soap (30.22%) and pest guard 5% (25.40%) ranked second in order of efficacy to reduce jassid population and were at par to each other. The

treatment of Fusarium SP (18.20%), *Verticillium lecanii* (17.46%), Buprofenzin I.G.R. (17.01%) and *Beauveria bassiana* (14.84%) proved to be least effective in reducing the jassid population.

Surwase *et al*.(2017) studied that, the bio-efficacy of newer insecticides against major sucking pest's insecticides Diafenthiuron 50% WG @ 300 g.a.i/ha reducing aphid population.

Meghana *et al*.(2018)revealed that, the treatment flonicamid 50 WG was observed as significantly superior insecticide in minimizing the sucking pestspopulation followed by Fipronil 5 SC, Acetamiprid 20 SP, Dinotefuron 20 SG, Diafenthiuron 50 WP and Thiamethoxam 25 WG.

Patil *et al.*(2018) carried out field experiment on the bioefficacy of new chemistry of molecule against sucking pest complex in *Bt* cotton at Agricultural Research Station, Dharwad farm during 2014-15 and 2015-16, season under rain fed situation.The bio-efficacy of Flonicamide 50% WG was evaluated in comparison with standard checks viz., Dinetofuran 20 SG, Thiamethoxam 25% WG and Fipronil 5 SC. Among the treatments, Flonicamide 50% WG was found to be most effective by recording the lowest population of sucking pest *viz.,* thrips, aphids and leaf hoppers. Among the test chemicals, Flonicamide 50% WG registered higher seed cotton yield of 20.75 and 26.95 q/ha and B.C ratio (1:2.65 and 1:2.77) during the consecutive years.

2.2 To study the effects of pesticides on natural enemies

Kaethner (1999) reported that, neem seed extract and neem oil was harmless to the egg and larvae of *Chrysoperlacarnea* Steph and *Coccinella septumpunctata* Thumb*.*

Rosaih (2001a) reported that, natural enemies like syrphids and spiders survive in all botanicals treatments and were almost equal to untreated control (1.87 spiders and 2.70syrphids/plant) as compared to monocrotophos (0.41 spiders and 1.66 syrphids/5 plants).

Rosaih (2001b) reported that, increased activity of natural enemies in plot treated with botanicals insecticides

Vadodaria *et al.* (2001) reported that, Imidacloprid 70 WS at rate of 10 g/kg of seed treatment recorded aphids and jassids below the economic threshold level, *i.e.* up to 35 days for aphids and 50 days for jassids. The other two doses of imidacloprid 70 WS (5 and 7.5 g/kg) were at par with 10 g/kg treatments. It also enhanced the growth of cotton plants and is applicable for integrated pest management as it encourages natural enemy population on cotton.

Mathirajan and Regupathy (2002) assessed the impact of thiamethoxam (0.2, 0.4 and 0.8 g /l), imidacloprid (0.2 ml/l) and methyl-o-demeton (1ml/l) on the predator*C. carnea*, under laboratory condition and revealed that thiamethoxam at 0.8 g/l recorded the highest egg mortality and proved to most toxic insecticide. Emergence of adults was reduced in methyl-o-demeton, imidacloprid and all 3concentrations of thiamethoxam.

Chalam *et al.* (2003) determined the susceptibility of A. gossypii infesting cotton to newer (Diafenthiuron, Imidacloprid, Acetamiprid, Thiamethoxam and Carbosulfan) and traditional pesticides alongside this, the toxicity of the new insecticides aphid was determined among the new insecticides; Acetamiprid recorded the highest toxicity followed by Diafenthiuron and Thiamethoxam.

Varghese (2003) noticed that, various organic and botanicals were quite safe to coccinellids and predatory mites which was found comparable to untreated plots.

Men *et al.* (2004) determined that, Pesticide applications decreased numbers of aphids, acarids and predatory spiders significantly on both transgenic and nontransgenic cotton.

Ameta and Sharma (2005) evaluated the bio-efficacy and toxicity of confidor 350 SC (60 and 75 ml/ha) and confidor 200 SL (100 and 125 ml/ha), against *Aphis gossypii, Amrasca biguttula biguttula*, the results revealed after two sprays. the application of 75 ml confidor 350 SC/ha at 15 days interval gave the highest reduction of population of *Aphis gossypii,Amrasca biguttula biguttula* and *Thrips tabaci* which was at par with 125 ml confidor 200 SL/ha. both confidor 350 SC and 200 SL did not cause any adverse effect on the grubs and adults of *Chrysoperla carnea* and *Coccinella spp.* the highest cotton yield was recorded with 2 sprays of 75 ml confidor 350 SC/ha. Which was followed by confidor 200 SL at 125 ml/ha.

Anitha (2007) studied the effect of botanicals and mycopathogens against *coccinellid* and *chrysoperla* predator of okra sucking pests and revealed that the treatment Neem oil 2 per cent, NSKE 5 per cent, azadirachtin and *V.lecanii* were found safer against population of coccinellid and *chrysoperla* because predatory population in all these treatments was found at par with control.

Gangadhar *et al*. (2007) evaluated the effects of imidacloprid and Pseudomonas fluorescens alone and in combinations for the management of leafhoppers (*Amrasca biguttula biguttula*), whiteflies (*Bemisia tabaci*) and thrips (*Thrips tabaci*) and their effects on natural enemies in cotton cv. H-1098. Results showed that cotton treated with imidacloprid +P. fluorescens was statistically superior compared to the other treatments,resulting in 22.5-33.3, 35-45.9 and 30.9-49.4% reduction in the nymphal, adult and nymphal and adult leafhopper, whitefly and thrips populations, respectively. This combination had no adverse effects on natural enemies of these pests.

Sharma *et al*. (2008) evaluated different chemical insecticides and some management practices, *i.e.* nimbecidine 0.03 EC, a neem [*Azadirachta indica*] formulation at 2.5 l/ha and intercropping cotton with sesame, on parasitodiation of cotton whitefly, B. tabaci, by *Encarsia lutea* and cotton aphid, *Aphis gossypii,* by *Aphidius*

*colemani*was studied on cotton during 2001-04 in Haryana. Observations on toxicity of endosulfan (0.07%), chlorphyrifos (0.05%), quinalphos (0.05%), profenofos (0.05%), thiodicarb (0.1%), carbaryl (0.1%), fenvalerate (0.006%), deltamethrin (0.0028%), cypermethrin (0.006%) and fipronil (0.05%) to *E. lutea* were recorded indicated that all the insecticides were toxic to this parasitoid. chlorpyrifos showed the highest toxicity, while fipronil and endosulfan were relatively less toxic. Among the chemical insecticides, deltamethrin (0.0028%), fenvalerate (0.006%), cypermethrin (0.006%) and endosulfan (0.07%) were evaluated. endosulfan against *E. lutea* and fenvalerate against *Aphidius colemani* were found relatively less toxic. Among the different management practices tested, treatment nimbecidine 0.03 EC sprays at 2.5 l/ha and intercropping of cotton with sesame recorded the highest parasitoidation (34.5%), while the insecticides, particularly the synthetic pyrethroids, had the greatest adverse effect on the whitefly and aphid parasitoids.

Fonseca *et al.* (2008) studied on selectivity of the most commonly used insecticides for controlling *Aphis gossypii* and on natural enemies occurring on cotton (*Gossypium hirsutum*).Treatments were acetamiprid 200 PS, carbosulfan 400 CE, diafenthiuron 500 PM, thiamethoxam 250 WG, imidacloprid 200 SC, and parathion-methyl 600 CE. The natural enemies of cotton pests were sampled with modified pit fall traps. The natural enemies mainly consisted of species under family Caraneidae (31%), Formicidae (29%), and Tachinidae (16%). Acetamiprid 200 PS was not selective to Formicidae, but was selective to Acaraneidae and Tachinidae. On the first day Thiamethoxam 250 WG had the greatest effect on formicidae and Tachinidae, when mortality rates of 100 per cent and 56 per cent , respectively, were recorded, but this insecticide was selective to Arachnidae. Imidacloprid 200 SC was not selective to ants and Tachinidae, but was selective to spiders. Carbosulfan 400 CE was selective to spiders. Parathion-methyl 600 EC only preserved the populations of Arachnidae.

Prabhaker *et al.* (2011) studied that, two systemic neonicotinoids, imidacloprid and thiamethoxam, are widely used for residual control of several insectpests in cotton. Evaluated their impact on six species of beneficial arthropods, including four parasitoidspecies. In laboratory results contradict suggestions of little impact of these systemic neonicotinoids on parasitoids or predators but field studies will be needed to better quantify the levels of such impacts under natural condition.

Aggarwal (2012) recorded significantly higher (76.66%) hatching of eggs of *C.sexmaculata* in buprofezin treated plots followed by endosulfan(73.33%),imidacloprid(70.00%) and chlorpyriphos (63.33%). The emergence of adults from the treated pupae was highest in buprofezin (83.33%), endosulfan (76.67%) and profenophos (53.33%). Buprofezin was found to be the safest insecticide followed by endosulfan to all the stages of *C. sexmaculata* from egg to adult stages, when used for the management of cotton mealy bug, Phenacoccus solenapsis (Tinsley).

Awasthi *et al*. (2013) conducted an experiment in the laboratory to evaluate toxicity of six insecticides, *viz.,*spinosad 45 SC, indoxacarb 15.8EC,emamectin benzoate 5 SG, acephate 75 SP,imidaclopride 17.8 SL against cotton aphid *Aphis gossypii* Glover and different stages of predatory coccinellids.On the basis of LC_{50}values, acetamiprid was the most toxic whereas; spinosad was the least toxic insecticides to cotton aphid. On the basis of LC_{50}values, spinosad was the safest insecticides for the different stages of the predatory coccinellids and acetamiprid was the most toxic followed by imidacloprid, indoxacarb, emamectin benzoate and acephate.

Hossain *et al.* (2013) reported that, Imidacloprid insecticides, Gaucho 70WS at 1.5, 2.5,3.5, 4.5 and 5.5 g/kg seed was used as seed treatment and monoctotophos40 WSC at 1120 ml/ha was applied as foliar spray on CB9 cotton cultivar. The activity of natural enemies, such as ladybird beetle, lacewing, syrphid, and spider population on

the sucking pests attacking cotton cultivar CB9 and yield of cotton were recorded. Ladybird beetles, lacewings, syrphids and spiders were abundant in the field but their population decreased in the treated plots compared to untreated control.

Adnan *et al.* (2014) conducted an experiment in laboratory , to manage the mango hopper, *Idioscopusclypealis L,* using three chemical insecticides , Imidacloprid(0.3%), Endosulfan (0.5%), and cypermethrin (0.4%) and natural neem oil (3%) with three replications of each. Natural enemies were also higher after 1st and 2nd spray in case of Neem oil.

Saner *et al.* (2014) examined that, different insecticides treatments lambda cyhalothrin5SC (0.96 ladybird beetles/plant) and imidacloprid17.8SL(0.92ladybird beetles/plant) were found ecofriendly.

Bharani *et al.* (2015) observed that,coccinellids bio pesticide treatments *Beauveria bassiana, Verticillium lecani* (3.26 and 3.12 coccinellids plant-5 respectively) were found safer following insecticides Imidacloprid 30.5 SC and Thiomithoxam 25 WG (2.64, 2.79 coccinellids plant-5 respectively) showed lower toxic compared to control treatment (3.53 coccinellids plant-5) in tomato ecosystem.

Gaber *et al*. (2015) found that,the selectivity effects of acetamiprid, imidacloprid, pirimicarb and malathion reduced the population of *C. undecimpunctata* with an average ranged from 78.05 to 96.43% and were classified as harmful. Thiamethoxam reduced the population with an average ranged from 68.72 to 69.20% and was classified as moderately harmful. Dinotefuran showed a slightly harmful effect to C. undecimpunctata with an average reduction 44.3 and 41.81% during 2013 and 2014 seasons. On the other hand, acetamiprid and dinotefuran caused a significant reduction in the population of *C. carnea* with an average ranged from 28.28 to 56.52% and were classified as harmless. Thiamethoxam and imidacloprid reduced the population with an average ranged from 55.53 and 64.39% and were classified as moderately harmful.

Singh *et al.* (2016)studied that, there are several groups of novel insecticides like bacterial fermentation products, diamides, neonicotinoides, phenyl pyrazoles, pyridine azomethines and tetronic and tetramic acid derivatives etc. which could be used in a compatible manner with the biocontrol agents under the IPM programmes. Their use has been documented to be safer to many natural enemies.

Anamika Kar (2017) stated that, two insecticides did not affect spider population but the coccinellid population was reduced with increase of doses of imidacloprid. Imidacloprid @ 175 and 150 ml/ha were found more toxic than thiamethoxam @ 200 g/ha and imidacloprid @ 125 ml/ha. This result revealed that imidacloprid had more adverse effect on coccinellids than thiamethoxam.

Nikam *et al.* (2017) reported that, Flonicamide 50% dinotefuran 20 SG, fipronil acetamipride imidacloprid 17.8 SL. these insecticide interventions found to be safe to the natural enemy activity as there was no significant variation among the treatments with respect to the natural enemies population (lady phid maggots). Hence, these insecticides can safely be includ sucking pests, which are increasing in trend.

Talha *et al.*(2017) studied that, all insecticides formulation tested exhibited ≥50% reduction in the population of green lacewing. Similarly,whitefly parasitism recorded in the confidor and jozer plots was very close to that of control plots for both post-treatment observations. Based on these findings, confidor and Jozer are recommended to the considered for their integration in sucking pest management strategies on transgenic crops such as *Bt* cotton.

Variya *et al.*(2018) examined that, the differences in population of all predators (Coccinellids,Chrysoperla and spider) was significantly lower in all the insecticidal treatment than control. However, the treatment, Neemazal F 5 WSC (4.9 nos/plant), and Acetamiprid 20 SP(4.8nos./plant),Buprofenzin 25 SC (4.8 nos./plant) had found somewhat safer for predators and recorded comparatively higher

population of predators than rest of the treatments at 7days after first, second and third spray.

Chapter III

MATERIAL AND METHODS

The present investigation entitled, “Management of sucking pests of Bt.Cotton” was planned to carry out the studies on the effect of different botanicals, biopesticides and chemical insecticides against the major insect pests on cotton under field condition at Entomology Reasearch Field, College of Agriculture, Nagpur, Maharashtra, India during *Kharif* 2018.Details of materials used and the methodology followed during the course of investigation are given below.

3.1 Material required

For conducting these studies land, cotton seed (RCH659), plant products, agricultural implements, manures and fertilizers, knapsack sprayer, measuring tape, rope, pegs, tags, bullock pair, labours, polythene bags, weighing balance botanical products (Neem oil, Neem seed extract) and chemical insecticides were utilized during conducting experiment and all these material were made available by Agricultural Entomology Section, College of Agriculture, Nagpur.

3.2 Details of experiment

1. Name	:	Cotton (*Gossypium hirsutum*)
2. Family	:	Malvaceae
3. Variety	:	Rashi BG-II
4. Experimental Design	:	Randomised Block Design
5. No. of Replications	:	03
6. No. of Treatments	:	08
7. Total plots	:	24

8. Plot size

a) Gross : 4.5X 3.0m = 13.5m^2

b) Net : 3.60 X 2.40m = 8.40m^2

9. Spacing

a) Row to Row : 90cm

b) Plant to Plant : 60cm

10. Inter Replication Spacing : 1.5 m

11. Inter Plot Spacing : 1.0 m

12. Row per plot : 05

13. Plant per row : 06

14. Total no. of plant/plot : 30

15. Method of sowing : Dibbling

16. Fertilizer dose : 100:50:50 NPK kg/ha

17. Irrigation : As per requirement

3.2.1 Treatment details

Table.1 Treatment details

Tr.No.	Treatment	Dose
T1	*Lecanicillium lecanii*(1x10^8cfu/g)	4g/l
T2	Neem Oil 2 %	20ml/l
T3	Neem Seed kernel Exract (NSKE5%)	50ml/l
T4	Imidacloprid 17.8SL	0.008%
T5	Flonicamid 50WG	0.02%
T6	Thiamethoxam 25WG	0.005%
T7	Acetamiprid 20SP	0.004%
T8	Control(water spray)	-

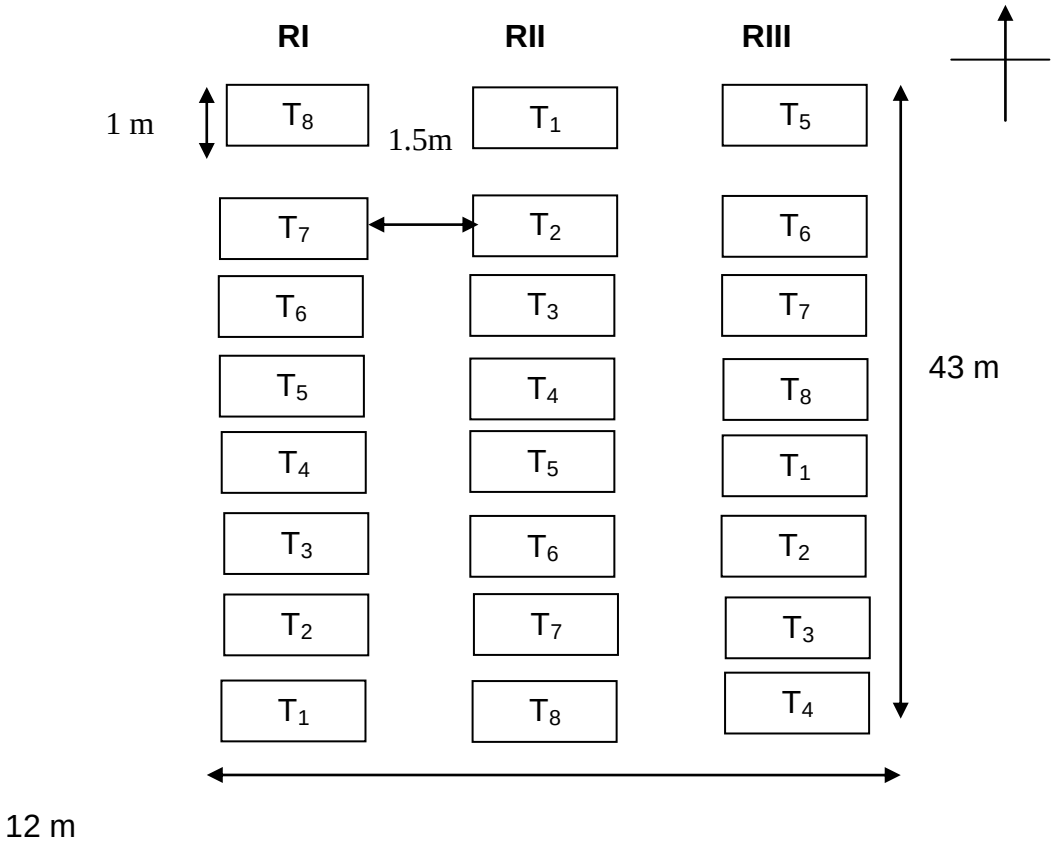

Fig. 1: Plan of Layout

T_1	*Lecanicillium lecanii*	@*4g*/l
T_2	Neem Oil	@2%
T_3	Neem Seed kernel Exract	@5%
T_4	Imidacloprid 17.8SL	@0.008%
T_5	Flonicamid 50WG	@0.02%
T_6	Thiamethoxam 25WG	@0.005%
T_7	Acetamiprid 20SP	@0.004%
T_8	Control (water spray)	

Table.2 Information of insecticides used in the experiment

SN.	Common Name	Formulation	Trade name	Chemical name	Source of supply
1	*Lecanicillium lecanii*	($1x10^8$cfu/g)	-	Microbial insecticides	Plant pathology section. college of Agriculture,Nagpur
2	Neem oil	2%	-	Azadirachtin	Locally procured
3	Neem seed Kernel extract	5%	-	Azadirachtin	Locally procured
4	Imidacloprid	17.8SL	Confidor	1-(6-chloro-3 pyridinyl methyl)N-Nitro-2-Imidazolinime	M/S Bayer crop sciences Ltd.Mumbai
5	Flonicamid	50WG	Ulala	N-cyanomethyl-4-trifluromethyl nicotinamino	M/S united phosphorus Ltd., Gujrat
6	Thiamethoxm	25WG	Evident	3-tetrahydro-5-methyl-N-nitro-4H-1,3,5-oxadiazin-4-imine	Chemt Chemicals Pvt. Ltd.,Mumbai
7	Acetamiprid	20SP	Pride	N[C-6-Cloro 3-pyridymethyl N_2cyano-N-methyl	M/S Dow Agro Science India Pvt.Ltd.Mumbai

Plate 1: General view of the experimental plot

3.3. Cultural operations

3.3.1 Land preparation

The field was prepared during summer by ploughing and two harrowing. Later the field was cleaned by picking the stubbles of previous crop. Well decomposed farm yard manure was added to the soil and thoroughly mixed by giving repeated harrowing. Before sowing, the layout was made in the field in accordance with experimental design with the help of measuring tape, nylon string and wooden pegs.

3.3.2 Sowing

The sowing was done on 2 July 2018.seed was sown by hand method, two or three seeds are dibbed at each hill.

3.3.3 Gap filling

Gap filling was done immediately after emergence for maintaining uniform plant population.

3.3.4 Thinning

Thinning was done when the crop was at 15 days old so as to s proper plant population per plot.

3.3.5 Application of fertilizers

The fertilizers were applied 100:50:50NPK kg/ha and half dose of nitrogen and full dose of phosphorus and potash were applied at the time of sowing and remaining half dose of nitrogen was applied one month after the basal dose.

3.4 Preparation of spray formulation

The insecticidal spray solution of desired concentration was freshly prepared every time at the site of experiment just before the start of spraying operation. The quantity of spray material required for coverage of crop will be gradually increased as the crop growth advances.

The spray solution of a desired concentration was prepared by adopting the following formula

$$V = \frac{C \times A}{\% \text{ of a. i.}}$$

Where,

V = Volume/Weight of commercial insecticide (ml or g)

C = Concentration required

A = Quantity of spray solution required in ml

% of a.i. = Percentage of active ingredient in commercial product

3.5 Time and method of application

The first treatment spray was given at ETL after the emergence of crop. Each spray was repeated at an interval of 15 days. Total 3 sprays were given with knapsack sprayer. Required quantity of spray solution of each treatment was prepared to desired concentration and plant in each plot was be sprayed thoroughly with knapsack sprayer. In all, three applications of treatments were undertaken at fortnightly (15days) interval.

3.5.1 Spray Details

Sr No.	Number of application	Date of application
1	First application	21-08-2018
2	Second application	06-09-2018
3	Third application	22-09-2018

3.6 Neem seed kernel extracts preparation:

50 grams of neem seeds were be shade dried, crushed and then soaked overnight in double the quantity of water. Later, the mixture was squeezed through the muslin cloth and the volume was

made upto one liter so as to obtain 5 per cent solution and 2g/l of soap powder.

3.7 Method of recording observation

From each plot, five plants were randomly selected. Selected plants were tagged. From each selected plants three leaves from upper, middle and bottom was selected at random and tagged for recording observations. Thus observations on population of sucking pests were recorded from 3 leaves of randomly selected five plants from plot.

Pre-treatment observations were recorded 24hrs before treatment. Post treatment observations were recorded on 3^{rd}, $7^{th}$and 10^{th} days after each spraying. Simultaneously the population of natural enemies was recorded on3^{rd}, 7^{th} and 10^{th} days after each spraying in experimental plot. For recording seasonal incidence of major insect pests on cotton a separate plot of 10×10 m^2 area was sown and observation was recorded.

3.8 Calculation for efficacy of treatments

The percentage reduction of the populations in each count was be calculated by using modified Abbott's Formula as given by Richard Flemming & Arthur Ratnakaran

$$\%\text{Population reduction} = 1 - \left(\frac{\text{Post treatment population In the treatment}}{\text{Pre-treatment population The treatment}} \times \frac{\text{Pre-treatment population in the untreated check}}{\text{Post treatment in the untreated check}} \right) 100$$

3.8.1 Statistical analysis

The data recorded so obtained on the pests, natural enemies and yield was subjected to statistical analysis after suitable transformation as per stastistical guidelines by Gomez and Gomez, 1984).

3.9 Meteorological data

The meteorological data such as maximum and minimum temperature, relative humidity and rainfall during the course of experimentation is given in appendix.

Chapter IV

RESULTS AND DISCUSSION

The present study entitled, “Management of sucking pests of Bt. Cotton.” was conducted at Insectary Farm of Entomology Section, College of Agriculture, Nagpur during *Kharif* 2018-2019. The result obtained during the course of these investigations is described under following headings.

1. To study the bio-efficacy of pesticides used for sucking pests of *Bt* cotton
2. To study the effects of pesticides on natural enemies.

4.1 To study the bio-efficacy of pesticides used for sucking pests of*Bt* Cotton

4.1.1 Efficacy of different treatments on per cent reduction of aphids at 3, 7 and 10 days after first spray.

The data presentedin Table 3 and fig. 2 revealed that significant difference in per cent reduction of aphid was found due to insecticidal treatments after 3, 7 and 10 days of their application. All the treatments were significantly superior over control ($T_{8:}$ Waters pray) in per cent reduction of aphid.

AT 3 DAS

Three days after first spray Flonicamid 50 WG recorded maximum per cent reduction (T_5:74.00%),which was significantly superior over rest of the treatments and it was statistically at par with Acetamiprid 20SP (T_7: 72.33%) and both the treatments were proved to be the most effective, resulted in significant reduction in aphid population as compared to all other treatments.

Imidacloprid 17.8 SL and Thiamethoxam 25WG was in the second group of effective treatments which caused 64.00, 62.00 per

cent reduction of aphid, respectively on the third days after the first spray application.

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent(T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp.*(10^8cfu/g) (T_1) Which caused 45.00, 42.35 and 37.33 per cent reduction of population of aphid and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of aphid population was observed in control (T_8:13.66%).

AT 7 DAS

Similar types of results were obtained at 7^{th} and 10^{th} days after first spraying. All the treatments were significantly superior over control (T_8: Water spray) in per cent reduction of aphid.

Seven days after treatment Flonicamid 50 WG recorded maximum per cent reduction (T_5:71.96%), which was significantly superior over restof the treatments and it was statistically at par with Acetamiprid 20SP(T_7:68.33%).

Imidacloprid 17.8 SL and Thiamethoxam 25 WG was in the second group of effective treatments which caused 62.44, 59.58 per cent reduction of aphid, respectively on the seven days after the spray application.

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp*.(10^8cfu/g)(T_1) Which caused 42.38, 39.47 and 35.60 per cent reduction of population of aphid and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of aphid population was observed in control (T_8:13.15%).

Table 3 : Efficacy of different treatments on per cent reduction of aphids at 3,7 and 10 days after three spraying

Tr.No.	Treatment	Dose	Per cent reduction in population of aphid								
			First spray			Second spray			Third spray		
			3 DAS	7DAS	10DAS	3 DAS	7 DAS	10DAS	3DAS	7DAS	10DAS
T1	*Lecanicillium lecanii* ($1x10^8$cfu/g)	4g/l	37.33 (37.60)	35.65 (36.57)	32.90 (34.93)	34.36 (35.80)	31.91 (34.30)	29.87 (33.06)	33.78 (35.68)	31.72 (34.18)	28.37 (32.02)
T2	Neem oil 2 %	20ml	45.00 (42.08)	42.38 (40.54)	41.07 (39.79)	43.19 (41.06)	40.95 (39.76)	40.20 (39.32)	42.05 (40.40)	38.87 (38.56)	39.14 (38.71)
T3	Neem Seed Kernel Extract 5 %	50ml	42.35 (40.49)	39.47 (38.84)	38.50 (38.24)	39.63 (38.87)	38.33 (38.15)	36.33 (36.74)	39.14 (38.67)	36.21 (37.36)	35.64 (36.54)
T4	Imidacloprid17.8SL	0.008%	64.00 (53.15)	62.44 (52.21)	58.57 (49.98)	62.40 (52.55)	56.48 (48.74)	53.50 (47.01)	60.41 (51.01)	50.40 (45.60)	52.28 (46.30)
T5	Flonicamid50WG	0.02%	74.00 (59.77)	71.96 (58.42)	64.71 (53.69)	71.66 (57.96)	68.10 (55.66)	62.66 (52.37)	71.65 (57.97)	64.10 (54.08)	60.75 (51.40)
T6	Thiamethoxam 25WG	0.005%	62.00 (52.12)	59.58 (50.58)	54.21 (47.51)	59.66 (50.69)	52.00 (46.14)	49.14 (44.50)	55.88 (48.36)	49.78 (44.86)	47.86 (43.76)
T7	Acetamiprid 20SP	0.004%	72.33 (58.44)	68.33 (55.92)	60.83 (51.27)	70.66 (57.61)	65.66 (54.52)	60.83 (51.24)	67.66 (55.84)	61.51 (51.90)	58.88 (50.44)
T8	Control(water spray)		13.66 (21.52)	13.15 (21.10)	12.99 (21.03)	13.17 (21.22)	12.68 (20.77)	12.56 (20.61)	13.33 (21.32)	13.21 (21.22)	13.02 (21.08)
	F test		Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
	SE(m)±		3.02	3.11	2.99	3.89	2.91	2.80	2.53	2.91	3.27
	CD at 5%		9.17	9.45	9.09	11.81	8.83	8.50	7.68	8.84	9.92

(Figures in parentheses are corresponding values of arc sin transformation)

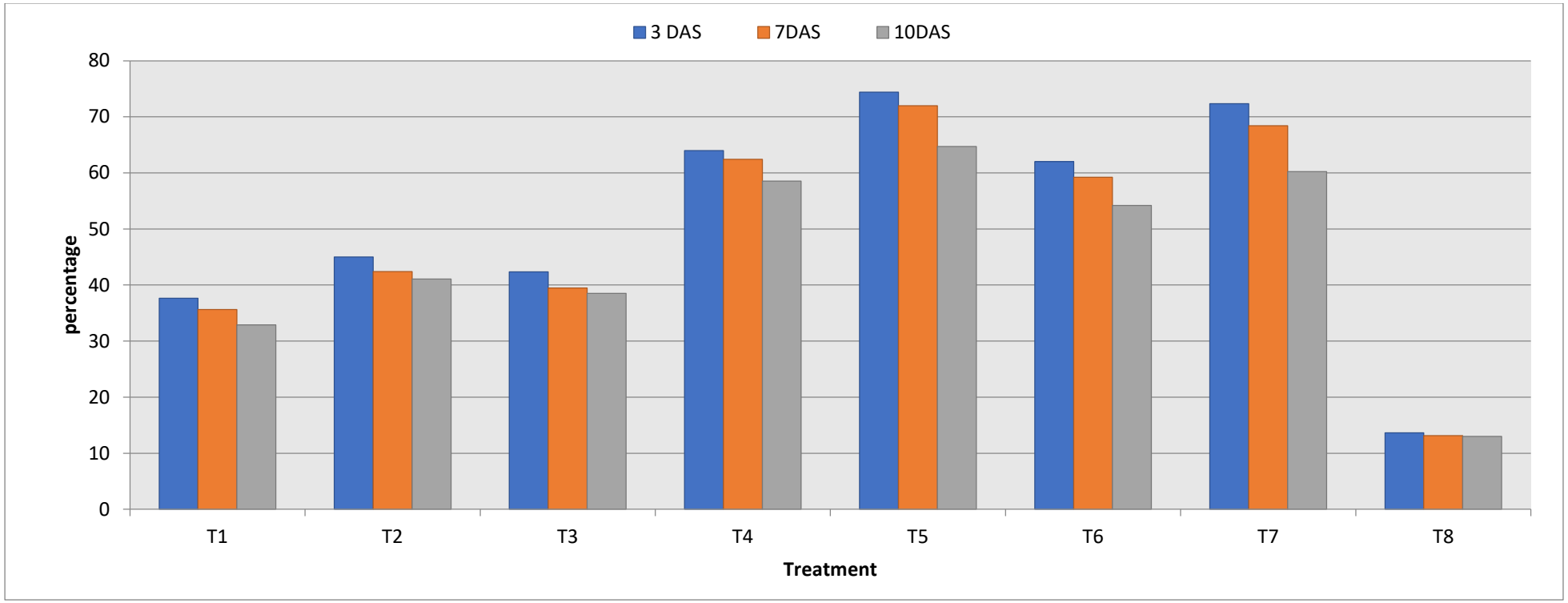

Fig : 2 Efficacy of different treatment on per cent reduction of aphid at 3,7 and 10 days after first spray

AT 10 DAS

Similar type of results were obtained on 10days after first spraying where all the treatments were significantly superior over control ($T_{8:}$ Water spray) in per cent reduction of aphid.

The treatment Flonicamid 50WG(T_5:64.71%) recorded maximum per cent reduction followed by Acetamiprid 20SP(T_7:60.83%) and both treatments were proved to be the most effective, resulted in significant reduction in population of aphid as compared to other insecticides.

Imidacloprid 17.8 SL and Thiamethoxam 25 WG was in the second group of effective treatment which caused 58.57, 54.21 per cent reduction of aphid, respectively on the ten days after the spray application.

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp*.(10^8cfu/g)(T_1) Which caused 41.07, 38.50 and 32.90 per cent reduction of population of aphid and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of aphid population was observed in control (T_8:12.99%).

The present findings are in agreement with the reports of Ghelani*etal*. (2014) who recorded the effectiveness of Flonicamid (0.02%) in controlling the aphid population in *Bt* cotton.

Chandi *et al.* (2016) found that flonicamide @ 75 g a.i./ha is effective for control of aphids in cotton.These findings are more or less coparable with the present findings.

4.1.2 Efficacy of different treatments on per cent reduction of aphids at 3,7and 10 days after second spray:

The results showed significant differences in the mean percentage reduction of aphid after was 3,7 and 10 days of their second spray application. It was evident from the Table.3 and fig.3 that all the treatments were significantly superior over control ($T_{8:}$Water spray) in per cent reduction of aphid.

AT 3 DAS

Three days after second spray Flonicamid 50 WG(T_5:71.66%) recorded maximum per cent reduction,which was significantly superior over rest of the treatments and it was statistically at par with Acetamiprid 20SP (T_7:70.66%) and both treatments were proved to be the most effective, resulted in significant reduction in aphid population as compared to other insecticides.

The next better treatments was Imidacloprid 17.8 SL (T_4) recorded 62.40 per cent reduction of aphid population and it was found at per with treatment of Thiamethoxam 25 WG (T_6:59.66%).

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp*.(10^8cfu/g) (T_1) Which caused 43.19,39.63 and 34.36 per cent reduction of population of aphid and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of aphid population was observed in control (T_8:13.17%)

AT 7 DAS

Similar type of results was obtained at 7^{th} and 10^{th} days after second spraying.All the treatments were significantly superior over control (T_8: Water spray) in per cent reduction of aphid.

Seven days after treatment Flonicamid 50 WG (T_5:68.10%) ranked first among all the treatments.The next best insecticides were Acetamiprid 20SP(T_7:65.66%),Imidacloprid 17.8SL(T_4:56.48%) and Thiamethoxam 25 WG(T_6:52.00%).

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp.*(10^8cfu/g) (T_1) Which caused 40.95, 38.33 and per

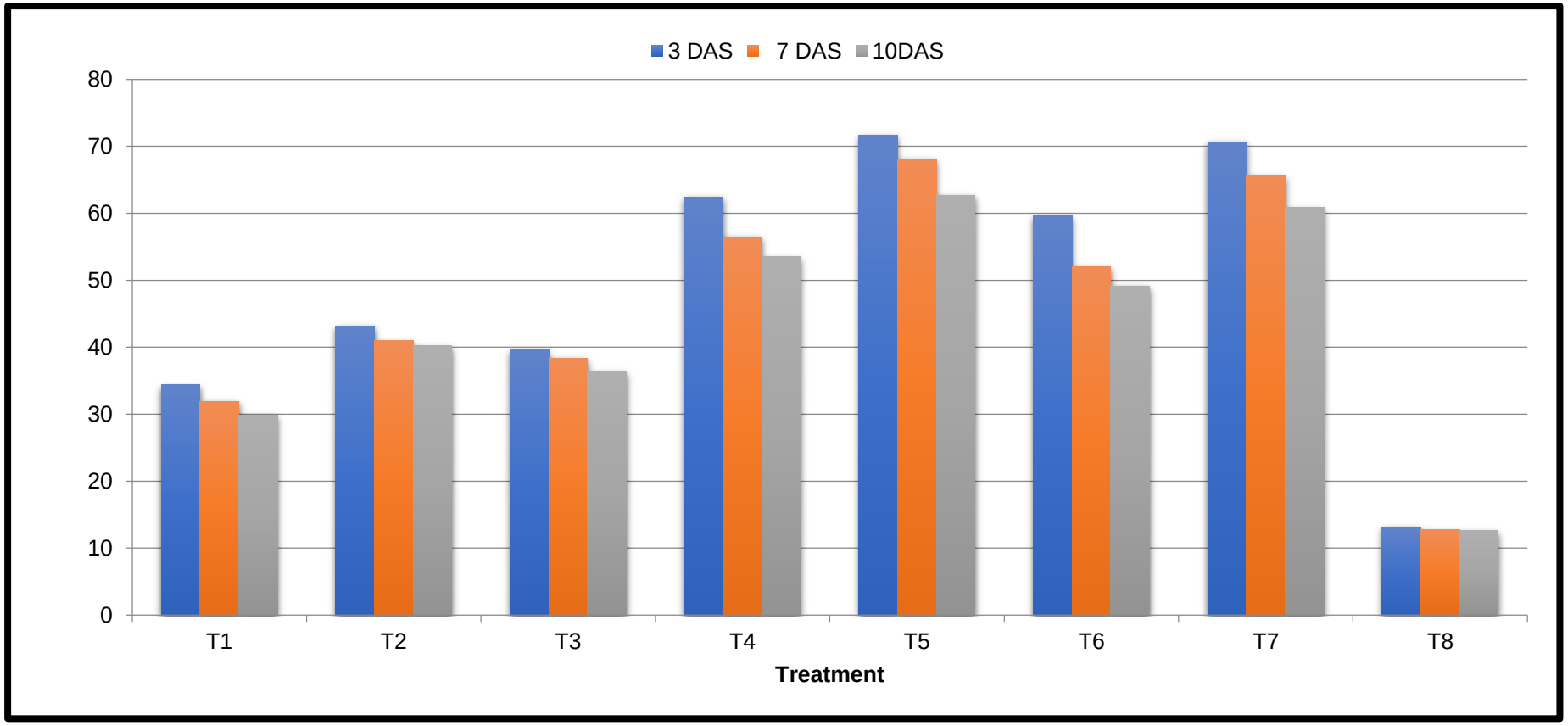

Fig:3 Efficacy of different treatments on per cent reduction of aphid at 3,7 and 10 days after second spray

cent reduction of population of aphid and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of aphid population was observed in control (T_8:12.68%).

AT 10 DAS

Similar types of results were obtained on 10days after second spraying. All the treatments were significantly superior over control (T_8: Water spray) in per cent reduction of aphid.

The treatment Flonicamid 50WG(T_5:62.66%) recorded maximum percent reduction followed by Acetamiprid 20SP(T_7:60.83) and both treatments were proved to be the most effective, resulted in significant reduction in population of aphid as compared to other insecticides.

Imidacloprid 17.8 SL and Thiamethoxam 25 WG was in the second group of effective treatments which caused 53.50, 49.14 per cent reduction of aphid, respectively on the ten days after the second spray application.

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp*.(10^8cfu/g)(T_1) Which caused 40.20,36.33 and 29.87 per cent reduction of population of aphid and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of aphid population was observed in control (T_8:12.56%).

The present findings are in conformity with the reports of Kolhe *et al.* (2009) who reported that Acetamiprid and Thiamethoxam were the most and equally effective treatments against the aphids.

Similar findings were reported by Samih *et al.* (2011) who obtained highest aphid mortality with Flonicamid and Imidacloprid in the laboratory experiment under controlled conditions. Bartual *et al.* (2012) to manage the aphids *Aphis gossypii* and *Aphis punicae*, and

the study revealed that new generation insecticide flonicamid was very effective in controlling aphids.

4.1.3 Efficacy of different treatments on per cent reduction of aphids at 3,7and 10 days after third spray:

The data presentedin table 3 and fig.4 revealed that significant difference in per cent reduction of aphid was found due to insecticidal treatments after 3,7and 10 days of their third spray application. All the treatments were significantly superior over control ($T_{8:}$Water spray) in percent reduction of aphid population.

AT 3 DAS

It was revealed that Flonicamid 50 WG recorded maximum per cent reduction (T_5:71.65%),which was significantly superior over rest of the treatments and it was statistically at par with Acetamiprid 20SP(T_7:67.66%) and both treatments were proved to be the most effective, resulted in significant reduction in aphid population as compared to other insecticides.

Imidacloprid 17.8 SL and Thiamethoxam 25 WG was in the second group of effective treatments which caused 60.41, 55.88 per cent reduction of aphid, respectively after 3rd days of the spray application.

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecaniciliumSpp*.(10^8cfu/g)(T_1) Which caused 42.05,39.14 and 33.78 per cent reduction of population of aphid and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of aphid population was observed in control (T_8:13.33%).

AT 7 DAS

Seven days after treatment Flonicamid 50WG (T_5:64.10%) ranked first among all the treatments.The next best insecticides were

Plate 2: Leaves damaged by Aphids (*Aphis gossypii*)

Nymph of jassid

Adult of jassid

Plate 3: Leaves damaged by Jassids (*Amrasca biguttula biguttula*)

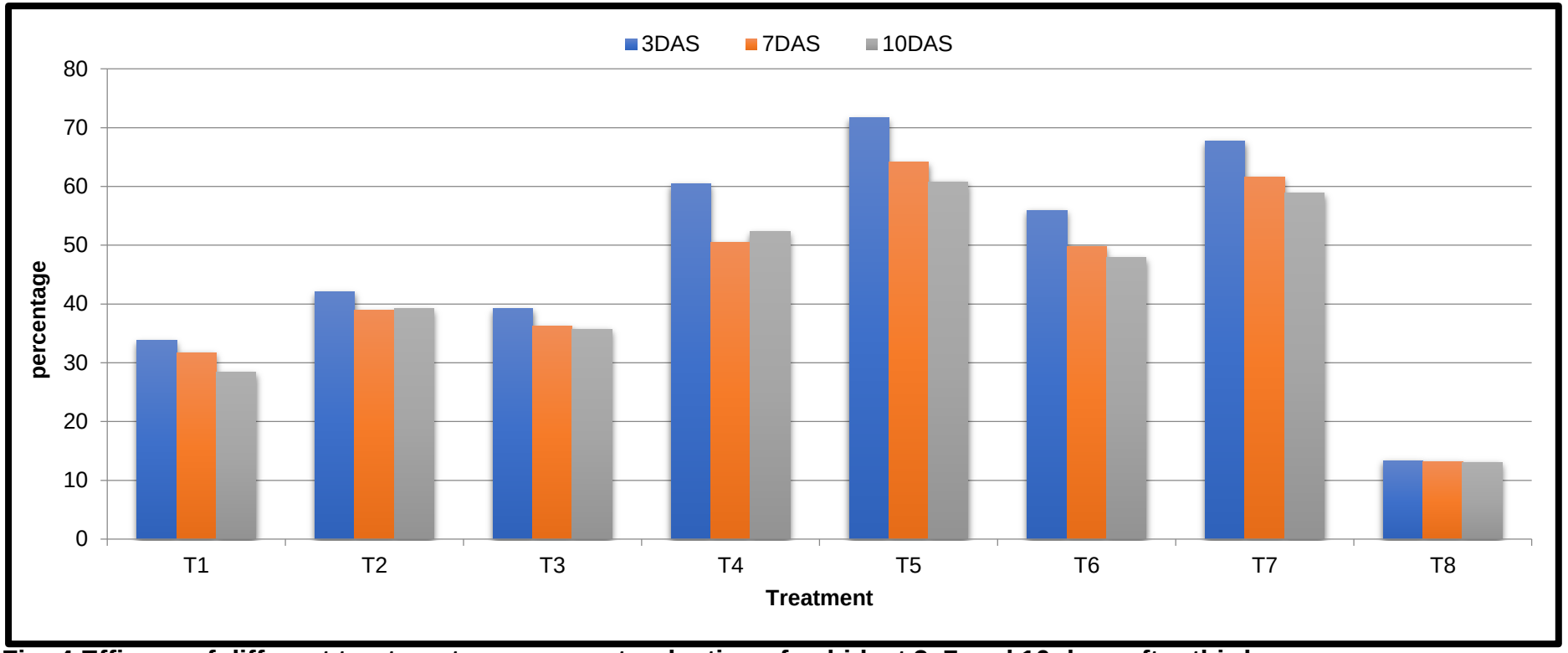

Fig: 4 Efficacy of different treatments on per cent reduction of aphid at 3, 7 and 10 days after third spray

Acetamiprid 20SP(T_7:61.51%),Imidacloprid 17.8SL(T_4:50.40%) and Thiamethoxam 25 WG(T6:49.78%).

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *Lecanicillium Spp*.(10^8cfu/g) (T_1) Which caused 38.87,36.21 and 31.72 per cent reduction of population of aphid and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of aphid population was observed in control (T_8:13.21%).

AT 10DAS

Similar type of results were obtained on 10days after third spraying where all the treatments were significantly superior over control (T_8: Water spray) in per cent reduction of aphid.

The treatment Flonicamid 50WG(T_5:60.75%) recorded maximum percent reduction followed by Acetamiprid 20SP(T_7:58.88%) and both treatments were proved to be the most effective,resulted in significant reduction in population of aphid as compared to other insecticides.

Imidacloprid 17.8 SL and Thiamethoxam 25 WG was in the second group of effective treatments which caused 52.28,47.86 per cent reduction of aphid, respectively on the ten days after the third spray application.

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp.*(10^8cfu/g) (T_1) Which caused 39.14, 35.64 and 28.37per cent reduction of population of aphid and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of aphid population was observed in control (T_8:13.02%).

The present findings are in agreement with the reports of Rouhani *et al.* (2013) reported that,Flonicamid at 0.1 mg/ml had the highest mortality against aphids.

Similar findings were reported by Gaurakhade *et al*.(2015) reported that,after third spray the application of Flonicamid 50 WG@ 0.02 per cent, Dinotefuran 20 SG @ 0.008 per cent proved effective in recording minimum aphid population.

4.2.1 Efficacy of different treatments on per cent reduction of jassids at 3,7 and 10 days after first spray.

The data presentedin Table 4 and fig. 5 revealed that significant difference in per cent reduction of jassids was found due to insecticidal treatments after 3,7 and 10 days of their application. All the treatments were significantly superior over control ($T_{8:}$ Water spray) in per cent reduction of jassid population.

AT 3 DAS

Three days after first spray Flonicamid 50 WG recorded maximum per cent reduction (T_5:76.30%),which was significantly superior over rest of the treatments and it was statistically at par with Imidacloprid 17.8 SL(T_4:70.97%) and both treatments were proved to be the most effective,resulted in significant reduction in population of jassid as compared to other insecticides.

The next best treatment wasThiamethoxam 25 WG recorded 68.73 per cent reduction of jassid population and it was found at par with treatment of Acetamiprid 20 SP (T_7:64.00%).

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp.*(10^8cfu/g) (T_1) Which caused 46.00, 44.93 and 38.82 per cent reduction of population of jassid and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of jassid population was observed in control (T8:13.21%).

AT 7 DAS

Seven days after treatment Flonicamid 50 WG (T_5:71.90%) ranked first among all the treatments.The next best insecticides were

Imidacloprid 17.8SL (T4:66.07%),Thiamethoxam25WG(T_6:63.99%).and Acetamiprid 20SP (T_7:60.48%).

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent(T_3) and *Lecanicillium Spp.*(10^8cfu/ml) (T_1) , Which caused 43.65, 40.65 and 38.09 per cent reduction of population of jassid and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of jassid population was observed in control (T_8:12.41%).

AT 10 DAS

Similar type of results were obtained on 10days after first spraying where all the treatments were significantly superior over control (T_8: Water spray)in per cent reduction of jassids.

The treatment Flonicamid 50 WG(T5:65.87%) recorded maximum percent reduction followed by Imidacloprid 17.8 SL(T4:62.61%) and both treatments were proved to be the most effective, resulted in significant reduction in population of jassid as compared to other insecticides.

Thiamethoxam 25 WG and Acetamiprid 20 SP was in the second group of effective treatment which caused 59.65, 54.32 per cent reduction of jassid, respectively on the ten day after the spray application. The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp.*(10^8cfu/g) (T_1) Which caused 43.08,40.10 and 43.08 per cent reduction of population of jassid and these treatments were statistically at par with each other.

Table 4: Efficacy of different treatments on per cent reduction of Jassids at 3, 7 and 10 days after three spraying

Tr.No.	Treatment	Dose	Per cent reduction in population of jassid								
			First spray			Second spray			Third spray		
			3 DAS	7DAS	10DAS	3 DAS	7DAS	10DAS	3 DAS	7DAS	10DAS
T1	*Lecanicillium lecanii* ($1x10^8$cfu/g)	4g/l	38.82 (38.44)	38.09 (38.02)	43.08 (40.93)	39.73 (38.89)	38.98 (38.49)	34.62 (35.96)	38.21 (38.03)	36.66 (37.16)	32.62 (34.75)
T2	Neem oil 2 %	20ml	46.00 (42.67)	43.65 (41.32)	43.08 (40.93)	47.00 (43.25)	43.58 (41.25)	42.66 (40.74)	46.36 (42.89)	42.35 (40.59)	41.42 (40.04)
T3	Neem Seed kernel Exract 5%	50ml	44.93 (42.06)	40.65 (39.53)	40.10 (39.22)	45.33 (42.30)	41.60 (40.09)	39.43 (38.81)	43.76 (41.37)	39.12 (38.62)	38.59 (38.31)
T4	Imidacloprid17.8SL	0.008%	70.97 (57.60)	66.07 (54.39)	62.61 (52.35)	69.48 (56.72)	65.77 (54.47)	62.25 (52.45)	68.21 (55.88)	66.27 (54.94)	60.62 (51.25)
T5	Flonicamid50WG	0.02%	76.30 (61.39)	71.90 (58.35)	65.87 (53.82)	73.91 (59.40)	70.66 (58.00)	66.33 (54.64)	72.15 (58.63)	69.82 (57.12)	65.28 (54.11)
T6	Thiamethoxam 25WG	0.005%	68.73 (56.05)	63.99 (53.15)	59.65 (50.61)	63.03 (52.72)	60.88 (51.35)	58.83 (50.07)	64.50 (53.56)	61.19 (51.74)	56.98 (48.85)
T7	Acetamiprid 20SP	0.004%	64.00 (53.15)	60.48 (51.25)	54.32 (47.59)	61.90 (51.95)	59.39 (50.46)	55.80 (48.42)	60.06 (50.87)	58.33 (49.84)	54.56 (47.67)
T8	Control(water spray)		13.21 (21.29)	12.41 (20.41)	12.38 (20.40)	13.43 (21.45)	13.19 (21.22)	12.90 (20.87)	14.73 (22.47)	14.01 (21.88)	14.02 (21.93)
	F test		Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
	SE(m)±		3.25	3.81	2.73	3.24	3.05	3.34	3.18	3.29	3.07
	CD at 5%		9.77	8.53	8.30	9.84	9.27	10.14	9.65	9.98	9.32

(Figures in parentheses are corresponding values of arc sin transformation)

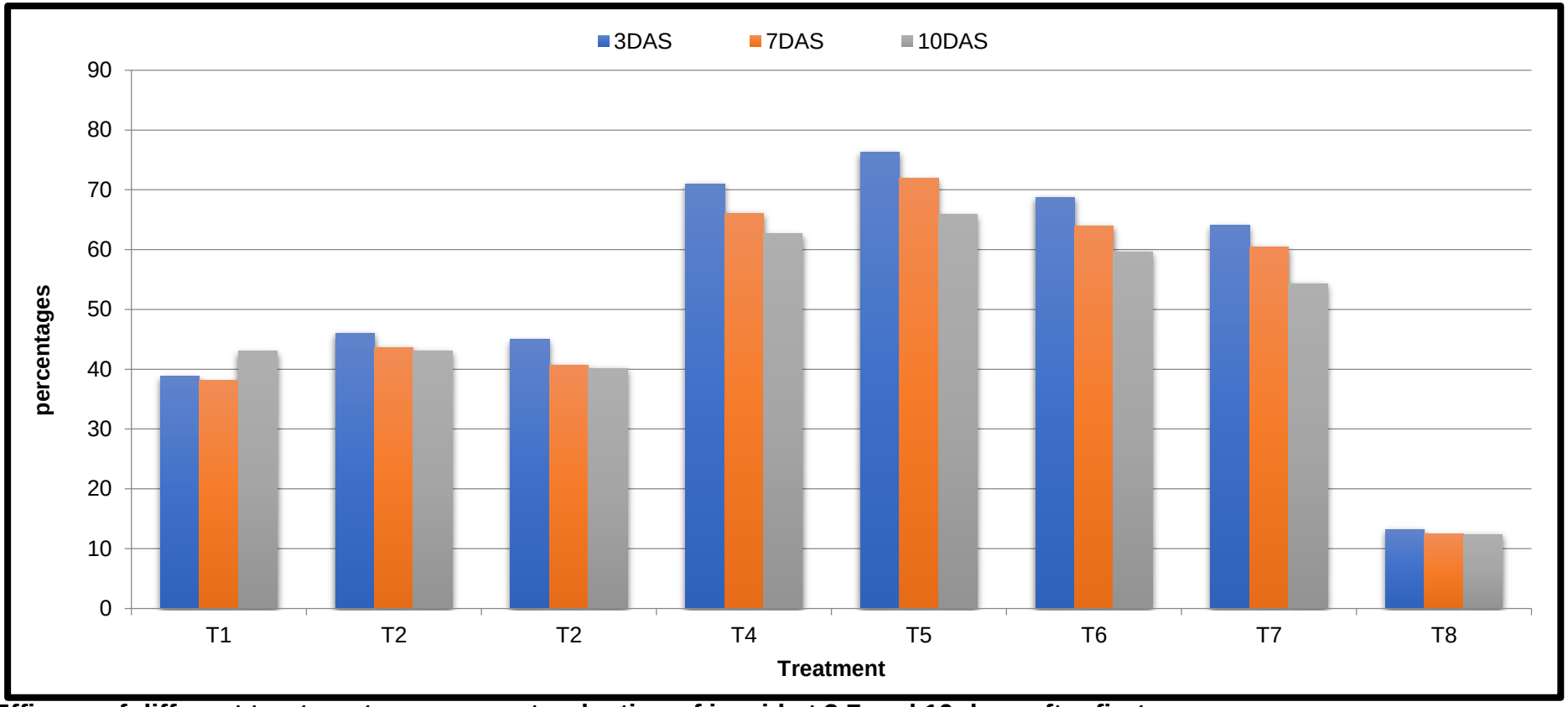

Fig:5 Efficacy of different treatments on per cent reduction of jassid at 3,7 and 10 days after first spray

However, significantly minimum per cent reduction of jassid population was observed in control (T_8:12.38%).

The present findings are in accordance with the finding of earlier workers. Naik *et al.(*2017)reported that,flonicamid 50WG found most effective in controlling both leaf hopper as well as whitefly population.

Similar findings were reported by Shasikant *et al*.(2010)who reported that,new formulation of imidacloprid @26.25 g a.i./ha which was found to be superior in reducing population of jassid.

4.2.2 Efficacy of different treatments on per cent reduction of jassids at 3,7 and 10 days after second spray:

The data presentedin Table 4 and fig.6 revealed that significant difference in per cent reduction of jassids was found due to insecticidal treatments after 3,7and 10 days of their second spray application. All the treatments were significantly superior over control ($T_{8:}$Water spray) in per cent reduction of jassid.

AT 3DAS

Three days after second spray Flonicamid 50 WG recorded maximum per cent reduction (T_5:73.91%),which was significantly superior over rest of the treatments and it was statistically at par with Imidacloprid 17.8 SL (T_4:69.48%) and both treatments were proved to be the most effective,resulted in significant reduction in population of jassid as compared to other insecticides.

The next best treatment wasThiamethoxam 25 WG recorded 63.03 per cent reduction of jassid population and it was found at par with treatment of Acetamiprid 20 SP (T_7:61.90%).

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp*.(10^8cfu/g) (T_1) Which caused 47.00, 45.33 and 39.73 per cent reduction of population of jassid and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of jassid population was observed in control (T_8:13.43%).

AT 7 DAS

Seven days after treatment Flonicamid 50WG (T_5:70.66%) ranked first among all the treatments.The next best insecticides were Imidacloprid17.8SL(T_4:65.77%),Thiamethoxam25WG(T_6:60.88%) andAcetamiprid 20SP (T_7:59.39%).

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *Lecanicillium Spp*.(10^8cfu/g)(T_1),Which caused 43.58, 41.60 and 38.98 per cent reduction of population of jassid and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of jassid population was observed in control (T_8:13.19%).

AT 10 DAS

Similar type of results were obtained on 10days after second spraying where all the treatments were significantly superior over control (T_8:Water spray) in per cent reduction of jassid.

The treatment Flonicamid 50 WG(T_5:66.33%) recorded maximum per cent reduction followed by Imidacloprid 17.8 SL(T_4:62.25%) and both treatments were proved to be the most effective, resulted in significant reduction in population of jassid as compared to other insecticides.

Thiamethoxam 25 WG and Acetamiprid 20SP was in the second group of effective treatments which caused 58.83, 55.80 per cent reduction of jassid, respectively on the ten days after the spray application.

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp*.(10^8cfu/g) (T_1) Which caused 42.66, 39.43and 34.62

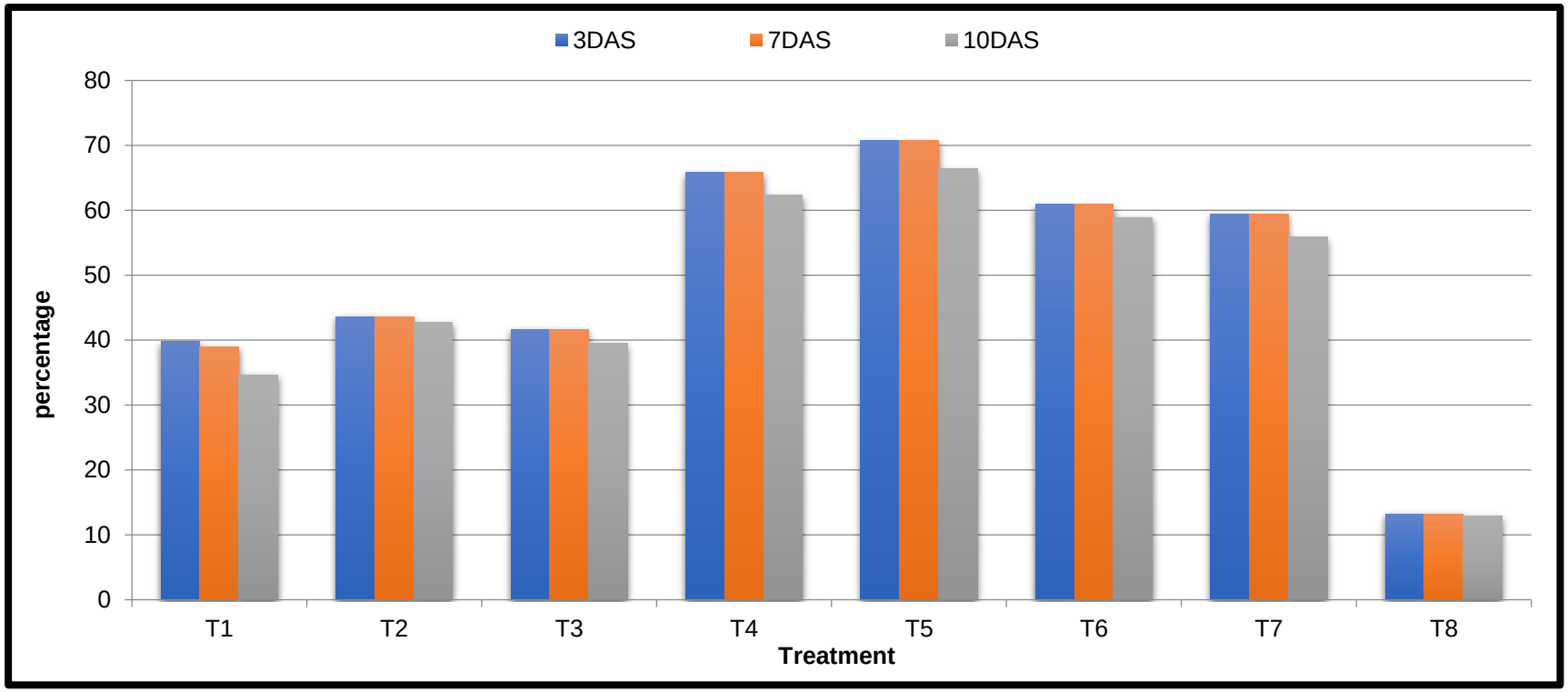

Fig:6 Efficacy of different treatments on per cent reduction of jassid at 3,7 and 10 days after second spray

per cent reduction of population of jassid and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of jassid population was observed in control (T_8:12.90%).

The present findings are in comformity with the reports of Afzal *et al*. (2014) who reported that Imidacloprid,acetamiprid and thiamethoxam were most effective against jassids up to 7 days after application. Chandi *et al.* (2016) who found that flonicamid @ 100 g a.i. ha-1 gave higher reduction of leafhopper population. After 10 DAS.Kalyan (2017) who found that, Flonicamid 50 WP@ 100g was found very effective in controlling jassid and whitefly population in cotton and also gave higher yield.

4.2.3 Efficacy of different treatments on per cent reduction of jassids at 3,7 and 10 days after third spray:

The data presentedin table 4 and fig.7 revealed that significant difference in per cent reduction of jassid was found due to insecticidal treatments after 3,7and 10 days of their third spray application. All the treatments were significantly superior over control (T_8:Water spray) in per cent reduction of jassid population.

AT 3 DAS

Three days after third spray Flonicamid 50 WG recorded maximum per cent reduction (T_5:72.15%),which was significantly superior over rest of the treatments and it was statistically at par with Imidacloprid 17.8 SL(T_4:68.21%) and both treatments were proved to be the most effective,resulted in significant reduction in population of jassid as compared to other insecticides.

The next best treatments wasThiamethoxam 25 WG recorded 64.50 per cent reduction of jassid population and it was found at par with treatment of Acetamiprid 20 SP (T_7:60.06%).

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and

LecaniciliumSpp.(10^8cfu/ml) (T_1) Which caused 46.36, 43.76 and 38.23 per cent reduction of population of jassid and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of jassid population was observed in control (T_8:14.73%).

AT 7 DAS

Seven days after treatment Flonicamid 50WG (T_5:69.82%) ranked first among all the treatments.The next best insecticides were Imidacloprid 17.8SL(T_4:66.27%),Thiamethoxam25WG(T_6:61.19%).and Acetamiprid 20SP (T_7:58.33%).

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *Lecanicillium Spp*.(10^8cfu/g) (T_1) Which caused 42.35, 39.12 and 36.66. Per cent reduction of population of jassid and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of jassid population was observed in control (T_8:14.01%).

AT 10 DAS

Similar type of results were obtained on 10days after third spraying where all the treatments were significantly superior over control (T_8:Water spray) in pe rcent reduction of jassid.

The treatment Flonicamid 50 WG(T_5:65.28%) recorded maximum per cent reduction followed by Imidacloprid 17.8 SL(T_4:60.28%) and both treatments were proved to be the most effective,resulted in significant reduction in population of jassid as compared to other insecticides.

Thiamethoxam 25 WG and Acetamiprid 20SP was in the second group of effective treatments which caused 56.98, 54.56 per cent reduction of jassid, respectively on the ten days after the spray application.

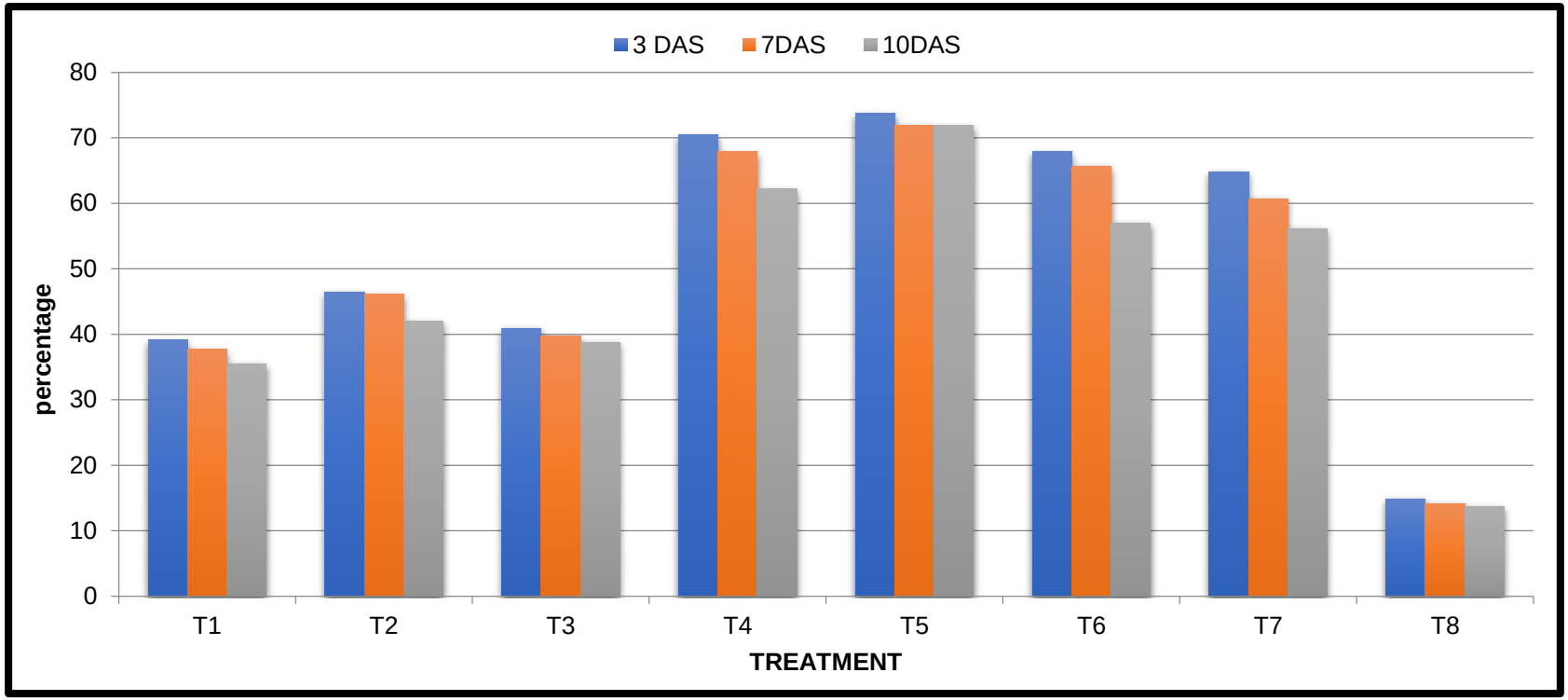

Fig:7 Efficacy of different treatments on per cent reduction of jassid at 3, 7 and 10 days after third spray

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp.* (10^8cfu/g) (T_1) Which caused 41.42, 38.59 and 32.62 per cent reduction of population of jassid and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of jassid population was observed in control (T_8:14.02%).

Similar report finding with the reportKumar and Dhawan (2011) who reported that, dinotefuran 20 SG and flonicamid 50WG were effective against cotton leafhopper.Flonicamid (50% WG @ 50g a.i ha-1) and acephate (75% SP @ 562.5g a.i h1) recorded 2.19 nymphs/3 leaves/ plant and 2.59 nymphs /3 leaves /plant respectively and both were highly effective in reducing the leafhopper population in high density planting system (CICR annual report. 2012 -13).

4.3.1 Efficacy of different treatments on per cent reduction of thrips at 3, 7and 10 days after first spray.

The data presentedin table 5 and fig.8 revealed that significant difference in per cent reduction of thrips was found due to insecticidal treatments after 3,7and 10 days of their application. All the treatments were significantly superior over control ($T_{8:}$ Waterspray) in per cent reduction of thrips.

AT 3 DAS

Three days after first spray Flonicamid 50 WG recorded maximum per cent reduction (T_5:73.67%),which was significantly superior over rest of the treatments and it was statistically at par with Imidacloprid 17.8 SL(T_4:70.42%) and both treatments were proved to be the most effective,resulted in significant reduction in population of thrips as compared to other insecticides.

The next best treatments wasThiamethoxam 25 WG recorded 67.85 per cent reduction of thrips population and it was found at par with treatment of Acetamiprid 20 SP (T_7:64.82%).

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp*.(10^8cfu/g) (T_1) Which caused 46.41, 40.91 and 39.13 per cent reduction of population of thrips and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of thrips population was observed in control (T_8:14.87%).

AT 7 DAS

Seven days after treatment Flonicamid 50WG (T_5:71.95%) ranked first among all the treatments.The next best insecticides were Imidacloprid 17.8SL(T_4:67.87%), Thiamethoxam25WG(T_6:65.66%).and Acetamiprid 20SP (T_7:60.68%).

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *Lecanicillium Spp*.(10^8cfu/g)(T_1),Which caused 46.11, 39.66 and 37.57 per cent reduction of population of thrips and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of thrips population was observed in control (T_8:14.11%).

AT 10 DAS

Similar type of results were obtained on 10days after first spraying where all the treatments were significantly superior over control (T_8: Water spray) in per cent reduction of thrips.

The treatment Flonicamid 50 WG (T_5:68.66%) recorded maximum per cent reduction followed by Imidacloprid 17.8 SL(T_4:62.20%) and both treatments were proved to be the most effective, resulted in significant reduction in population of thrips as compared to other insecticides.

Table 5: Efficacy of different treatments on per cent reduction of Thrips at 3,7 and 10 days after three spraying

Tr. No.	Treatment	Dose	Per cent reduction in population of Thrips								
			First spray			Second spray			Third spray		
			3 DAS	7DAS	10DAS	3 DAS	7 DAS	10DAS	3DAS	7DAS	10DAS
T1	*Lecanicillium lecanii* ($1x10^8$cfu/g)	4g/l	39.13 (36.84)	37.57 (37.74)	35.47 (36.41)	38.33 (38.11)	36.66 (37.18)	34.80 (36.11)	35.99 (36.81)	33.71 (34.95)	31.33 (34.01)
T2	Neem oil 2%	20ml	46.41 (42.67)	46.11 (41.56)	42.01 (40.35)	43.21 (41.05)	43.00 (40.93)	40.78 (39.63)	40.56 (39.45)	38.01 (37.95)	36.43 (37.05)
T3	Neem Seed Kernel Extract 5 %	50ml	40.91 (38.94)	39.66 (38.59)	38.77 (38.40)	41.43 (40.01)	40.70 (39.54)	39.39 (38.77)	38.77 (38.44)	36.55 (37.12)	34.48 (35.88)
T4	Imidacloprid17.8SL	0.008%	70.42 (55.65)	67.87 (55.18)	62.20 (52.15)	68.63 (56.18)	62.08 (52.15)	60.21 (51.26)	67.84 (55.47)	63.20 (52.79)	56.51 (48.81)
T5	Flonicamid 50WG	0.02%	73.67 (57.56)	71.95 (58.80)	68.66 (56.00)	71.32 (58.09)	70.10 (57.02)	66.65 (54.82)	70.54 (57.30)	68.26 (55.91)	62.64 (52.52)
T6	Thiamethoxam 25WG	0.005%	67.85 (54.14)	65.66 (54.77)	57.13 (49.04)	67.39 (55.21)	60.82 (51.28)	56.53 (48.85)	65.33 (54.04)	58.61 (50.35)	54.77 (47.73)
T7	Acetamiprid 20SP	0.004%	64.82 (51.26)	60.68 (51.21)	56.15 (48.59)	64.41 (53.40)	59.66 (50.67)	54.11 (47.35)	63.66 (53.15)	56.26 (48.59)	52.39 (46.35)
T8	Control (water spray)		14.87 (22.65)	14.11 (22.11)	13.69 (22.00)	14.55 (22.38)	14.09 (21.99)	13.40 (22.36)	13.01 (22.68)	12.97 (20.78)	12.06 (20.29)
	F test		Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
	SE(m)±		2.88	3.28	2.77	2.69	2.89	3.40	2.78	3.74	2.56
	CD at 5%		8.75	12.63	8.41	8.17	8.77	10.31	8.46	11.35	7.78

(Figures in parentheses are corresponding values of arc sin transformation)

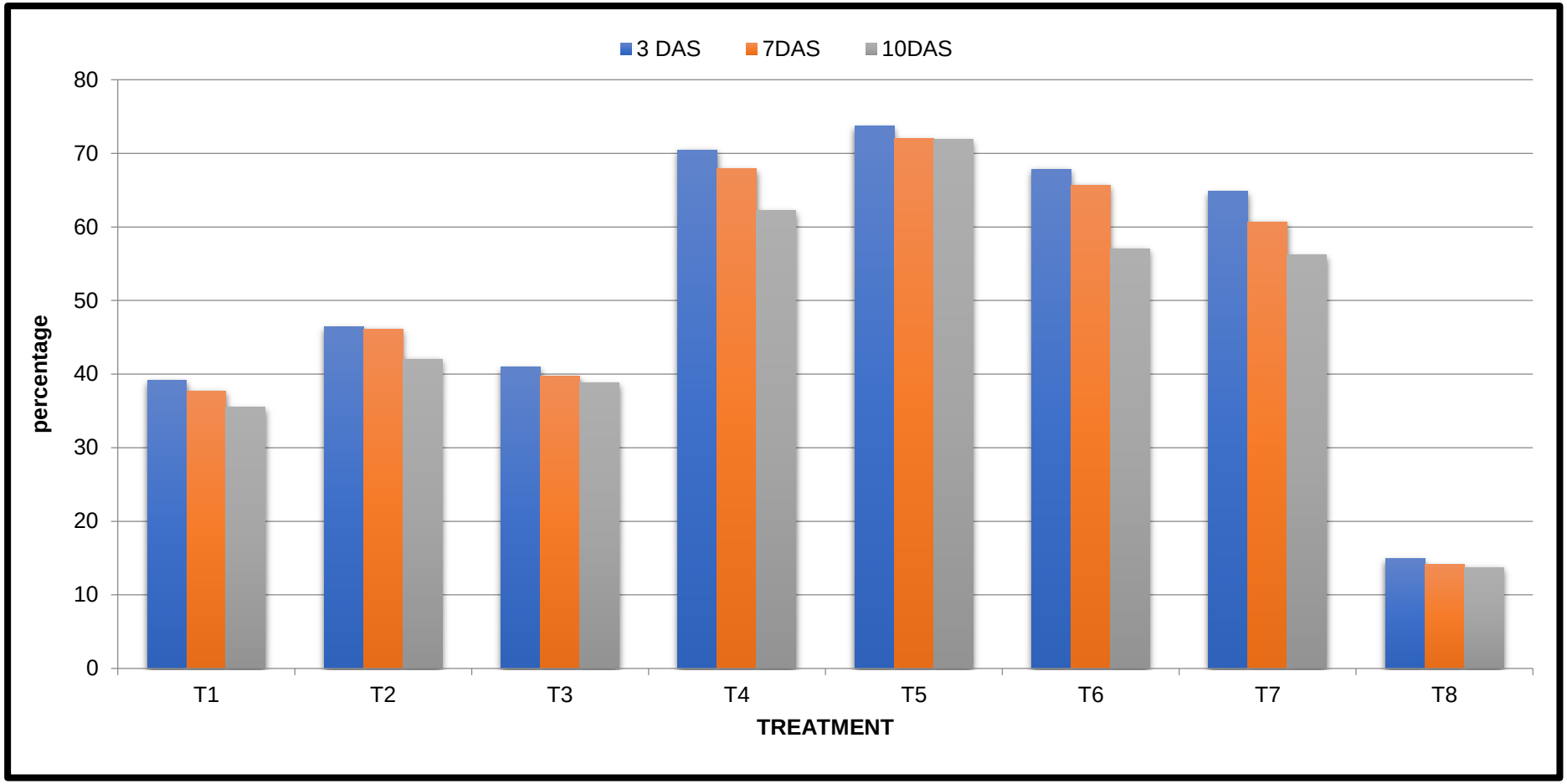

Fig:8 Efficacy of different treatments on per cent reduction of thrips at 3,7 and 10 days after first spray

Thiamethoxam 25 WG and Acetamiprid 20SP was in the second group of effective treatments which caused 57.13, 56.15 per cent reduction of thrips, respectively on the ten days after the spray application.

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp*.(10^8cfu/g) (T_1), Which caused 42.01, 38.77 and 35.47 per cent reduction of population of thrips and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of thrips population was observed in control (T_8:13.69%).

Similar findings were reported by Patil *et al.*(2018) who reported that, among the treatments, Flonicamide 50% WG was found to be most effective by recording the lowest population thrips,

Th present results also get support from the observations of Kolhe *et al*.(2009) who found that Imidaclopride was most effective against thrips.

4.3.2 Efficacy of different treatments on per cent reduction thrips at 3,7 and 10 days after second spray:

The data presentedin table 5 and fig.9 revealed that significant difference in per cent reduction of thrips was found due to insecticidal treatments after 3,7and 10 days of their second spray application. All the treatments were significantly superior over control (T_8:Water spray) in per cent reduction of thrips.

AT 3DAS

Three days after second spray application, Flonicamid 50 WG recorded maximum per cent reduction (T_5:71.32%),which was significantly superior over rest of the treatments and it was statistically at par with Imidacloprid 17.8 SL(T_4:68.63%) and both treatments were proved to be the most effective, resulted in significant reduction in population of thrips as compared to other insecticides.

The next best treatments wasThiamethoxam 25 WG recorded 67.39 per cent reduction of thrips population and it was found at par with treatment of Acetamiprid 20 SP (T_7:64.41%).

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp.* (10^8cfu/g) (T_1) Which caused 43.21, 41.43and 38.33 per cent reduction of population of thrips and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of thrips population was observed in control (T_8:14.55%).

AT 7 DAS

Seven days after treatment Flonicamid 50WG (T_5:70.10%) ranked first among all the treatments.The next best insecticides were Imidacloprid17.8SLT_4:62.08%),Thiamethoxam25WG(T_6:60.82%) and Acetamipride 20SP (T_7:59.66%).

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3)and*Lecanicillium Spp.*10^8cfu/g (T_1) Which caused 43.00, 40.70 and 36.66 Per cent reduction population of thrips and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of thrips population was observed in control (T_8:14.09%).

AT 10DAS

Similar type of results were obtained on 10days after second spraying where all the treatments were significantly superior over control (T_8: Water spray) in per cent reduction of thrips.

The treatment Flonicamid 50 WG(T_5:66.65%) recorded maximum per cent reduction followed by Imidacloprid17.8 SL(T_4:60.21%) and both treatments were proved to be the most effective, resulted in significant reduction in population of thrips as compared to other insecticides.

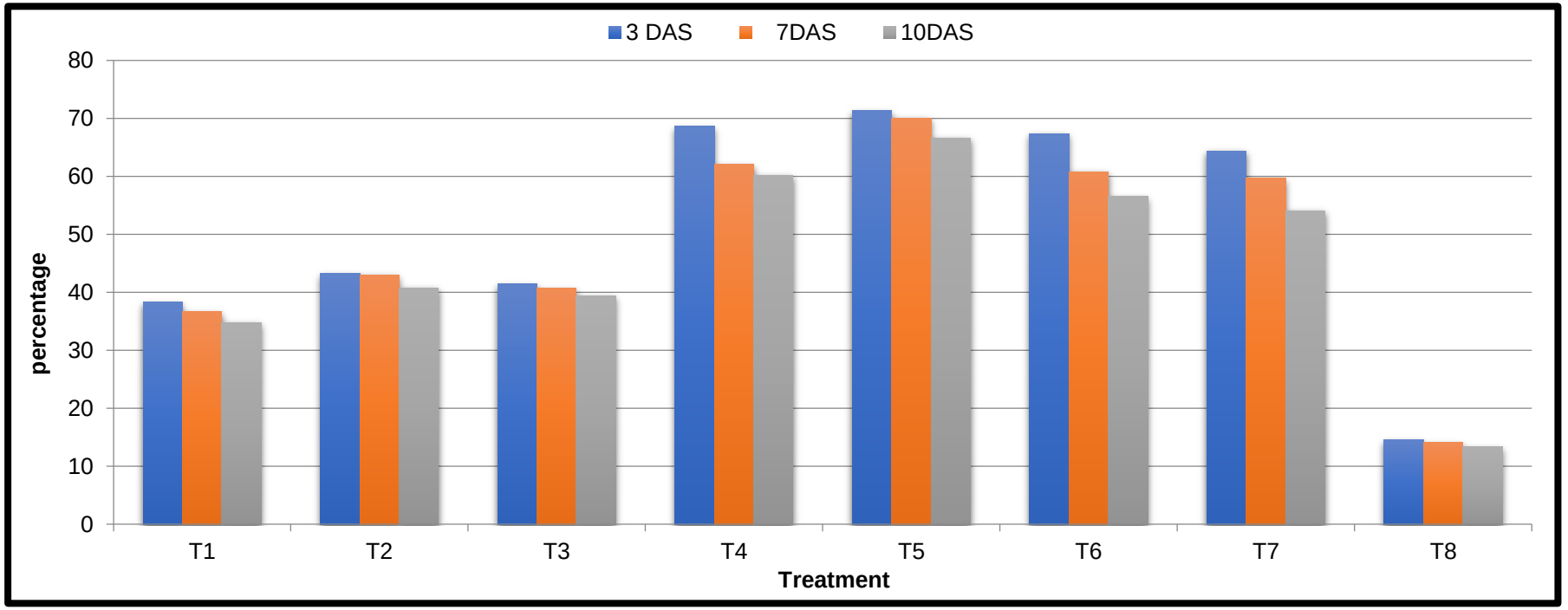

Fig:10 Efficacy of different treatment on per cent reduction of thrips at 3,7 and 10 days after second spray

Thiamethoxam 25 WG and Acetamiprid 20SPwas in the second group of effective treatment which caused 56.53, 54.11 per cent reduction of thrips, respectively on the 10^{th} days after the spray application.

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicIlliumSpp.*10^8cfu/g (T_1) Which caused 40.78, 39.39 and 34.80 per cent reduction of population of thrips and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of thrips population was observed in control (T_8:13.40%).

Similar findings were reported by Ravikumar *et al.* (2016) observed that, maximum mortality of thrips with flonicamid 50 WG.

These results are on similar line withNemade *et al*.(2017) revealed that,newer molecule Flonicamid 50% WG @ 100 g a.i./ha was found promising to managed the major sucking pests of *Bt* cotton.

4.3.3 Efficacy of different treatments on per cent reduction of thrips at 3,7 and 10 days after third spray:

The data presentedin table 5 and fig.10 revealed that significant difference in per cent reduction of thrips was found due to insecticidal treatments after 3,7and10 days of their third spray application. All the treatments were significantly superior over control ($T_{8:}$ Water spray) in per cent reduction of thrips population.

Three days after third spray application, Flonicamid 50 WG recorded maximum per cent reduction (T_5:70.54%),which was significantly superior over rest of the treatments and it was statistically at par with imidacloprid 17.8 SL (T_4:67.84%)and both treatments were proved to be the most effective, resulted in significant reduction in thrips population as compared to other insecticides.

Thiamethoxam 25 WG and Acetamiprid 20 SP was in the second group of effective treatments which caused 65.33, 63.66 per

cent reduction of thrips, respectively on after third days of the spray application.

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp.*10^8cfu/g (T_1) Which caused 40.56, 38.77 and 35.99 per cent reduction of population of thrips and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of thrips population was observed in control (T_8:13.01%).

AT 7 DAS

Seven days after treatment Flonicamid 50 WG recorded maximum per cent reduction (T_5:68.26%),which was significantly superior over rest of the treatments and it was statistically at par with imidacloprid 17.8 SL(T_4:63.20%).

Thiamethoxam 25 WG and Acetamiprid 20 SP was in the second group of effective treatments which caused 58.61, 56.26 per cent reduction of thrips, respectively on the seven day after the third spray application.

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp.*10^8cfu/g (T_1) Which caused 38.01,36.55 and 33.71 per cent reduction of population of thrips and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of thrips population was observed in control (T_8:12.97%).

AT 10 DAS

Similar type of results were obtained on 10days after third spraying where all the treatments were significantly superior over control ($T_{8:}$ Water spray)in per cent reduction of thrips.

The treatment Flonicamid 50 WG (T_5:62.64%) recorded maximum per cent reduction followed by Imidacloprid 17.8 SL

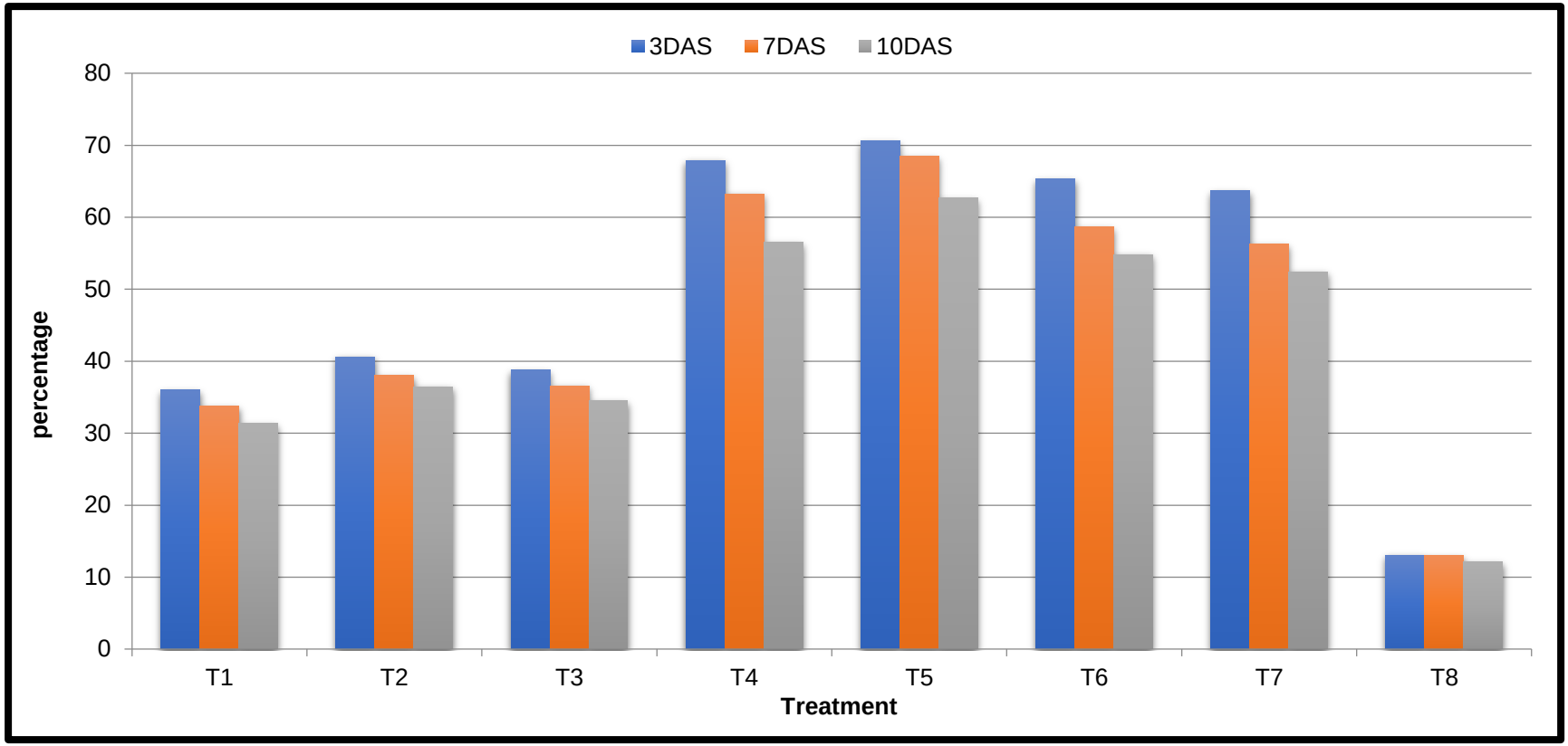

Fig:10 Efficacy of different treatment on per cent reduction of thrips at 3,7 and 10 days after third spray

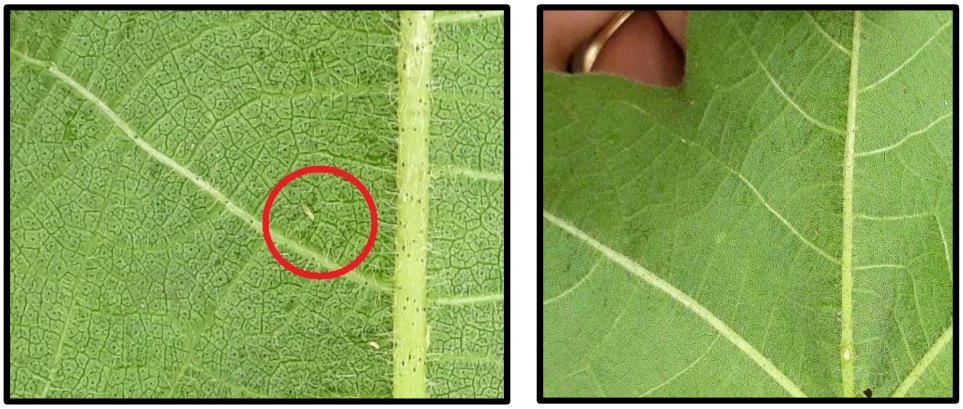

Plate 4:Leaves damaged by Thrips (*Thrips tabaci*)

Plate 5: Leaves damaged by whiteflies(*Bemisia tabaci*)

(T_4:56.51%) and both treatments were proved to be the most effective,resulted in significant reduction in population of thrips as compared to other insecticides.

Thiamethoxam 25 WG and Acetamiprid 20SP was in the second group of effective treatments which caused 54.77, 52.39 per cent reduction of thrips, respectively on the ten days after the spray application.

The remaining treatments were effective in descending order of their efficacy were of Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp*.(10^8cfu/g) (T_1) Which caused 36.43,34.48 and 31.33 per cent reduction of population of thrips and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of thrips population was observed in control (T_8:12.06%).

These results are in corroboration with Ghelani (2014), who studied that the application of flonicamide 0.02 per cent resulted in effective control of thrips in *Bt* cotton.

The present findings are in conformity with the reports of Saleem and Khan (2001) who reported good control of sucking insects with Imidacloprid 20SL@250ml/acre.

4.4.1 Efficacy of different treatments on per cent reduction of whiteflies at 3,7 and 10 days after first spray.

The data presentedin table 6 and fig.11 revealed that significant difference in per cent reduction of whiteflies was found due to insecticidal treatments after 3,7 and 10 days of their application. All the treatments were significantly superior over control (T_8:Water spray) in per cent reduction of whiteflies.

AT 3 DAS

Three days after first spray application, Acetamiprid 20 SP recorded maximum per cent reduction (T_7:73.35%),which was significantly superior over rest of the treatments and it was statistically

at par with Flonicamid 50 WG (T_5:71.16%) and treatments were proved to be the most effective, resulted in significant reduction in population of whitefly as compared to other insecticides.

The next best treatments was Imidacloprid 17.8 SL recorded 68.52 per cent reduction of whitefly population and it was found at par with treatment of Thiamethoxam25 WG (T_6:64.62%).

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp.*(10^8cfu/g) (T_1) Which caused 46.92, 42.56 and 36.53 per cent reduction of population of whitefly and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of whitefly population was observed in control (T_8:13.56%).

AT 7 DAS

Seven days after treatment Acetamiprid (T_7:70.47%) ranked first among all the treatments.The next best insecticides were Flonicamid 5 WG(T_5:68.22%),Imidacloprid 17.8SL(T_4:66.92%) andThiamethoxam 25 WG (T_6:62.50%).

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *Lecanicillium Spp*.(10^8cfu/g) (T_1),Which caused 43.67, 41.44 and 34.67 per cent reduction of population of whitefly and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of whitefly population was observed in control (T_8:12.92%).

AT 10 DAS

Similar type of results were obtained on 10days after first spraying where all the treatments were significantly superior over control (T_8: Water spray) in per cent reduction of whitefly.

Table 6: Efficacy of different treatments on per cent reduction of whiteflies at 3,7 and 10 days after three spraying

Tr. No.	Treatment	Dose	Per cent reduction of whitefly population								
			First spray			Second spray			Third spray		
			3 DAS	7DAS	10DAS	3 DAS	7DAS	10DAS	3 DAS	7DAS	10DAS
T1	*Lecanicillium lecanii* ($1x10^8$cfu/g)	4g/l	36.53 (37.16)	34.67 (36.02)	32.66 (34.78)	35.07 (36.26)	31.41 (33.96)	30.82 (33.61)	32.86 (34.87)	31.94 (34.30)	31.01 (33.71
T2	Neem oil 2 %	20ml	46.62 (43.12)	43.67 (41.28)	41.66 (40.02)	45.20 (42.23)	44.85 (42.02)	42.34 (40.56)	43.22 (41.07)	41.89 (40.29)	40.33 (39.39)
T3	Neem Seed Kernel Extract 5 %	50ml	42.56 (40.62)	41.44 (39.88.)	38.69 (38.42)	40.21 (39..29)	40.15 (39.25)	39.70 (38.70)	40.98 (39.75)	40.15 (39.26)	38.51 (38.31)
T4	Imidacloprid 17.8 SL	0.008%	68.52 (55.95)	66.92 (54.56)	60.56 (51.21)	68.41 (56.61)	64.69 (53.72)	62.36 (52.35)	68.93 (56.50)	66.95 (55.17)	63.44 (52.91)
T5	Flonicamid 50 WG	0.02%	71.16 (58.10)	68.22 (55.56)	66.81 (54.81)	70.47 (57.64)	70.02 (57.08)	65.48 (54.30)	65.48 (54.30)	67.15 (55.21)	65.65 (54.25)
T6	Thiamethoxam 25WG	0.005%	64.62 (53.65)	62.50 (52.33)	56.78 (49.03)	64.82 (53.64)	62.49 (52.57)	56.8 (49.18)	62.44 (52.24)	60.94 (50.96)	57.66 (49.47)
T7	Acetamiprid 20SP	0.004%	73.35 (59.09)	70.47 (57.29)	68.33 (56.31)	75.08 (60.52)	67.33 (55.77)	68.42 (56.52)	72.37 (59.33)	70.26 (57.48)	67.88 (55.70)
T8	Control(water spray)		13.56 (21.60)	12.92 (2103)	12.80 (20.89)	14.34 (22.44)	14.05 (22.11)	13.08 (23.38)	12.52 (20.66)	12.45 (23.65)	12.03 (20.17)
	F test		Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
	SE(m)±		3.61	2.85	3.74	4.03	3.71	4.09	3.14	3.01	3.44
	CD at 5%		10.96	8.67	11.37	12.25	11.36	12.41	9.53	9.14	10.44

(Figures in parentheses are corresponding values of arc sin transformation)

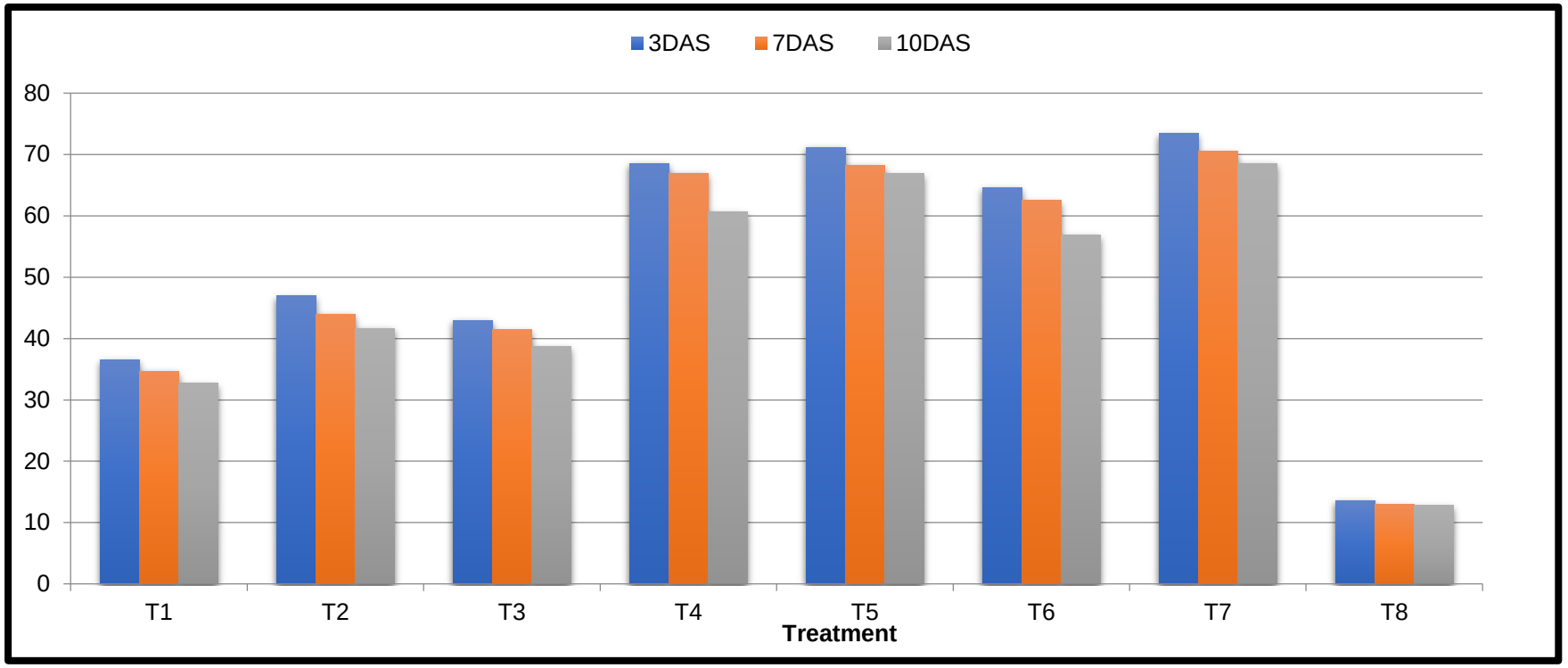

Fig:11 Efficacy of different treatments on per cent reduction of whitefly at 3, 7 and 10 days after first spray

The treatment Acetamiprid 20 SP (T_7:68.48%) recorded maximum per cent reduction followed by Flonicamid 50 WG (T_5:66.81%) and both treatments were proved to be the most effective,resulted in significant reduction in population of whitefly as compared to other insecticides.

Imidacloprid 17.8 SL and Thiamethoxam 25 WG was in the second group of effective treatments which caused 60.56, 56.78 per cent reduction of whitefly, respectively on the ten days after the spray application.

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp.* (10^8cfu/g)(T_1) Which caused 41.66, 38.69 and 32.66 per cent reduction of population of whitefly and these treatments were statistically at par with each other. However, significantly minimum per cent reduction of whitefly population was observed in control (T_8:12.80%).

Similar findings were reported by Ulaganathan and Gupta (2004) reported that, Acetamiprid 0.003 per cent were effective in reducing whitefly population in cotton.

Muhmmad *et al.* (2004) reported that,Acetamiprid and thiamethoxam were the most promising insecticides against whitefly.

4.4.2 Efficacy of different treatments on per cent reduction whiteflies at 3,7 and 10 days after second spray:

The data presentedin table 6 and fig.12 revealed that significant difference in per cent reduction of whitefly was found due to insecticidal treatments after 3,7and10 days of their second spray application. All the treatments were significantly superior over control (T_8:Water spray) in per cent reduction of whitefly.

AT 3 DAS

Three days after second spray application, Acetamiprid 20 SP recorded maximum per cent reduction (T_7:75.08%),which was significantly superior over rest of the treatment and it was statisticallyat

par with Flonicamid 50 WG (T_5:70.47%) and both treatments were proved to be the most effective, resulted in significant reduction in population of whitefly as compared to other insecticides.

The next best treatments was Imidacloprid 17.8 SL recorded 68.41 per cent reduction of whitefly population and it was found at par with treatment of Thiamethoxam25 WG (T_6:64.82%).

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3)and *LecanicilliumSpp*.(10^8cfu/g) (T_1) Which caused 45.20, 40.20 and 35.07 per cent reduction of population of whitefly and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of whitefly population was observed in control (T_8:14.34%).

AT 7 DAS

Seven days after treatment Acetamiprid (T_7:70.02%) ranked first among all the treatments.The next best insecticides were Flonicamid 50WG(T_5:67.33%),Imidacloprid 17.8SL(T_4:64.69%).and Thiamethoxam 25 WG (T_6:62.49%).

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3),*Lecanicillium Spp*.(10^8cfu/g)(T_1),Which caused 44.85, 40.15 and 31.41 per cent reduction of population of whitefly and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of whitefly population was observed in control (T_8:14.05%).

AT 10 DAS

Similar type of results were obtained on 10days after second spraying where all the treatments were significantly superior over control (T_8:Water spray) in per cent reduction of whitefly population.

The treatment Acetamiprid 20 SP (T_7:68.42%) recorded maximum per cent reduction followed by Flonicamid 50 WG

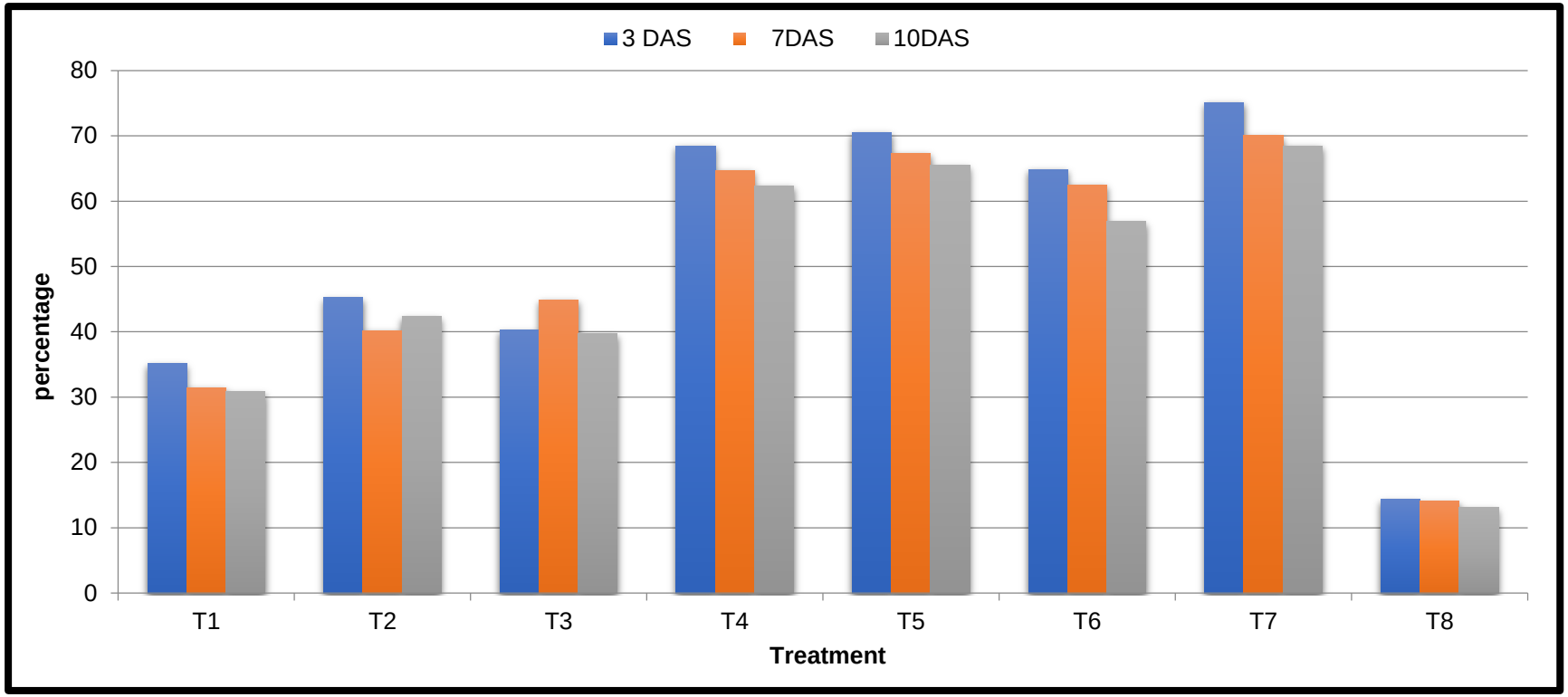

Fig: 12 Efficacy of different treatments on per cent reduction of whitefly at 3, 7 and 10 days after second spray

(T_5:65.48%) and both treatments were proved to be the most effective, resulted in significant reduction in population of whitefly as compared to other insecticides.

Imidacloprid 17.8 SL and Thiamethoxam 25 WG was in the second group of effective treatments which caused 62.36, 56.80 per cent reduction of whitefly,respectively on the ten days after the spray application.

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp*.(10^8cfu/g) (T_1) Which caused 42.34, 39.70 and 30.82 per cent reduction of population of whitefly and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of whitefly population was observed in control (T_8:13.08%).

Similar results were also obtained by earlier workers like Bhamare and Wadnerkar (2013),who stated that acetamiprid 20 SP provided significantly better control of *Bemisia tabaci* on cotton.Raghuraman and Gupta(2005) who reported that,Acetamiprid @40 g a.i./ha and Imidacloprid @100g a.i./ha were found to be the most effective treatment against whitefly on cotton.

4.4.3 Efficacy of different treatments on per cent reduction of whitefly at 3, 7 and 10 days after third spray:

The data presentedin table 6 and fig.13 revealed that significant difference in per cent reduction of whitefly was found due to insecticidal treatments after 3,7and10 days of their third spray application. All the treatment where significantly superior over control (T_8:Water spray) in per cent reduction of whitefly population.

AT 3 DAS

Three days after third spray application, Acetamiprid 20 SP recorded maximum per cent reduction (T_7:72.37%),which was significantly superior over rest of the treatments and it was statistically at par with Flonicamid 50 WG (T_5:68.93%) and both treatments were

proved to be the most effective,resulted in significant reduction in population of whitefly as compared to other insecticides.

The next best treatments was Imidacloprid 17.8 SL recorded 65.48 per cent reduction of whitefly population and it was found at par with treatment of Thiamethoxam25 WG (T_6:62.44%).

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp.* (10^8cfu/g) (T_1) Which caused 43.22, 40.98and 32.86 per cent reduction of population of whitefly and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of whitefly population was observed in control (T_8:12.52%).

AT 7 DAS

Seven days after treatment Acetamiprid (T_7:70.26%) ranked first among all the treatments.The next best insecticides were Flonicamid50WG(T_5:67.15%),Imidacloprid17.8SL(T_4:66.95%).andThia methoxam 25 WG (T_6:60.74%).

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5% (T_3) and *Lecanicillium Spp.* (10^8cfu/g) (T_1) Which caused 41.89, 40.15 and 31.94 per cent reduction of population of whitefly and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of whitefly population was observed in control (T_8:12.45%).

AT 10 DAS

Similar type of results were obtained on 10days after third spraying where all the treatments were significantly superior over control (T_8: Water spray) in per cent reduction of whitefly.

The treatment Acetamiprid 20 SP (T_7:67.88%) recorded maximum per cent reduction followed by Flonicamid 50 WG (T_5:65.65%) and both treatments were proved to be the most effective

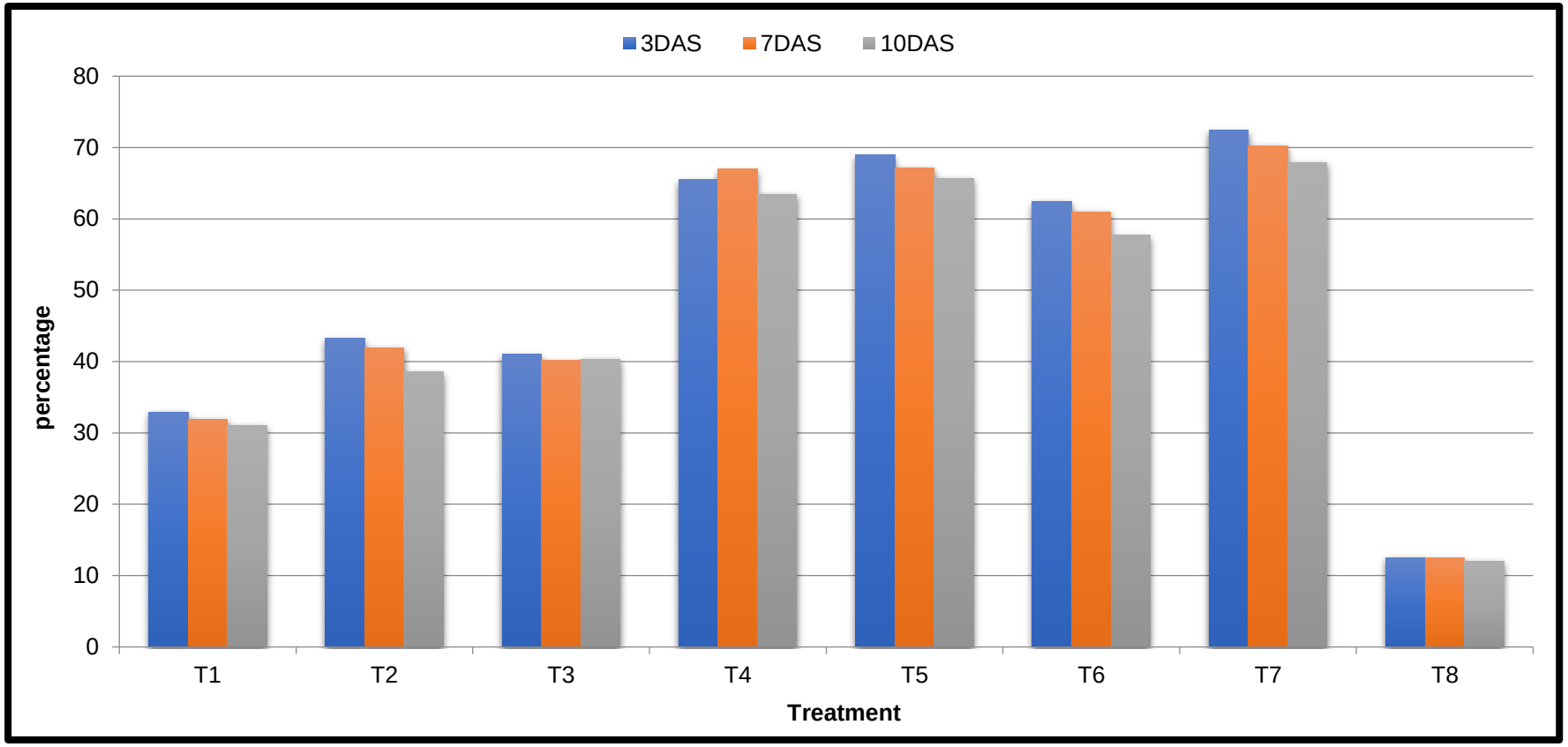

Fig: 13 Efficacy of different treatments on per cent reduction of whitefly at 3,7 and 10 days after third spray

Resulted in significant reduction in population of whitefly as compared to other insecticides.

Imidacloprid 17.8 SL and Thiamethoxam 25 WG was in the second group of effective treatments which caused 63.44, 57.66 per cent reduction of whitefly, respectively on the ten days after the spray application.

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp*.(10^8cfu/g) (T_1) Which caused 40.33, 38.51 and 31.01 per cent reduction of population of whitefly and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of whitefly population was observed in control (T_8:12.03%).

The present findings are in accordance with the finding of earlier workers like Nieto and Simonetta (2008) studiedon apples and peaches revealed that flonicamid exhibited a high control of various species of aphids and whiteflies.Nadeem *et al.* (2011) who reported that Acetamipride was the most effective against adult population of whitefly.

4.5 Cumulative efficacy of different treatments on mean per cent reduction of sucking pests at 3, 7 and 10 days after three spraying

A) Aphids:

The data on Cumulative efficacy of different treatments on mean per cent reduction of aphid population presented in Table .7 and depicted in Fig.14 indicated that all the treatments were significantly superior over control (T_8:Water spray) in per cent reduction of aphid at 3rd day after three spraying.The treatment Flonicamid 50 WG recorded maximum per cent reduction (T_5:72.56%),which was significantly superior over rest of the treatments and it was statistically at par with Acetamiprid 20SP (T_7:70.21%).

Imidacloprid 17.8 SL and Thiamethoxam 25WG was in the second group of effective treatments which caused 62.27, 59.18 per cent reduction of aphid.

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp*.(10^8cfu/ml) (T_1) Which caused 43.41,40.37 and 35.27 per cent reduction of population of aphid and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of aphid population was observed in control (T_8:13.38%).

Seven days after three spraying treatment Flonicamid 50 WG recorded maximum per cent reduction (T_5:68.05%), which was significantly superior over rest of the treatments and it was statistically at par with Acetamipride 20SP (T_7:65.20%).

Imidacloprid 17.8 SL and Thiamethoxam 25WG was in the second group of effective treatments which caused 56.44, 53.66 per cent reduction of aphid and statistically at par with each other.

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp.*(10^8cfu/g) (T_1) Which caused 40.73, 38.00 and 33.09 per cent reduction of population of aphid and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of aphid population was observed in control (T_8:13.01%).

Ten days after three spraying treatment Flonicamid 50 WG recorded maximum per cent reduction (T_5:62.71%),which was significantly superior over rest of the treatment and it was statistically at par with Acetamiprid 20SP (T_7:59.97%).

Table 7 : Cumulative efficacy of different treatments on per cent reduction of sucking pests at 3,7 and 10 days after three spraying

Tr No.	Treatment	Dose	Aphids			Jassids			Thrips			Whiteflies		
			3DAS	7DAS	10DAS	3DAS	7DAS	10DAS	3DAS	7DAS	10DAS	3DAS	7DAS	10DAS
T1	*Lecanicillium lecanii* ($1x10^8$cfu/g)	4g/l	35.27 (36.41)	33.09 (35.10)	30.38 (33.43)	38.92 (38.58)	37.91 (37.99)	39.54 (38.91)	37.81 (37.93)	36.01 (36.86)	33.87 (35.57)	34.82 (36.14)	32.67 (34.84)	31.49 (34.12)
T2	Neem oil 2 %	20ml	43.41 (41.20)	40.73 (39.64)	40.13 (39.30)	46.45 (42.95)	43.19 (41.07)	42.52 (40.69)	43.39 (41.18)	42.37 (40.59)	39.74 (39.06)	45.11 (42.18)	43.56 (41.29)	40.83 (39.70)
T3	Neem Seed Kernel Extract 5%	50ml	40.37 (39.43)	38.00 (38.04)	36.82 (37.34)	44.67 (41.93)	40.45 (39.48)	39.59 (38.98)	40.37 (39.43)	38.97 (38.61)	37.54 (37.77)	41.36 (40.01)	40.58 (39.55)	39.57 (38.97)
T4	Imidacloprid17.8SL	0.008%	62.27 (52.09)	56.44 (48.70)	54.78 (47.73)	69.55 (56.49)	66.03 (54.33)	61.94 (51.89)	68.96 (56.13)	64.38 (53.35)	59.64 (50.54)	67.47 (55.21)	66.18 (54.42)	62.12 (52.00)
T5	Flonicamid 50WG	0.02%	72.56 (58.40)	68.05 (55.59)	62.71 (52.35)	74.12 (59.41)	70.79 (57.27)	65.67 (54.11)	71.84 (57.94)	70.10 (56.84)	67.05 (54.98)	70.18 (56.89)	67.56 (55.26)	65.98 (54.30)
T6	Thiamethoxam 25WG	0.005%	59.18 (50.28)	53.66 (47.09)	50.40 (45.21)	65.42 (53.97)	62.02 (51.94)	58.76 (50.03)	66.85 (54.53)	61.69 (51.76)	56.10 (48.49)	63.96 (53.09)	61.97 (51.91)	57.10 (49.06)
T7	Acetamiprid 20SP	0.004%	70.21 (56.21)	65.20 (53.85)	59.97 (50.73)	61.98 (51.92)	59.40 (50.40)	54.40 (47.51)	64.29 (53.29)	58.86 (50.09)	54.21 (47.40)	73.60 (59.06)	70.25 (56.92)	68.26 (55.69)
T8	Control(water spray)		13.38 (21.45)	13.01 (21.14)	12.85 (21.00)	13.79 (21.78)	13.20 (21.29)	12.92 (21.06)	14.14 (22.07)	13.72 (21.73)	13.05 (21.16)	13.47 (21.52)	13.14 (21.24)	12.63 (20.81)
	F test		Sig	Sig	Sig	sig	sig	Sig	Sig	Sig	sig	sig	Sig	Sig
	SE(m)±		0.32	0.69	0.43	0.51	0.35	0.73	0.27	0.50	0.45	0.30	0.35	0.39
	CD at 5%		1.99	2.11	1.32	1.57	1.08	2.23	0.84	1.54	1.37	0.92	1.06	1.18

(Figures in parentheses are corresponding values of arc sin transformatio

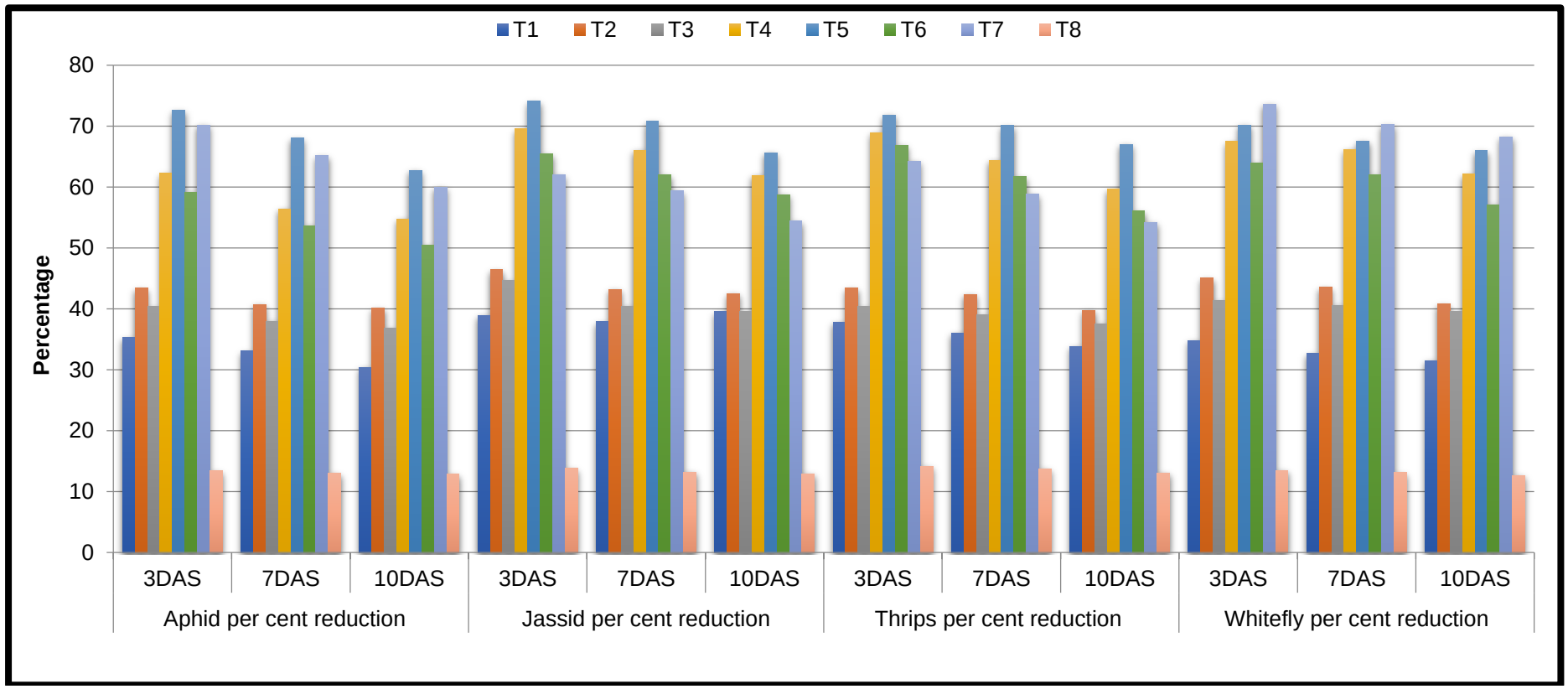

Fig: 14 Cumulative efficacy of different treatments on per cent reduction of sucking pests at 3,7 and 10 days after three spray

Imidacloprid 17.8 SL and Thiamethoxam 25WG was in the second group of effective treatments which caused 54.78, 50.40 per cent reduction of aphid and statistically at par with each other.

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp.*(10^8cfu/g) (T_1) Which caused 40.13,36.82 and 30.38 per cent reduction of population of aphid and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of aphid population was observed in control (T_8:12.85%).

B) Jassid:

The data on Cumulative efficacy of different treatments on mean per cent reduction of jassid population presented in Table .7 and depicted in Fig.13 indicated that all the treatments were significantly superior over control (T_8:Water spray) in per cent reduction of jassid at 3rd day after three spraying Flonicamid 50 WG recorded maximum per cent reduction(T_5:74.12%),which was significantly superior over rest of the treatments and it was statistically at par with Imidacloprid 17.8 SL(T_4:69.55%) .

The next best treatment wasThiamethoxam 25 WG recorded 65.42 per cent reduction of jassid population and it was found at par with treatment of Acetamiprid 20 SP (T_7:61.98%).

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3)and *LecaniciliumSpp.*(10^8cfu/g) (T_1), Which caused 46.45, 44.67 and 38.92 per cent reduction of population of jassid and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of jassid population was observed in control (T_8:13.79%).

Seven days after three spraying Flonicamid 50 WG recorded maximum per cent reduction (T_5:70.79%), which was significantly superior over rest of the treatments and it was statistically at par with Imidacloprid 17.8 SL (T_4:66.03%).

The next best treatment wasThiamethoxam 25 WG recorded 62.02 per cent reduction of jassid population and it was found at par with treatment of Acetamiprid 20 SP (T_7:59.40%).

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecaniciliumSpp.*(10^8cfu/g) (T_1) Which caused 43.19, 40.45 and 37.91 per cent reduction of population of Jassid and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of jassid population was observed in control (T_8:13.20%).

Ten days after three spraying Flonicamid 50 WG recorded maximum per cent reduction (T_5:65.67%), which was significantly superior over rest of the treatments and it was statistically at par with Imidacloprid 17.8 SL(T_4:61.94%).

The next best treatment wasThiamethoxam 25 WG recorded 58.76per cent reduction of jassid population and it was found at par with treatment of Acetamiprid 20 SP (T_7:54.40%).

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3)and *LecaniciliumSpp.*10^8cfu/g (T_1) Which caused 42.52, 39.59 and 39.54 per cent reduction of population of jassid and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of jassid population was observed in control (T_8:12.92%).

C) Thrips:

The data on Cumulative efficacy of different treatments on mean per cent reduction of thrips population presented in Table .7 and depicted in Fig.13 indicated that all the treatments were significantly superior over control ($T_{8:}$water spray) in per cent reduction of thrips at 3rd day after three sprayingFlonicamid 50 WG recorded maximum per cent reduction(T_5:71.84%),which was significantly superior over rest of the treatments and it was statistically at par with imidacloprid 17.8 SL (T_4:68.96)and both treatments were proved to be the most effective,resulted in significant reduction in thrips population as compared to other insecticides.

Thiamethoxam 25 WG and Acetamiprid 20 SP werein the second group of effective treatments which caused 66.85, 64.29 per cent reduction of thrips.

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp.(*10^8cfu/g) (T_1) Which caused 43.39, 40.37 and 37.81 per cent reduction of population of thrips and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of thrips population was observed in control (T_8:14.14%).

seven days after three spraying Flonicamid 50 WG recorded maximum per cent reduction (T_5:70.10%),which was significantly superior over rest of the treatments and it was statistically at par with imidacloprid 17.8 SL (T_4:64.38)and both treatments were proved to be the most effective,resulted in significant reduction in thrips population as compared to other insecticides.

Thiamethoxam 25 WG and Acetamiprid 20 SP were in the second group of effective treatments which caused 61.69, 58.86 per cent reduction of thrips.

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp*.(10^8cfu/g) (T_1) Which caused 42.37, 38.97 and 36.01 per cent reduction of population of thrips and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of thrips population was observed in control (T_8:13.72%).

Ten days after three spraying Flonicamid 50 WG recorded maximum per cent reduction (T_5:67.05%),which was significantly superior over rest of the treatments and it was statistically at par with Imidacloprid 17.8 SL (T_4:59.64%).

Thiamethoxam 25 WG and Acetamiprid 20 SP were in the second group of effective treatments which caused 56.10, 54.21 per cent reduction of thrips.

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *Lecanicillium Spp.*(10^8cfu/g) (T_1) Which caused 39.74, 37.54 and 33.87 per cent reduction of population of thrips and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of thrips population was observed in control (T_8:13.05%).

D) Whitefly:

The data on Cumulative efficacy of different treatments on mean per cent reduction of whitefly population presented in Table .7 and depicted in Fig.13 indicated that all the treatments were significantly superior over control (T_8:Water spray) in per cent reduction of whitefly at 3rd day after three spraying. Acetamiprid 20 SP recorded maximum per cent reduction (T_7:73.60%),which was significantly superior over rest of the treatments and it was statistically at par with Flonicamid 50 WG (T_5:70.18%).

The next best treatments was Imidacloprid 17.8 SL recorded 67.47 per cent reduction of whitefly population and it was found at par with treatment of Thiamethoxam25 WG (T_6:63.96%).

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp.*(10^8cfu/g) (T_1) Which caused 45.11, 41.36 and 34.82 per cent reduction of population of whitefly and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of whitefly population was observed in control (T_8:13.47%).

Seven days after three spraying Acetamiprid 20 SP recorded maximum percent reduction (T_7:70.25%),which was significantly superior over rest of the treatment and it was statistically at par with Flonicamid 50 WG (T_5:67.56%).

The next best treatment was Imidacloprid 17.8 SL recorded 66.18 per cent reduction of whitefly population and it was found at par with treatment of Thiamethoxam25 WG (T_6:61.97%). The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp.*10^8cfu/g (T_1) Which caused 43.56, 40.58 and 32.67 per cent reduction of population of whitefly and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of whitefly population was observed in control (T8:13.14%).

Ten days after three spraying Acetamiprid 20 SP recorded maximum pe rcent reduction (T_7:68.26%),which was significantly superior over rest of the treatments and it was statistically at par with Flonicamid 50 WG (T_5:65.98%) and both treatments were proved to be the most effective,resulted in significant reduction in population of whitefly as compared to other insecticides.

he next best treatments was Imidacloprid 17.8 SL recorded 62.12 per cent reduction of whitefly population and it was found at par with treatment of Thiamethoxam25 WG (T_6:57.10%).

The remaining treatments were effective in descending order of their efficacy were Neem oil 2 per cent (T_2), NSKE 5 per cent (T_3) and *LecanicilliumSpp.* (10^8cfu/g) (T_1) Which caused 40.83, 39.57 and 31.49 per cent reduction of population of whitefly and these treatments were statistically at par with each other.

However, significantly minimum per cent reduction of whitefly population was observed in control (T_8:12.63%).

4.6 To study the effects of pesticides on natural enemies.

4.6.1 Effect of different treatments on Coccinellids / five plant population at 3,7 and 10 days after three spraying.

At first spray

The data on effect of different treatments on Coccinellids in cotton presented in Table 8 and fig. 15 revealed that all the treatments were significantly superior. In the present investigation the data recorded at 3 days after spray the maximum no. of Coccinellids population found in (T_8) control water (1.58/plant), followed by (T_2) Neem oil (1.55/plant),NSKE (T_3) (1.49/plant) and (T_1)*Lecanicillium lecanii* (1.43/plant) were found at par with each other. Among the insecticidal treatments lowest no.of population found in Thiamethoxam 0.005 per cent (0.77/plant).

The data recorded at 7 days after first spray revealed that, the maximum no. of Coccinellids population found in (T_8) control water(1.64/plant), followed by (T_2) Neem oil (1.61/plant),NSKE (T_3) (1.60/plant) and (T_1)*Lecanicillium lecanii* (1.51/plant) were found at par with each other among the insecticidal treatments lowest no.of population found in Thiamethoxam 0.005 per cent (0.78/plant).

The data recorded at 10 days after first spray revealed that, the maximum no. of Coccinellids population found in (T_8) control water(1.73/plant),followed by (T_2) Neem oil (1.69/plant),NSKE (T_3) (1.56/plant) and (T_1)*Lecanicillium lecanii* (1.56/plant) were found at par with each other. Among the insecticidal treatments lowest no.of population found in Thiamethoxam 0.005 per cent (1.14/plant).

Biopesticides are safe to natural enemies'viz.,coccinellids.The present findings are in agreement with Hansraj *et al*. (2013)

At second spray

In the present investigation the data recorded at 3 days after second spray the maximum no. of Coccinellids population found in (T_8) control water(1.60/plant), followed by (T_2) Neem oil (1.59/plant),NSKE (T_3) (1.51/plant) and (T_1)*Lecanicillium lecanii* (1.49/plant) were found at par with each other among the insecticidal treatments lowest no.of population found in Thiamethoxam 0.005 per cent (1.03/plant).

The data recorded at 7 days after second spray revealed that, the maximum no. of Coccinellids population found in (T_8) control water(1.66/plant), followed by (T_2) Neem oil (1.63/plant),NSKE (T_3) (1.55/plant) and (T_1)*Lecanicillium lecanii* (1.53/plant) were found at par with each other. Among the insecticidal treatments lowest no.of population found in Thiamethoxam 0.005 per cent (0.68/plant).

The data recorded at 10 days after second spray revealed that, the maximum no .of Coccinellids population found in (T_8) control water (1.70/plant),followed by (T_2) Neem oil (1.70/plant),NSKE (T_3) (1.68/plant) and (T_1)*Lecanicillium lecanii* (1.58/plant) were found at par with each other.Among the insecticidal treatment lowest no.of population found in Thiamethoxam 0.005 per cent (1.11/plant).

These findings are discussed here in light of the work done by the earlier researchers.Prasad *et al.*(2011)who reported thiomithoxam showing toxic to coccinellids upto 7 DAT in brinjal ecosystem.

At third spray

In the present investigation the data recorded at 3rd days after third spray the maximum no. of Coccinellids population found in (T_8) control water (1.65/plant),followed by (T_2) Neem oil (1.64/plant),NSKE (T_3) (1.62/plant) and (T_1)*Lecanicillium lecanii* (1.51/plant) were found at par with each other. Among the insecticidal treatments lowest no.of population found in Thiamethoxam 0.005 per cent (0.75/plant).

The data recorded at 7 days after third spray revealed that, the maximum no. of Coccinellids population found in (T_8) control water(1.70/plant), followed by (T_2) Neem oil (1.68/plant),NSKE (T_3) (1.66/plant) and (T_1)*Lecanicillium lecanii* (1.54/plant) were found at par with each other. Among the insecticidal treatments lowest no.of population found in Thiamethoxam 0.005 per cent (0.72/plant).

The data recorded at 10 days after third spray revealed that, the maximum no. of Coccinellids population found in (T_8) control water (1.75/plant), followed by (T_2) Neem oil (1.70/plant),NSKE (T_3) (1.69/plant) and (T_1)*Lecanicillium lecanii* (1.58/plant) were found at par with each other. Among the insecticidal treatments lowest no.of population found in Thiamethoxam 0.005 per cent (1.17/plant)

The present findings correlates with the studies of Anitha (2007) studied the effect of botanicals and mycopathogens against coccinellid and *chrysoperla* predator of okra sucking pests and revealed that the treatment Neem oil 2 per cent, NSKE 5 per cent, azadirachtin and *V.lecanii* were found safer against population of coccinellid and *chrysoperla* because predatory population in all these treatments was found at par with control.

According to Neharkar and suryavanshi (2003) the insecticidal treatment shown significant less number of LBBt han botanical.

These results are in accordance with the present findings

Table 8: Effect of different treatments on Coccinellids/ five plant population at 3,7 and 10 days after three spraying

Tr. No.	Treatment	Dose	Population of coccinellids/five plant											
			First spray				Second spray				Third spray			
			1 DBS	3DAS	7DAS	10DAS	1DBS	3DAS	7DAS	10DAS	1DBS	3DAS	7DAS	10DAS
T1	*Lecanicillium lecanii* ($1x10^8$cfu/g)	4g/l	1.45 (1.40)	1.43 (1.39)	1.51 (1.41)	1.56 (1.43)	1.49 (1.41)	1.49 (1.40)	1.53 (1.42)	1.58 (1.44)	1.50 (1.41)	1.51 (1.42)	1.54 (1.54)	1.58 (1.44)
T2	Neem oil	20ml	1.60 (1.45)	1.55 (1.43)	1.61 (1.45)	1.69 (1.47)	1.63 (1.46)	1.59 (1.44)	1.63 (1.46)	1.70 (1.48)	1.64 (1.46)	1.64 (1.46)	1.68 (1.47)	1.70 (1.48)
T3	Neem Seed Kernel Extract 5%	50ml	1.58 (1.44)	1.49 (1.41)	1.60 (1.44)	1.56 (1.43)	1.60 (1.41)	1.51 (1.42)	1.55 (1.42)	1.68 (1.47)	1.65 (1.47)	1.62 (1.46)	1.66 (1.47)	1.69 (1.48)
T4	Imidacloprid17.8SL	0.008%	1.50 (1.41)	0.98 (1.20)	1.08 (1.25)	1.18 (1.29)	1.64 (1.45)	0.98 (1.20)	1.04 (1.23)	1.33 (1.35)	1.62 (1.46)	1.03 (1.24)	1.07 (1.25)	1.35 (1.36)
T5	Flonicamid 50WG	0.02%	1.60 (1.44)	1.03 (1.23)	1.09 (1.26)	1.20 (1.30)	1.60 (1.45)	1.03 (1.23)	1.11 (1.27)	1.34 (1.36)	1.58 (1.44)	1.07 (1.26)	1.13 (1.28)	1.40 (1.38)
T6	Thiamethoxam 25WG	0.005%	1.56 (1.43)	0.77 (1.22)	0.78 (1.12)	1.14 (1.28)	1.54 (1.41)	0.74 (1.11)	0.68 (1.05)	1.11 (1.27)	1.62 (1.46)	0.75 (1.11)	0.72 (1.10)	1.17 (1.29)
T7	Acetamiprid 20SP	0.004%	1.60 (1.44)	0.95 (1.20)	0.96 (1.19)	1.08 (1.25)	1.54 (1.42)	0.97 (1.20)	1.03 (1.23)	1.33 (1.35)	1.67 (1.47)	0.99 (1.21)	1.06 (1.23)	1.34 (1.36)
T8	Control (water spray)		1.47 (1.40)	1.58 (1.44)	1.64 (1.46)	1.73 (1.49)	1.50 (1.41)	1.60 (1.45)	1.66 (1.47)	1.70 (1.48)	1.55 (1.39)	1.65 (1.46)	1.70 (1.48)	1.75 (1.50)
	F test		NS	Sig	Sig	Sig	NS	Sig	sig	Sig	NS	Sig	Sig	Sig
	SE(m)±		0.04	0.07	0.03	0.05	0.08	0.07	0.08	0.04	0.07	0.06	0.08	0.04
	CD at 5%		0.12	0.23	0.09	0.17	0.26	0.24	0.25	0.13	0.22	0.20	0.24	0.13

(Figures in parentheses are square root transformed value.)

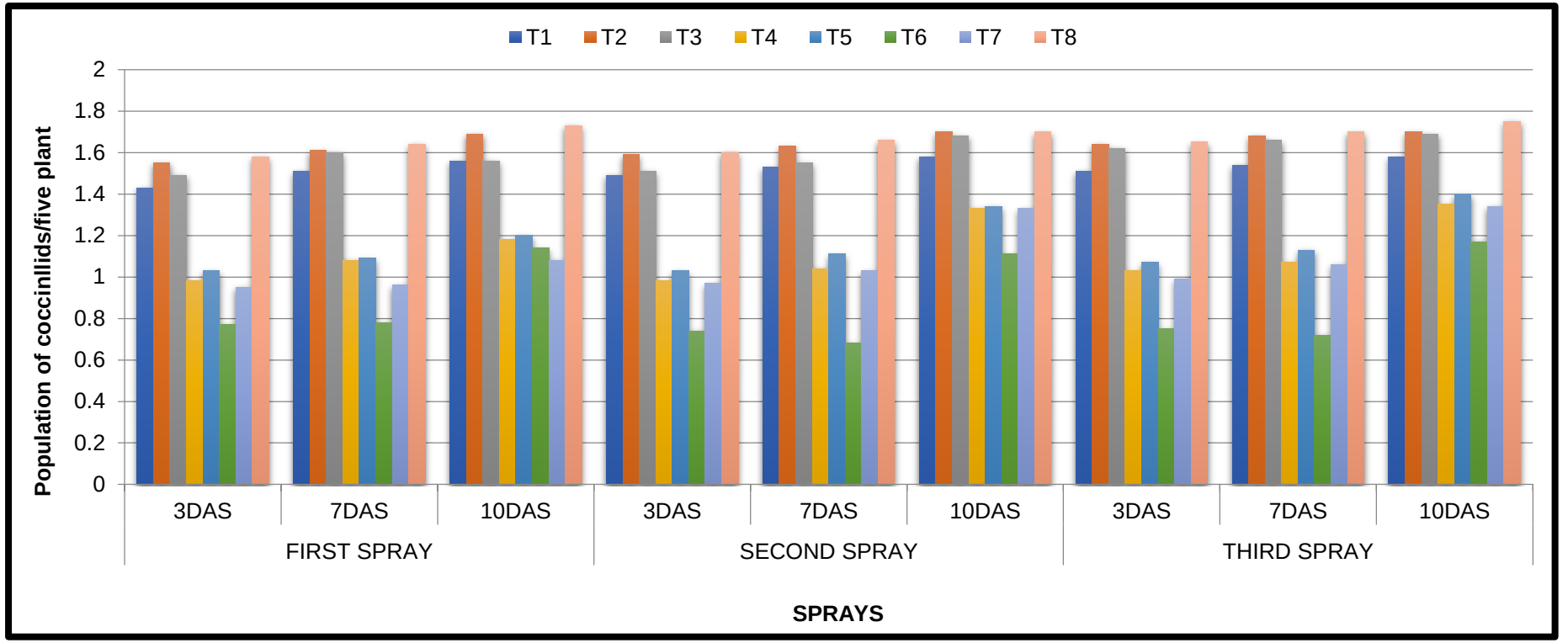

Fig:15 Effect of different treatments on Coccinellids / five plant population at 3,7 and 10 days after three spray

Eggs of *Coccinellid spp.*

Grub of *Coccinellid spp.*

Adult of *Coccinellid spp.*
Plate 6: *Coccinellid spp* on Cotton leaf

4.6.2 Effect of different treatments on *Chrysoperla* / five plant population at 3,7 and 10 days after three spraying .

At first spray

The data on effect of different treatments on *Chrysoperla* predator in cotton presented in Table 9 and fig. 16 revealed that, all the treatments were significantly superior .In the present investigation the data recorded at 3 days after spray the maximum no. of *Chrysoperla* population found in (T_8) control water(1.11/plant),followed by (T_2) Neem oil (1.09/plant),NSKE (T_3) (1.03/plant) and (T_1)*Lecanicillium lecanii* (0.98/plant) were found at par with each other. Among the insecticidal treatments lowest no.of population found in Thiamethoxam 0.005 per cent (0.50/plant).

The data recorded at 7 days after first spray revealed that, the maximum no. of *Chrysoperla* population found in (T_8) control water (1.15/plant),followed by (T_2) Neem oil (1.11/plant), NSKE (T_3) (1.09/plant) and (T_1) *Lecanicillium lecanii* (1.04/plant) were found at par with each other. Among the insecticidal treatments lowest no.of population found in Thiamethoxam 0.005 per cent (0.54/plant).

The data recorded at 10 days after first spray revealed that, the maximum no. of *Chrysoperla* population found in (T_8) control water(1.15/plant),followed by (T_2) Neem oil (1.13/plant), NSKE (T_3) (1.12/plant) and (T_1) *Lecanicillium lecanii* (1.06/plant) were found at par with each other among the insecticidal treatments lowest no.of population found in Thiamethoxam 0.005 per cent (0.59/plant).

Table 9: Effect of different treatments on *Chrysoperla* / plant populationat 3,7 and 10 days after three spray

Tr. No.	Treatment	Dose	Population of *Chrysoperla*/five plant											
			First spray				Second spray				Third spray			
			1DBS	3DAS	7DAS	10DAS	1DBS	3DAS	7DAS	10DAS	1DBS	3DAS	7DAS	10DAS
T1	*Lecanicillium lecanii* ($1x10^8$cfu/g)	4g/l	1.05 (1.24)	0.98 (1.22)	1.04 (1.24)	1.06 (1.25)	0.97 (1.20)	0.82 (1.15)	0.86 (1.16)	0.99 (1.22)	0.93 (1.19)	0.79 (1.13)	0.83 (1.14)	1.00 (1.22)
T2	Neem oil	20ml	0.99 (1.22)	1.09 (1.23)	1.11 (1.27)	1.13 (1.28)	0.84 (1.16)	0.90 (1.18)	0.95 (1.19)	1.07 (1.25)	0.80 (1.11)	0.88 (1.16)	0.91 (1.18)	1.02 (1.23)
T3	Neem Seed Kernel Extract 5%	50ml	1.13 (1.27)	1.03 (1.26)	1.09 (1.26)	1.12 (1.27)	0.92 (1.19)	0.88 (1.17)	0.91 (1.17)	1.02 (1.23)	0.89 (1.18)	0.84 (1.14)	0.88 (1.16)	1.01 (1.23)
T4	Imidacloprid17.8SL	0.008%	1.03 (1.24)	0.67 (1.08)	0.68 (1.08)	0.73 (1.10)	0.82 (1.15)	0.42 (0.96)	0.44 (0.97)	0.53 (1.01)	0.78 (1.14)	0.42 (0.96)	0.48 (0.99)	0.53 (1.01)
T5	Flonicamid 50WG	0.02%	1.02 (1.23)	0.75 (1.12)	0.78 (1.13)	0.85 (1.15)	0.83 (1.16)	0.44 (0.97)	0.48 (0.99)	0.65 (1.07)	0.80 (1.16)	0.44 (0.97)	0.51 (1.00)	0.62 (1.06)
T6	Thiamethoxam 25WG	0.005%	1.05 (1.24)	0.50 (0.99)	0.54 (1.02)	0.59 (1.04)	0.84 (1.16)	0.35 (0.92)	0.39 (0.94)	0.45 (0.97)	0.82 (1.15)	0.33 (0.91)	0.36 (0.93)	0.43 (0.96)
T7	Acetamiprid 20SP	0.004%	1.00 (1.23)	0.55 (1.01)	0.64 (1.07)	0.66 (1.08)	0.82 (1.1)	0.40 (0.95)	0.43 (0.96)	0.49 (1.00)	0.84 (1.13)	0.40 (0.95)	0.46 (0.98)	0.51 (1.00)
T8	Control (water spray)		1.02 (1.20)	1.11 (1.26)	1.15 (1.18)	1.15 (1.28)	0.93 (1.19)	0.95 (1.20)	1.03 (1.24)	1.09 (1.26)	0.87 (1.17)	0.97 (1.21)	0.93 (1.20)	1.04 (1.24)
	F test		NS	Sig	Sig	Sig	NS	Sig	Sig	Sig	NS	sig	sig	Sig
	SE(m)±		0.06	0.06	0.05	0.06	0.04	0.05	0.07	0.06	0.0	0.06	0.06	0.05
	CD at 5%		0.19	0.20	0.18	0.20	0.15	0.16	0.21	0.20	0.21	0.20	0.18	0.16

(Figures in parentheses are square root transformed value.)

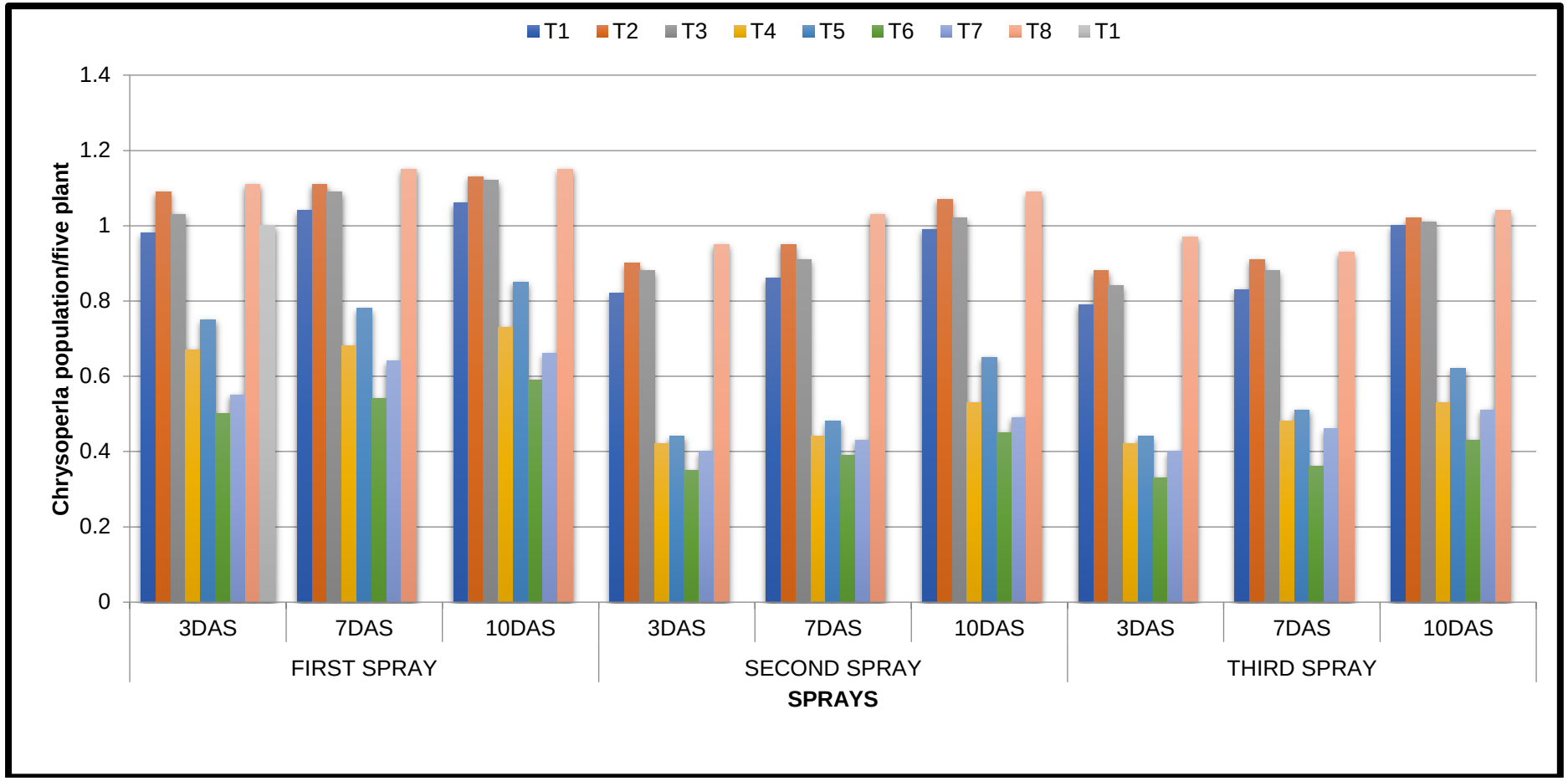

Fig:16 Effect of different treatments on *Chrysoperla* / five plant population at 3,7 and 10 days after three spray

Eggs of *Chrysoperla spp.*

Larvae of *Chrysoperla spp.*

Adult of*Chrysoperla spp.*

Plate 7 : Life stages of *Chrysoperla spp.*

At second spray

In the present investigation the data recorded at 3 days after spray the maximum no. of *Chrysoperla* population found in (T_8) control water (0.95/plant),followed by (T_2) Neem oil (0.90/plant),NSKE (T_3) (0.88/plant) and (T_1)*Lecanicillium lecanii* (0.82/plant) were found at par with each other. Among the insecticidal treatments lowest no.of population found in Thiamethoxam 0.005 per cent (0.35/plant).

The data recorded at 7 days after second spray revealed that, the maximum no. of *Chrysoperla* population found in (T_8) control water(1.03/plant),followed by (T_2) Neem oil (0.95/plant),NSKE (T_3) (0.91/plant) and (T_1)*Lecanicillium lecanii* (0.86/plant) were found at par with each other. Among the insecticidal treatments lowest no.of population found in Thiamethoxam 0.005 per cent (0.39/plant).

The data recorded at 10 days after second spray revealed that, the maximum no. of *Chrysopela* population found in (T_8) control water (1.09/plant), followed by (T_2) Neem oil (1.07/plant),NSKE (T_3) (1.02/plant) and (T_1)*Lecanicillium lecanii* (0.99/plant) were found at par with each other.Among the insecticidal treatments lowest no.of population found in Thiamethoxam 0.005 per cent (0.45/plant).

At third spray

In the present investigation the data recorded at 3 days after spray the maximum no.of*Chrysoperla* population found in (T_8) control water(0.97/plant),followed by (T_2) Neem oil (0.88/plant),NSKE (T3) (0.84/plant) and (T_1)*Lecanicillium lecanii* (0.79/plant) were found at par with each other. Among the insecticidal treatments lowest no.of population found in Thiamethoxam 0.005 per cent (0.33/plant).

The data recorded at 7 days after third spray revealed that, the maximum no. of *Chrysoperla* population found in (T_8) control water (0.93/plant),followed by (T_2) Neem oil (0.91/plant),NSKE (T3) (0.88/plant) and (T_1)*Lecanicillium lecanii* (0.83/plant) were found at par

with each other. Among the insecticidal treatments lowest no.of population found in Thiamethoxam 0.005 per cent (0.36/plant).

The data recorded at 10 days after third spray revealed that, the maximum no. of *Chrysoperla* population found in (T_8) control water (1.04/plant), followed by (T_2) Neem oil (1.02/plant),NSKE (T3) (1.01/plant) and (T_1)*Lecanicillium lecanii* (1.00/plant) were found at par with each other. Among the insecticidal treatments lowest no.of population found in Thiamethoxam 0.005 per cent (0.43/plant).

The present finding correlates with the studies of Kaethner (1999) who reported that, neem seed extract and neem oil were harmless to the egg and larvae of *Chrysoperlacarnea* Steph and *Coccinella septumpunctata* Thumb*.* Rosaih (2001b) reported that, increased activity of natural enemies in plot treated with botanicals insecticides.

Anitha (2007) studied the effect of botanicals and mycopathogens against coccinellid and *chrysoperla* predator of okra sucking pests and revealed that the treatment Neem oil 2 per cent , NSKE 5 per cent, azadirachtin and *V.lecanii* were found safer against population of coccinellid and *chrysoperla* because predatory population in all these treatments was found at par with control.These findings matched more or less with the present findings.

4.6.3 Effect of different treatments on spider/five plant population at 3,7 and 10 days after three spraying.

At first spray

The data on effect of different treatments on spider in cotton presented in Table 10 and fig 17 revealed that all the treatments were significantly superior .In the present investigation the data recorded at 3 days after spray the maximum no. of spider population found in (T_8) control water(1.44/plant),followed by (T_2) Neem oil (1.43/plant),NSKE (T3) (1.38/plant) and (T_1)*Lecanicillium lecanii* (1.35/plant) were found at

par with each other. Among the insecticidal treatments lowest no.of population found in Thiamethoxam 0.005 per cent (0.65/plant).

The data recorded at 7 days after first spray revealed that, the maximum no. of spider population found in (T_8) control water (1.52/plant),followed by (T_2) Neem oil (1.47/plant), NSKE(T3) (1.43/plant) and (T_1)*Lecanicillium lecanii* (1.41/plant) were found at par with each other. Among the insecticidal treatments lowest no.of population found in Thiamethoxam 0.005 per cent (0.66/plant).

The data recorded at 10 days after first spray revealed that, the maximum no. of spider population found in (T_8) control water(1.65/plant),followed by (T_2) Neem oil (1.51/plant),NSKE (T3) (1.50/plant) and (T_1)*Lecanicillium lecanii* (1.46/plant) were found at par with each other. Among the insecticidal treatments lowest no.of population found in Thiamethoxam 0.005 per cent (0.78/plant).

At second spray

In the present investigation the data recorded at 3 days after spray the maximum no. of spider population found in (T_8) control water(1.53/plant),followed by (T_2) Neem oil (1.50/plant),NSKE (T3) (1.45/plant) and (T_1)*Lecanicillium lecanii* (1.38/plant) were found at par with each other. Among the insecticidal treatments lowest no.of population found in Thiamethoxam 0.005 per cent (0.55/plant).

Table 10 : Effect of different treatments on spider / five plant population at 3,7 and 10 days after three spraying

Tr. No.	Treatment	Dose	Population of spider/five plant											
			First spray				Second spray				Third spray			
			1DBS	3DAS	7DAS	10DAS	1DBS	3DAS	7DAS	10DAS	1DBS	3DAS	7DAS	10DAS
T1	*Lecanicillium lecanii* ($1x10^8$cfu/g)	4g/l	1.40 (1.38)	1.35 (1.36)	1.41 (1.38)	1.46 (1.39)	1.46 (1.40)	1.38 (1.37)	1.44 (1.39)	1.36 (1.36)	1.48 (1.41)	1.47 (1.40)	1.50 (1.41)	1.56 (1.43)
T2	Neem oil 2%	20ml	1.38 (1.37)	1.43 (1.38)	1.47 (1.40)	1.51 (1.41)	1.42 (1.38)	1.50 (1.41)	1.52 (1.44)	1.58 (1.44)	1.46 (1.40)	1.54 (1.42)	1.60 (1.45)	1.65 (1.46)
T3	Neem Seed Kernel Extract 5%	50ml	1.45 (1.40)	1.38 (1.37)	1.43 (1.38)	1.50 (1.41)	1.54 (1.43)	1.45 (1.39)	1.49 (1.40)	1.46 (1.39)	1.58 (1.44)	1.50 (1.41)	1.52 (1.42)	1.58 (1.44)
T4	Imidacloprid17.8SL	0.008%	1.50 (1.41)	0.93 (1.18)	0.98 (1.21)	1.10 (1.26)	1.54 (1.46)	0.96 (1.21)	1.05 (1.24)	1.18 (1.30)	1.56 (1.44)	1.06 (1.25)	1.10 (1.27)	1.31 (1.34)
T5	Flonicamid 50WG	0.02%	1.60 (1.45)	1.08 (1.26)	1.18 (1.29)	1.28 (1.33)	1.64 (1.43)	1.06 (1.25)	1.15 (1.28)	1.34 (1.35)	1.65 (1.46)	1.10 (1.26)	1.15 (1.28)	1.35 (1.36)
T6	Thiamethoxam 25WG	0.005%	1.50 (1.41)	0.65 (1.07)	0.66 (1.11)	0.78 (1.13)	1.40 (1.38)	0.55 (1.01)	0.62 (1.06)	0.62 (1.06)	1.48 (1.41)	0.84 (1.15)	0.85 (1.16)	1.20 (1.30)
T7	Acetamiprid 20SP	0.004%	1.30 (1.34)	0.73 (1.10)	0.74 (1.11)	1.08 (1.25)	1.51 (1.42)	0.84 (1.15)	0.92 (1.19)	1.10 (1.26)	1.56 (1.43)	0.91 (1.18)	0.96 (1.21)	1.25 (1.32)
T8	Control(water spray)		1.42 (1.39)	1.44 (1.39)	1.52 (1.42)	1.65 (1.46)	1.48 (1.34)	1.53 (1.42)	1.57 (1.43)	1.64 (1.46)	1.50 (1.41)	1.58 (1.43)	1.65 (1.46)	1.70 (1.48)
	F test		NS	Sig	sig	Sig	NS	Sig	Sig	Sig	NS	Sig	sig	Sig
	SE(m)±		0.08	0.07	0.07	0.06	0.10	0.06	0.07	0.07	0.08	0.06	0.06	0.06
	CD at 5%		0.25	0.23	0.23	0.20	0.32	0.21	0.24	0.23	0.25	0.20	0.21	0.18

(Figures in parentheses are square root transformed value.)

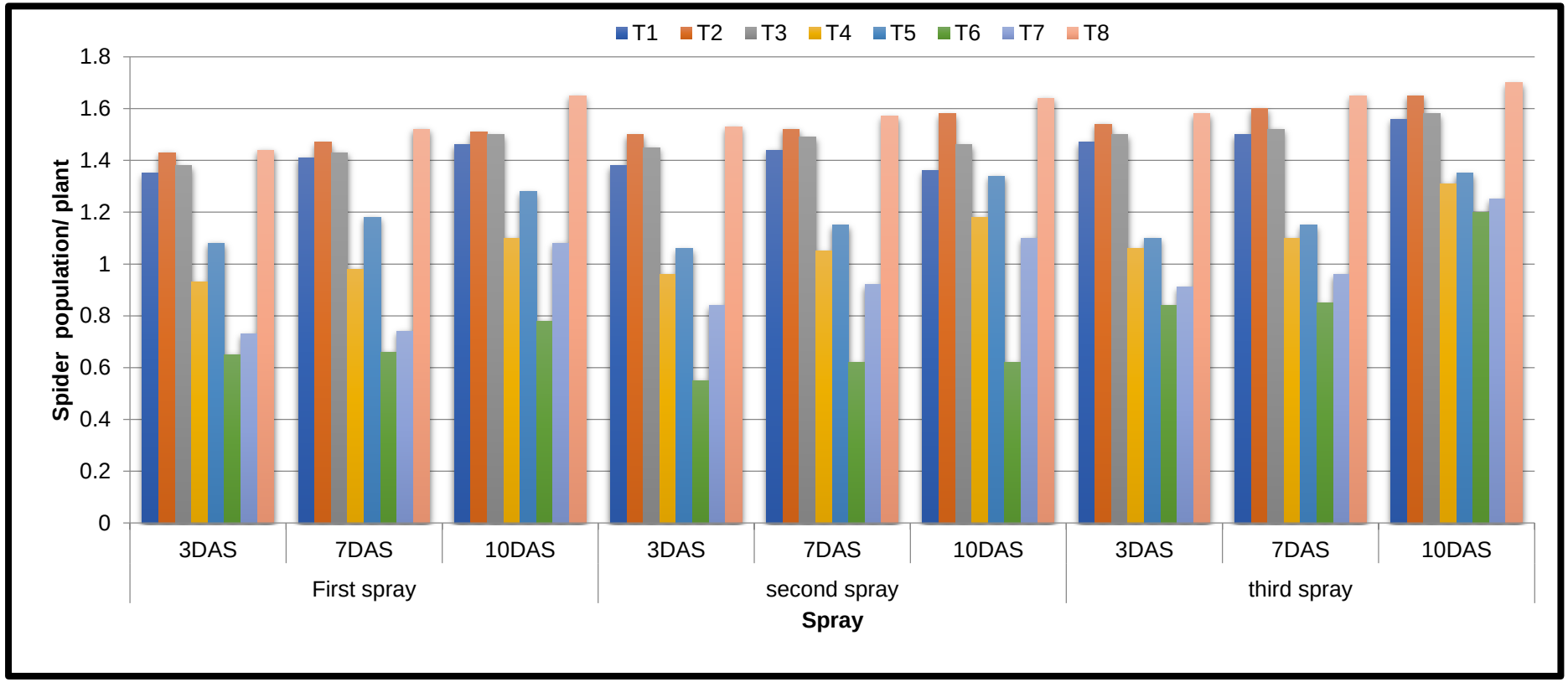

Fig:17 Effect of different treatments on Spider/ five plant populationat 3,7 and 10 days after three spray

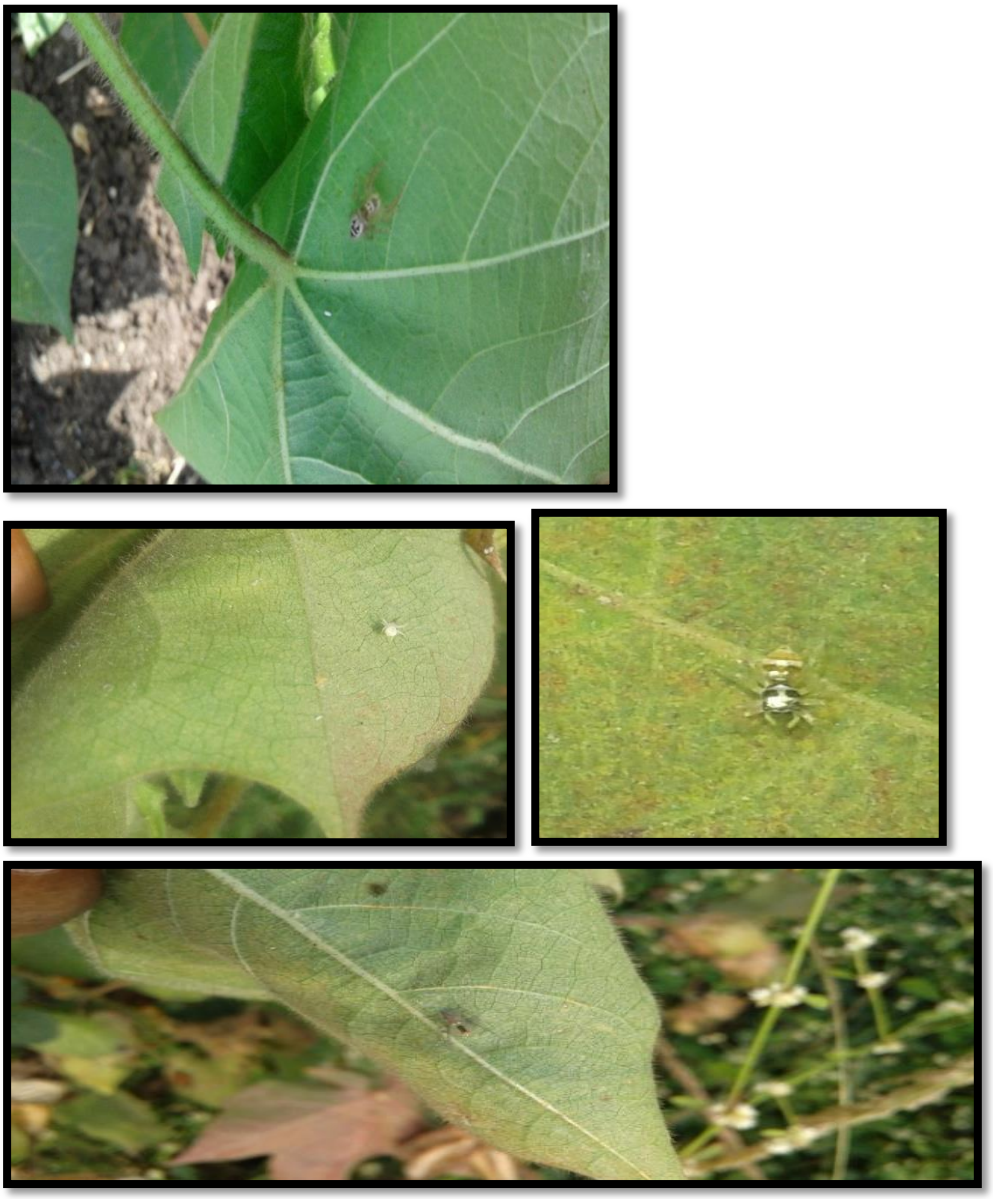

Plate 8: Different spiders on cotton leaf

The data recorded at 7 days after second spray revealed that, the maximum no. of spider population found in (T_8) control water(1.57/plant),followed by (T_2) Neem oil (1.52/plant),NSKE (T3) (1.49/plant) and (T_1)*Lecanicillium lecanii* (1.44/plant) were found at par with each other. Among the insecticidal treatments lowest no.of population found in Thiamethoxam 0.005 per cent (0.62/plant).

The data recorded at 10 days after second spray revealed that, the maximum no. of spider population found in (T_8) control water(1.64/plant),followed by (T_2) Neem oil (1.58/plant),NSKE (T3) (1.46/plant) and (T_1)*Lecanicillium lecanii* (1.36/plant) were found at par with each other. Among the insecticidal treatments lowest no.of population found in Thiamethoxam 0.005 per cent (0.62/plant).

However, numerically more number of natural enemies was observed in untreated control plot. Halappa and patil (2014) These findings matched more or less with the present findings.

At third spray

In the present investigation the data recorded at 3 days after spray the maximum no. of spider population found in (T_8) control water (1.58/plant), followed by (T_2) Neem oil (1.54/plant),NSKE (T_3) (1.50/plant) and (T_1)*Lecanicillium lecanii* (1.47/plant) were found at par with each other. Among the insecticidal treatments lowest no.of population found in Thiamethoxam 0.005 per cent (0.84/plant).

The data recorded at 7 days after third spray revealed that, the maximum no. of spider population found in (T_8) control water(1.65/plant),followed by (T_2) Neem oil (1.60/plant),NSKE (T3) (1.52/plant) and (T_1)*Lecanicillium lecanii* (1.50/plant) were found at par with each other. Among the insecticidal treatments lowest no.of population found in Thiamethoxam 0.005 per cent (0.85/plant).

The data recorded at 10 days after third spray revealed that, the maximum no. of spider population found in (T_8) control water (1.70/plant),followed by (T_2) Neem oil (1.65/plant),NSKE (T_3) (1.58/plant) and (T_1)*Lecanicillium lecanii* (1.56/plant) were found at par with each other. Among the insecticidal treatments lowest no.of population found in Thiamethoxam 0.005 per cent (1.20/plant).

Varghese (2003) noticed that various organic and botanicals were quite safe to coccinellids and predatory mites which was found comparable to untreated plots. These findings matched more or less with the present findings.

Rosaih (2001a) who reported that , natural enemies like syrphids and spiders survive in all botanicals treatments and were almost equal to untreated control (1.87 spiders and 2.70 syrphids/plant) as compared to monocrotophos (0.41 spiders and 1.66 syrphids/5 plants).

4.7 Coccinellids

4.7.1 Cumulative effect of different treatments on mean population of coccinellids at mean of 3, 7 and 10 days after three spraying

After first spray

The Coccinellids (grub and adults count, in all the treatments were uniform a day before spraying as indicated by the non –significant difference among the treatments.

The data presented in table 11 and depicted in fig.18 on the population of Coccinellids (grubs and adulits) after 3,7 and 10 DAS revealed that, the predator population was spared in all the treatments, However,Thiamethoxam 0.005 per cent (0.90 coccinellids /plant) recorded relatively lower population of Coccinellids. Mean population of Coccinellids after 3,7 and 10 DAS during first spray indicated that, untreated control (1.65/plant), Neem oil 2.0 per cent (1.62/plant),NSKE 5.0 per cent (1.55/plant)*LecanicilliumSpp.* @4g/l(1.50 /plant), recorded equivalent population of Coccinellids as they were statistically at par control.

The predator population in the plot treated with Flonicamid 0.02 per cent (1.11/plant),Imidacloprid 0.008 per cent (1.08 /plant) and Acetamiprid 0.004 per cent (0.90/plant) was reduced significantly over control.

After second spray

The Coccinellids (grub and adults count, in all the treatments were uniform a day before spraying as indicated by the non –significant difference among the treatments.

The data presented in table 11 and depicted in fig.18 on the population of Coccinellids (grubs and adulits) after 3,7 and 10 DAS revealed that, the predator population was spared in all the treatments, However,Thiamethoxam 0.005 per cent (0.84/plant) recorded relatively lower population of Coccinellids. Mean population of Coccinellids after 3,7 and 10 DAS during second spray indicated that untreated control (1.65/plant), Neem oil 2.0 per cent (1.64/plant), NSKE 5.0 per cent (1.58/plant)*LecanicilliumSpp.*@4g/l(1.53 /plant), recorded equivalent population of Coccinellids as they were statistically at par control.

The predator population in the plot treated with Flonicamid 0.02 per cent (1.16/plant),Imidacloprid 0.008 per cent (1.12 /plant) and Acetamiprid 0.004 per cent (1.11/plant) was reduced significantly over control.

After third spray

The Coccinellids (grub and adults count, in all the treatments were uniform a day before spraying as indicated by the non –significant difference among the treatments.

The data presented in table 11 and depicted in fig.18 on the population of Coccinellids (grubs and adulits) after 3,7 and 10 DAS revealed that, the predator population was spared in all the treatments, However,Thiamethoxam 0.005 per cent (0.88 /plant) recorded relatively lower population of Coccinellids. Mean population of Coccinellids after 3,7 and 10 DAS during first spray indicated that untreated control (1.70/plant), Neem oil 2.0 per cent (1.67/plant), NSKE 5.0 per cent (1.66/plant)*LecanicilliumSpp.*@4g/l(1.54 /plant), recorded equivalent population of Coccinellids as they were statistically at par control.

Table 11: Cumulative effect of different treatments on Natural enemies at mean of 3,7 and 10 days after three spray

Tr No	Treatment	Dose	Coccinellids			*Chrysoperla*			Spider		
			First Spray	Second spray	Third spray	First spray	Second spray	Third spray	First Spray	Second spray	Third spray
T1	*Lecanicillium lecanii* ($1x10^8$cfu/g)	4g/l	1.50 (1.41)	1.53 (1.43)	1.54 (1.43)	1.03 (1.24)	0.89 (1.18)	0.87 (1.17)	1.41 (1.38)	1.39 (1.38)	1.51 (1.42)
T2	Neem oil	20ml	1.62 (1.45)	1.64 (1.46)	1.67 (1.47)	1.10 (1.26)	0.97 (1.21)	0.94 (1.20)	1.47 (1.40)	1.53 (1.43)	1.60 (1.45)
T3	Neem Seed Kernel Extract 5%	50ml	1.55 (1.43)	1.58 (1.44)	1.66 (1.47)	1.09 (1.26)	0.94 (1.20)	0.91 (1.19)	1.44 (1.39)	1.47 (1.40)	1.53 (1.43)
T4	Imidacloprid17.8 SL	0.008%	1.08 (1.26)	1.12 (1.27)	1.15 (1.28)	0.69 (1.09)	0.46 (0.98)	0.48 (0.99)	1.00 (1.23)	1.06 (1.25)	1.16 (1.29)
T5	Flonicamid 50WG	0.02%	1.11 (1.27)	1.16 (1.29)	1.20 (1.30)	0.79 (1.14)	0.52 (1.01)	0.52 (1.01)	1.18 (1.30)	1.18 (1.30)	1.20 (1.30)
T6	Thiamethoxam 25WG	0.005%	0.90 (1.18)	0.84 (1.16)	0.88 (1.17)	0.54 (1.02)	0.40 (0.95)	0.37 (0.93)	0.70 (1.09)	0.60 (1.05)	0.96 (1.21)
T7	Acetamiprid 20SP	0.004%	1.00 (1.22)	1.11 (1.27)	1.13 (1.28)	0.62 (1.06)	0.44 (0.97)	0.46 (0.98)	0.85 (1.16)	0.95 (1.20)	1.04 (1.24)
T8	Control (water spray)		1.65 (1.47)	1.65 (1.47)	1.70 (1.48)	1.14 (1.28)	1.02 (1.23)	0.98 (1.22)	1.54 (1.43)	1.58 (1.44)	1.64 (1.46)
	F test		Sig	Sig	Sig	Sig	Sig	Sig	sig	Sig	Sig
	SE(m)±		0.01	0.01	0.02	0.05	0.006	0.007	0.01	0.01	0.01
	CD at 5%		0.04	0.06	0.07	0.02	0.02	0.02	0.04	0.04	0.05

(Figures in parentheses are square root transformed value)

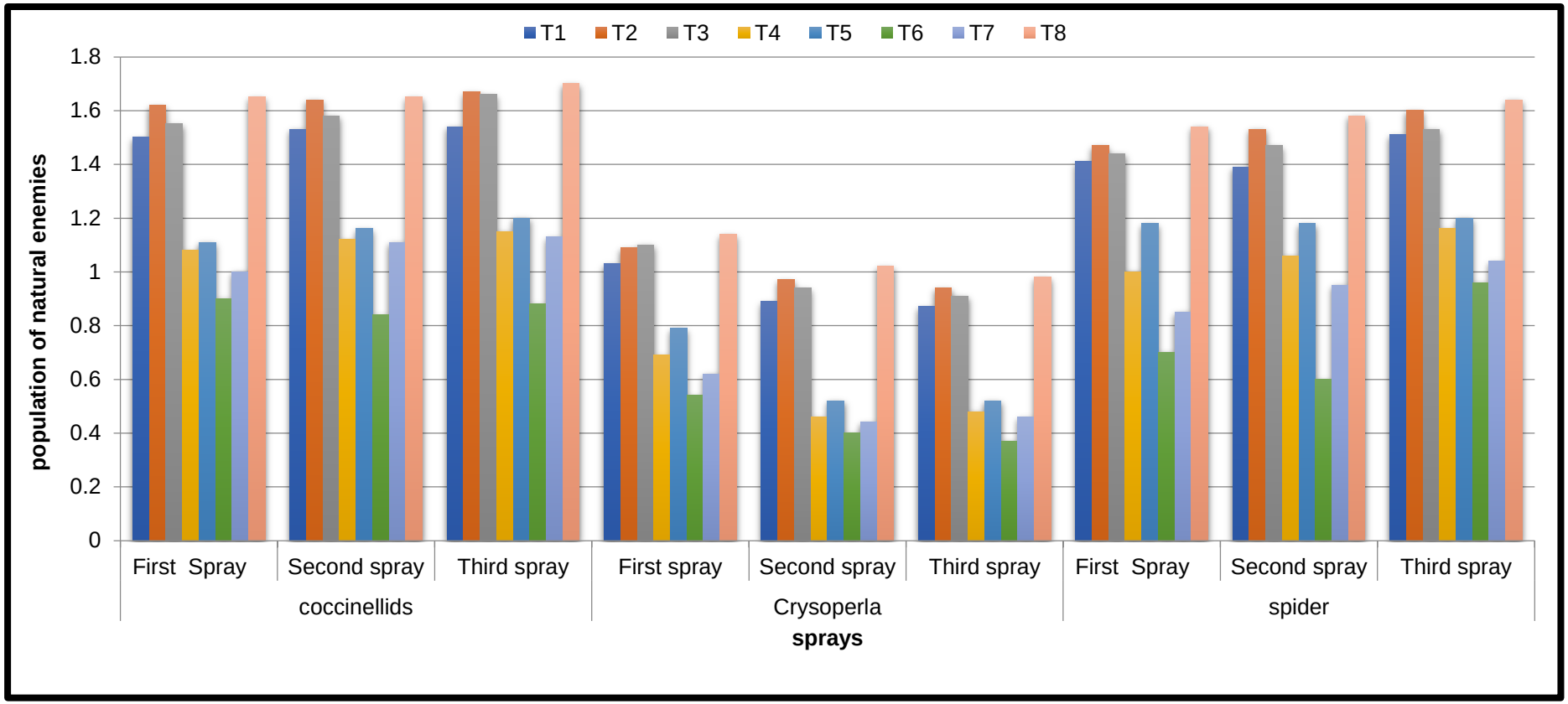

Fig :18 cumulative effect of different treatments on natural enemies after three spraying

The predator population in the plot treated with Flonicamid 0.02 per cent (1.20/plant),Imidacloprid 0.008 per cent (1.15/plant) and Acetamiprid 0.004 per cent (1.13/plant) was reduced significantly over control.

4.8 *Chrysoperla*

4.8.1 Cumulative effect of different treatments on mean population of *Chrysoperla* at 3, 7 and 10 days after three spraying

After first spray

The *Chrysoperla* count, in all the treatments were uniform a day before spraying as indicated by the non–significant differenc among the treatments.

The data presented in table 11 and depicted in fig.18 on the population of *Chrysoperla* after 3,7 and 10 DAS revealed that the predator population was spared in all the treatments, However,Thiamethoxam 0.005 per cent (0.69 /plant) recorded relatively lower population of *Chrysoperla*. Mean population of *Chrysoperla* after 3,7 and 10 DAS during first spray indicated that,untreated control (1.14/plant), Neem oil 2.0 per cent (1.10/plant),NSKE 5.0 per cent (1.09/plant)*LecanicilliumSpp.* @4g/ l 1.09/plant), recorded equivalent population of *chrysoperla* as they were statistically at par control.

The predator population in the plot treated with Flonicamid 0.02 per cent (0.79 /plant),Imidacloprid 0.008 per cent (0.69 /plant) and Acetamiprid 0.004 per cent (0.62/plant) was reduced significantly over control.

After second spray

The *chrysoperla* count, in all the treatments were uniform a day before spraying as indicated by the non–significant difference among the treatments.

The data presented in table 11 and depicted in fig.18 on the population of *Chrysoperla* after 3,7 and 10 DAS revealed that, the predator population was spared in all the treatments, However,Thiamethoxam 0.005 per cent (0.40 /plant) recorded relatively lower population of *Chrysoperla*. Mean population of *chrysoperla* after 3,7 and 10 DAS during second spray indicated that untreated control (1.02/plant), Neem oil 2.0 per cent (0.97/plant),NSKE 5.0 per cent (0.94/plant) and *Lecanicillium Spp.* @4g/l(0.89/plant), recorded equivalent population of *chrysoperla* as they were statistically at par control.

The predator population in the plot treated with Flonicamid 0.02 per cent (0.52 /plant), Imidacloprid 0.008 per cent (0.46/plant) and Acetamiprid 0.004 per cent (0.44/plant) was reduced significantly over control.

After third spray

The *Chrysoperla* count, in all the treatments were uniform a day before spraying as indicated by the non–significant difference among the treatments.

The data presented in table 11 and depicted in fig.18 on the population of *Chrysoperla* after 3,7 and 10 DAS revealed that, the predator population was spared in all the treatments, However,Thiamethoxam 0.005 per cent (0.37/plant) recorded relatively lower population of *Chrysoperla*. Mean population of *Chrysoperla* after 3,7 and 10 DAS during third spray indicated that, untreated control (0.98/plant), Neem oil 2.0 per cent (0.94/plant),NSKE 5.0 per cent (0.91/plant)*LecanicilliumSpp.* @4g/l(0.87/plant), recorded equivalent population of *Chrysoperla* as they were statistically at par control.

The predator population in the plot treated with Flonicamid 0.02 per cent (0.52 /plant), Imidacloprid 0.008 per cent (0.48/plant) and Acetamiprid 0.004 per cent (0.46/plant) was reduced significantly over control.

4.9 Spider

4.9.1 Cumulative effect of different treatments on mean population of Spider at 3, 7 and 10 days after three spraying

After first spray

The Spider count, in all the treatments were uniform a day before spraying as indicated by the non–significant difference among the treatments.

The data presented in table 11 and depicted in fig.18 on the population of Spider after 3,7 and 10 DAS revealed that, the predator population was spared in all the treatments, However,Thiamethoxam 0.005 per cent (0.70/plant) recorded relatively lower population of spider. Mean population of spider after 3,7 and 10 DAS during first spray indicated that untreated control (1.54/plant), Neem oil 2.0 per cent (1.47/plant), NSKE 5.0 per cent (1.44/plant)*LecanicilliumSpp.* @4g/l(1.41 /plant), recorded equivalent population spider as they were statistically at par control.

The predator population in the plot treated with Flonicamid 0.02 per cent (1.18/plant), Imidacloprid 0.008 per cent (1.0/plant) and Acetamiprid 0.004 per cent (0.85/plant) was reduced significantly over control.

After second spray

The spider count, in all the treatments were uniform a day before spraying as indicated by the non –significant difference among the treatments

The data presented in table 11 and depicted in fig.18 on the population of spider after 3,7 and 10 DAS revealed that, the predator population was spared in all the treatments, However,Thiamethoxam 0.005 per cent (0.60/plant) recorded relatively lower population of spider. Mean population of spider after 3,7 and 10 DAS during second spray indicated that untreated control (1.58/plant), Neem oil 2.0 per cent (1.55/plant),NSKE 5.0 per cent (1.49/plant)*LecanicilliumSpp.*

@4g/l(1.43/plant), recorded equivalent population spider as they were statistically at par control.

The predator population in the plot treated with Flonicamid 0.02 per cent (1.18/plant), Imidacloprid 0.008 per cent (1.06/plant) and Acetamiprid 0.004 per cent (0.95/plant) was reduced significantly over control.

After third spray

The spider count, in all the treatments were uniform a day before spraying as indicated by the non–significant difference among the treatments.

The data presented in table 11 and depicted in fig.18 on the population of spider after 3,7 and 10 DAS revealed that, the predator population was spared in all the treatments, However,Thiamethoxam 0.005 per cent (0.96/plant) recorded relatively lower population of spider. Mean population of spider after 3,7 and 10 DAS during third spray indicated that untreated control (1.64/plant), Neem oil 2.0 per cent (1.60/plant),NSKE 5.0 per cent (1.53/plant)*LecanicilliumSpp.* @4g/l(1.51/plant), recorded equivalent population spider as they were statistically at par control.

The predator population in the plot treated with Flonicamid 0.02 per cent (1.20/plant), Imidacloprid 0.008 per cent (1.16/plant) and Acetamiprid 0.004 per cent (1.04/plant) was reduced significantly over control.

5.1. Seasonal incidence of sucking pests on cotton

5.1.1 Seasonal incidence of aphids

The data on seasonal incidence on aphid during kharif 2018 (Table.12 and Fig.19) revealed that the incidence of aphid initiated during 29th standard week (0.8 aphid/three leaves) and Countiued upto 49th SMW gradually attained maximum (17.53 aphids/three leaves) during 39rd standard week. Population was decreased in 48th standard week (6.0aphids /3leaves).

The Trend of aphids infestation were more or less similer with the report of Bhute *et al*.(2012)where in the incidence of aphids was highest during 37th SMW.

5.1.2 Correlation analysis of Aphids

The correlation coefficient was compared between the aphid population and whether parameters.The analysis in the Table.13 revealed that aphid population negative non-significant with rainfall (r=-368),positively significant with maximum temperature (r=0.781**) and minimum temperature (r=0.614**), negative significant with morning relative humidity (r=-0.525*)and evening humidity (r=-0.514*).

These findings are in harmony with the results ofSrinivasa Rao (2004) reported that the minimum temperature had significant positive influence on the aphid population.Mohapatra (2008) reported that the temperature showed positive significant correlation with the population of aphids on cotton.

5.1.3 Seasonal incidence of Jassids

The data on seasonal incidence on jassid during kharif 2018 (Table.12 and Fig.19) revealed thatIncidence of jassid initiated during 29th standard week (0.2 jassid/threeleaves) and gradually attained maximum (10.2 jassid/three leaves) during 37th standard week.Population was decreased from 38th standard week onwards.

The Trend of aphids infestation were more or less similer with the report ofRajput *et al*.(2010) reported the peak incidence of jassids on cotton in 3rd - 9th September to 17th -23rd September with maximum population in 37th SMW.

5.1.3 Correlation analysis of Jassids

Incidence jassid was positive significantly correlated with maximum temperature (r= 583**) and with min temperature (r=0.710**).

While the association was negative non-significant relationship morning with relative humidity (r=-0.202),evening humidity (r=-0.201) and rainfall (r=-0.230) (Table 13).

These findings are in harmony with the results ofMurugesan *et al.* (2004) reported positive correlation between maximum temperature and wind velocity on the population of leafhopper, while the correlation was negative with sunshine hours and rainfall. Kalkal *et al.(*2013) reported that Leafhopper and whitefly population was significantly positively correlated with temperature while negatively correlated with rainfall.

5.1.4Seasonal incidence of thrips

The data on seasonal incidence on thrips during kharif 2018(Table 12 and Fig.19) revealed that Incidence of thrips initiated during 29th standard week (1.2 thrips/three leaves) and its peak incidence (8.4 thrips/three leaves) during 37th standard week.similer result with Soujanya *et al*.(2010) reported the peak incidence of thrips on 35th to 37th standard week.

5.1.5 Correlation analysis of thrips

Incidence of thrips was positive significantly correlated with maximum temperature (r=0.459*) and with minimum temperature (r=0.750) positive non-significant correlation with morning humidity(r=0.0030)and evening humidity(r=0.065).highly non-significant negative relationship with rainfall (r=-0.171) (Table 13).

These findings are in harmony with the results ofSoni and Dhakad (2017) reported that rainfall expressed non-significant negative correlation (r = - 0.318) with population of thrips.

Sitaramaraju *et al.* (2010) reported the major activity of thrips during 38th standard weeks. whereas, maximum and minimum temperatures had positive, significant correlation.

5.1.6 Seasonal incidence of whitefly:

Incidence of whitefly initiated during 29th standard week (0.8whitefly/three leaves) and its peak incidence (15.4 whiteflis/three leaves) during 39th standard week. Population was decreased from 40 standard week onwards (Table 12).Kataria *et al.* (2017) revealed that the peak incidence of whitefly was recorded in last fortnight of Septemberin2013(98.60whitefly/3leaves),2014(101.00whitefly/3leaves) and 2016 (38.42whitefly/3leaves).

5.1.7 Correlation analysis of whitefly

Incidence of whitefly per plant was positively significant correlated with maximum temperature (r=0.724**) and minimum temperature (r=0.596**). Negative significant relationship with morning relative humidity (r= -0.467*) and evening relative humidity (r=-0.416*). However non-significant negative relationship was noticed with rainfall (r=-0.325) (Table13).

These findings are in harmony with the results of Shivanna *et al.*(2009) reported significant positive correlation with minimum temperature and population of whitefly.Kedar *et al.* (2016) revealed that evening relative humidity and wind speed had significant negative correlation with whitefly.

Table 12:Seasonal incidence of sucking pests on *Bt* Cotton in relation to weather parameters during *Kharif* – 2018

Month	Meterological week(MW)	Temp ^{0} C		R.H.%		Total Rainfall (mm)	Average No.of sucking pests			
		Max.	Min.	Mor.	Eve.		Aphid	Jasssid	Thrips	Whitefly
July	26	31.5	19.6	79	66	107.6	0	0	0	0
	27	31.5	19.9	86	67	308	0	0	0	0
	28	29.6	19.7	83	76	31.8	0	0	0	0
	29	29.7	20.2	81	75	57	0.8	0.2	1.2	0.8
	30	29	21.9	82	96	45.4	2.8	1.2	3.2	1.3
Aug	31	32.9	22.5	69	51	0	5.6	2.3	3.8	2.9
	32	30.4	22.4	79	68	7.8	6.2	3	4	4.2
	33	30.3	21.7	85	67	35	8.8	5.2	5	4
	34	28.9	22.2	85	71	89.2	3.2	4.2	4.8	1.2
Sep	35	27.8	21.7	86	77	21.4	4.2	6.1	3.5	4.2
	36	29.6	21.1	81	69	25.6	6.8	7.2	7.1	5
	37	33.5	23.4	71	52	0	10.3	10.2	8.4	6.8
	38	33.5	23.6	77	67	44.6	14	8.2	7.2	13.4
	39	33.7	24.1	76	65	0	17.53	8	6.4	15.4
Oct	40	34.7	23.8	72	49	0	15.2	7.1	6	11.4
	41	33.7	22.6	68	44	0	13.8	6.2	5.6	10.6
	42	34.6	23.2	69	40	0	12.12	5.8	3.2	10.2
	43	34.3	21.3	68	41	0	11.6	5	2.6	9.4
Nov	44	31.4	20.8	67	43	0	10.46	4.6	1.8	6.8
	45	32.8	20.1	68	39	0	9.8	3.5	1.2	6.6
	46	33	18.9	67	46	0	9.2	2.6	1	6
	47	32.4	17.3	74	45	0	8.2	2.2	0.8	4
Dec	48	30	16.2	70	32	0	6	1.4	0.6	3.6
	49	28.1	15.4	76	43	16.6	5	1	0.4	3
	50	27.3	14.9	78	67	3.2	0	0	0.2	1.8
	51	25	12.8	78	66	0	0	0	0	0
	52	25.5	11.2	71	69	0	0	0	0	0

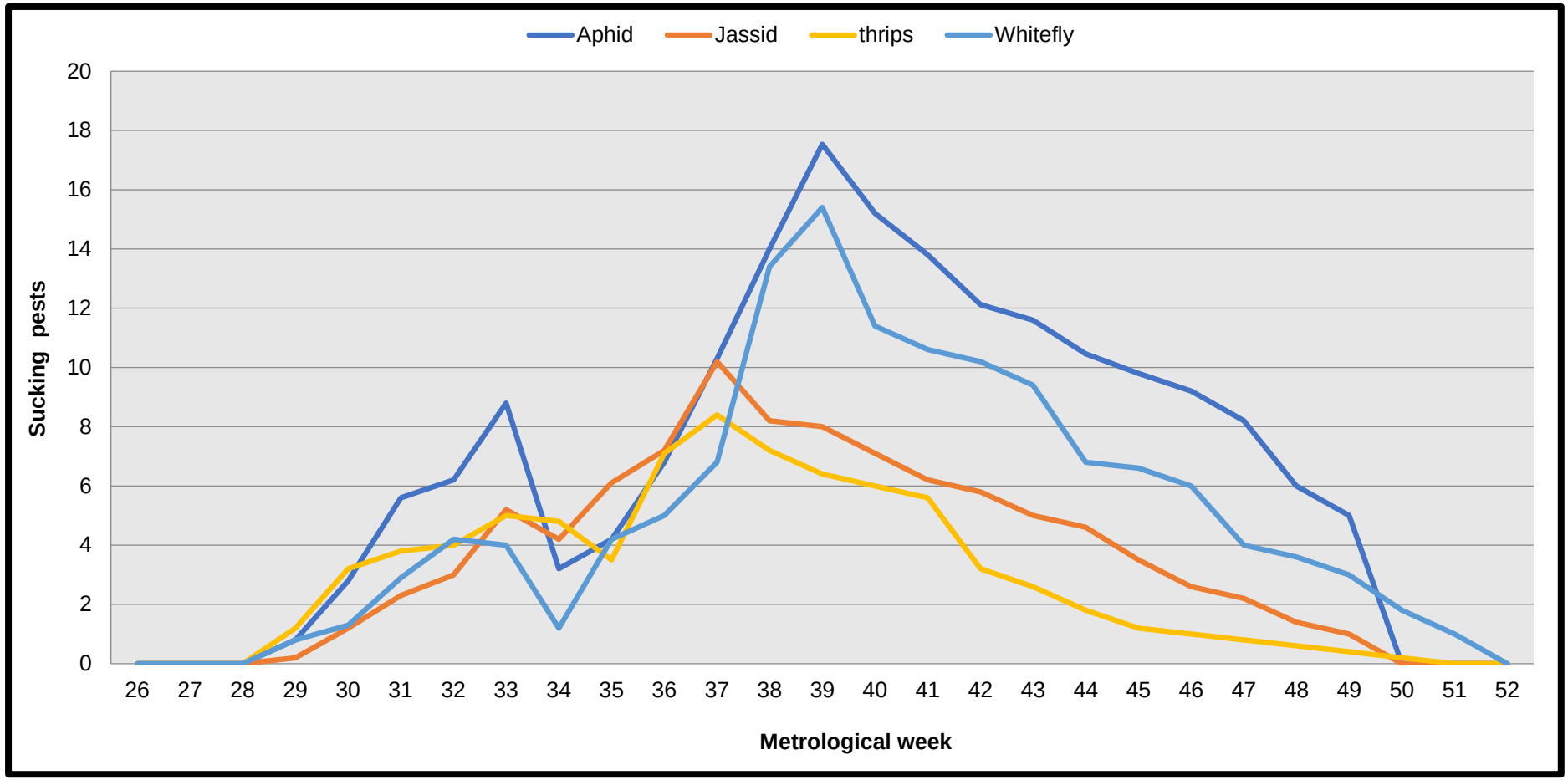

Fig :19 Seasonal incidence of sucking pests on Bt-cotton during 2018

Table13. Correlation between weather parameters and incidence of sucking pests during Kharif 2018.

Sr.No.	Sucking pests	Metrological parameters				
		Temperature (C^0)		Relative humidity (%)		Rainfall (mm)
		Max.	Min	Morning	evening	
		Correlation coefficient ('r') value				
1	Aphid	0.781**	0.614**	-0.525*	-0.514*	-0.368
2	Jassid	0.583**	0.710**	-0.202	-0.203	-0.230
3	Thrips	0.458*	0.750**	0.0030	0.065	-0.171
4	Whitefly	0.736**	0.596**	-0.467*	-0.416*	-0.325

-*Significant at 5% and **Significant at 1%

6.1 Effect of different treatments on yield of *Bt*-cotton

The data presented in Table 14 and graphically illustrated in Fig. 20 revealed that, all the treatments recorded significantly more yield as compared to control plot 7.7 q/ha.Among the treatments, Flonicamid 50WG (T_5) registerd significantly higher yield of 21.48 q/ha with13.78 q/ha increased yield over control.It was significantly superior over rest of the treatments and found at par with the treatment of Acetamiprid 20 SP(T_7) which recorded 17.92 q/ha and 10.22 q/ha increased yield over control.

Next to these treatments the yield recorded in treatment of Imidacloprid 17.8 SL (T_4) obtained 17.62 q/ha and 9.92q/ha increased over control.followed by Thiamethoxam 25 WG (T_6:15.56q/ha) and Neem oil 2.0 per cent (T_2:15.11q/ha) with 7.86q/ha and 7.41q/ha increasing yield over control and these treatments were statistically at par among them.

The remaining treatments (T_3) Neem Seed Extract 5.0 per cent and (T_1) *Lecanicilliumlecanii*.Recorded14.15 q/ha and11.89 q/ha yield with 6.45 q/ha and 4.19 q/ha increasing yield over control.

However,significantly minimum yield recorded with control(T_8: water spray).

Ravi Kumar *et al.* (2016) who reported that, flonicamid 10 WG which was effective against all sucking pests and recorded highest number of bolls per plant (59.33) and yield (23.45 q.ha-1).

Nemade *et al.(*2017) revealed that the highest seed cotton yield (1681.02 Kg/ha.) was obtained from Flonicamid 50% WG @ 75 g a.i./ha.

Table14: Effect of different treatments on yield of cotton (q/ha).

Sr. No.	Treatment	Dose	Seed cotton yield (kg/ha)				Yield of cotton (q/ha)
			RI	RII	RIII	Mean	
T1	*Lecanicillium lecanii* ($1x10^8$cfu/g)	4g/l	2.05	1.60	1.15	1.60	11.89
T2	Neem oil 2 %	20ml/l	2.00	2.01	2.10	2.04	15.11
T3	NSKE 5%	50ml/l	2.24	1.89	1.60	1.91	14.15
T4	Imidacloprid 17.8 SL	0.008%	2.60	2.50	2.05	2.38	17.62
T5	Flonicamid 50 WG	0.02%	3.20	3.00	2.50	2.90	21.48
T6	Thiamethoxam 25 WG	0.005%	2.30	1.60	2.39	2.10	15.56
T7	Acetamiprid 20 SP	0.004%	2.76	2.40	2.10	2.42	17.92
T8	Control (water spray)	-	1.56	1.00	0.59	1.05	7.7
	F test						Sig
	SE(m)±						0.15
	CD at 5%						0.21
	CV						12.82

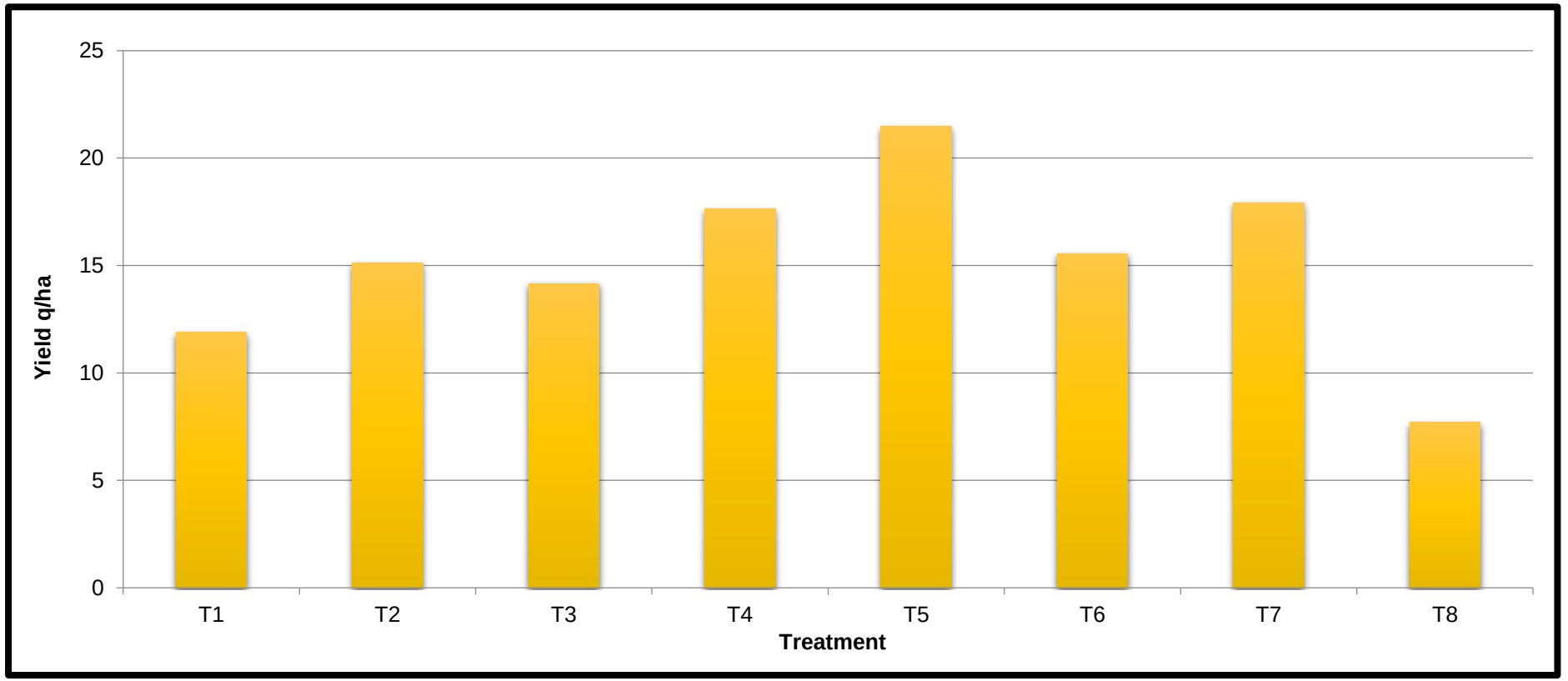

Fig: 20 Effect of different treatment on yield (q/ha)

Chapter V

SUMMARY AND CONCLUSIONS

Cotton is currently the leading plant fibre crop worldwide and is grown commercially in the temperate and tropical regions.Cotton is always an attractive host for several insect pests from sowing to harvesting and globally,.In india with the introduction and successfully implementation of transgenic *bt*-cotton not only solved the problem of bollworm complex but also cut down the number of insecticidal spray which probably lead to severe incidence of sucking pests and occupied major pests status and cause considerable damage in traditional and bt cotton in india at present.For the safer management of these pests a field experiment was carried out at Agricultural Entomology Section, College of Agriculture, Nagpur during *Kharif* 2018 on Management of sucking pests of Bt. Cotton.

7.1 To study the bio-efficacy of pesticides used for sucking pests of *Bt* Cotton.

7.1.1 Aphid

Among the seven insecticides evaluated against aphid infesting the *Bt*cotton, three were of bio-pesticides and four were chemical pesticides.From chemical pesticides,Flonicamid 0.02 per cent found most effective followed by Acetamiprid 0.004 per cent, Imidacloprid 0.008 per cent and Thiamethoxam 0.05 per cent. Among biopesticides, Neem oil 2.0 per cent found more effective followed by NSKE 5.0 per cent and *Lecanicilliumleccanii* 4g/l

7.1.2 Jassid

Among the seven insecticides evaluated against jassid infesting the *Bt*cotton, three were of bio-pesticides and four were chemical pesticides**.** Among bio-pesticides, Neem oil 2.0 per cent found more effective followed by NSKE 5.0 per cent and *Lecanicilliumleccani* 4g/l

Further it was found that the chemical insecticides caused high per cent reduction. Flonicamid 0.02 per cent was top most effective against cotton jassid followed by Imidacloprid 0.008 per cent, Thiamethoxam 0.005 per cent and Acetamiprid 0.004 per cent.

7.1.3 Thrips

Among the seven insecticides evaluated against thrips infesting the *Bt*cotton, three were of bio-pesticides and four were chemical pesticides**.** Flonicamid 0.02 per cent was top most effective against cotton Thrips followed by Imidacloprid 0.008 per cent.Thiamethoxam 0.005 per cent and Acetamiprid 0.004 per cent. Among biopesticides,Neem oil 2.0 per cent found more effective followed by NSKE 5.0 per cent and *Lecanicilliumleccani* 4g/l.

7.1.4 Whitefly

Among the seven insecticides evaluated against whitefly infesting the *Bt*cotton, three were of bio-pesticides and four were chemical pesticides**.** In chemical pesticides Acetamiprid 0.004 per cent found superior to whitefly followed by Flonicamid 0.02 per cent, Imidacloprid 0.008 per cent and Thiamethoxam 0.005 per cent. Among bio-pesticides,Neem oil 2.0 per cent found more effective followed by NSKE 5.0 per cent and *Lecanicilliumleccani* 4g/l.

7.2 To study the effects of pesticides on natural enemies.

7.2.1 Coccinellids

The treatment with bio-pesticides *viz.,*Neem oil 2.0 per cent, NSKE 5.0 per cent and *Lecanicillium spp.* 4g/l were found safer against Coccinellids predator because population was not reduced after their application in the cotton field.

The treatment with chemical pesticides *viz,* Flonicamid 0.02 per cent, Imidacloprid 0.008 per cent and Acetamiprid 0.04 per cent were found moderate safer against coccinellids at 3, 7and 10 DAS during three spray and were statistically at per with each other,while the

treatment Thiamethoxam 0.005 per cent was found with lower coccinellids population at 3,7 and 10 DAS.

7.2.2*Chrysoperla*

The treatment with bio-pesticides *viz.,* Neem oil 2.0 per cent, NSKE 5.0 per cent and *Lecanicillium spp.* 4g/l were found safer against *chrysoperla* because population of the *chrysoperla* was not reduced after their application in the cotton field.

The treatment with chemical pesticides *viz,* Flonicamid 0.02 per cent,Imidacloprid 0.008 per cent and Acetamiprid 0.04 per cent were found moderate safer against *chrysoperla* at 3,7 and 10 DAS during three spray and were statistically at per with each other, while the treatment thiamethoxam 0.005 per cent was found with lower *chrysoperla* population at 3, 7 and 10 DAS.

7.2.3 Spider

The treatment with biopesticides *viz.,* Neem oil 2.0 per cent, NSKE 5.0 per cent and *Lecanicillium spp.* 4g/l were found safer against spider because population of the spiderwas not reduced after their application in the cotton field.

The treatment with chemical pesticides *viz,* Flonicamid 0.02 per cent,Imidacloprid 0.008 per cent and Acetamiprid 0.04 per cent were found moderate safer against spider at 3,7 and 10 DAS during three spray and were statistically at per with each other,while the treatment Thiamethoxam 0.005 per cent was found with lowerspider population at 3,7 and 10 DAS.

7.3 Seasonal incidence of major insect pests on cotton.

1. Incidence of aphidinitiated during 29th standard week (0.8 /plant) and gradually attained maximum (17.53 larva/mrl) during 39th standard week. Population was decreased from 40th standard week onwards.

2. Incidence of jassid initiated during 29th standard week (0.2 /plant) gradually attained maximum (10.4/plant) during 37th standard week. Population was decreased from 38th standard week onwards.

3. Incidence of thrips initiated during 29th standard week (1.2 /plant) and its peak incidence (8.4/plant) during 37th to 49st standard week.

4. Incidence of whitefly initiated during 29th standard week (0.8/plant) and its peak incidence (15.4/plant) during 39th standard week. Population was decreased from 40st standard week onwards and negligible population was recorded.

7.4 Yield

The data revealed that the crop treated with insecticides produced significantly higher cotton yield over control. However, significantly highest yield was obtained from the plot treated with Flonicamid 0.02 per cent and it was statistically at par with the yield received from the treatment of Acetamiprid 0.004 per cent. The crop treated with Imidacloprid 0.008 per cent and Thiamethoxam 0.005 per cent were statistically at par with each other.

The crop treated with biopesticides highest yield obtained from the plot Neem oil 2.0 per cent followed by NSKE 5.0 per cent and *Lecanicillium leccanii*4g/l.

From the above findings of present investigations following conclusions could be drawn:

1. Flonicamid 0.02 per cent was found maximum reduction in aphid population. The next best treatments was Acetamiprid 0.004 per cent followed by Imidacloprid 0.008 per cent and Thiamethoxam 0.005 per cent.

2. The highest effectiveness was observed in Flonicamid 0.02 per cent plot in reducing the jassid population. The next best response was found Imidacloprid 0.008 per cent followed by, Thiamethoxam 0.005 per cent.

3. The population reduction of thrips was found maximum in Flonicamid 0.02 per cent.The next best performances were found in Imidacloprid followed by Thiametoxam and Acetamiprid.

4. The overall reduction in whitefly population was found in Acetamiprid 0.004 per cent further treatment Flonicamid, Imidacloprid and Thiamethoxam.

Effect of various insecticides on field population of natural enemies of cotton sucking pests revealed that the treatment with biopesticides *viz,* Neem oil 2.0 per cent, NSKE 5.0 and *Lecanicillium lecanii*were found safer against Coccinellids, *Chrysoperla* and spider.

The treatment with chemical pesticides Flonicamid 0.02 per cent, Imidacloprid 0.008 per cent and Acetamiprid 0.004 per cent were found moderately safer against population of natural enemies. Thiamethoxam 0.005 per cent toxic to natural enemies.

Chapter VI

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APPENDIX

STATEMENT SHOWING THE WEEKLY METROLOGICAL DATA FOR THE YEAR 2018 RECORDED AT COLLEGE OF AGRICULTURE NAGPUR.

Date		Met Week	Temp ^{0}c		R.H. %		Total Rainfall (mm)	No. of Rainy days	BSH	Wind Speed Km/hr	Evaporation (mm)	Remarks
			Max	Min	Morn	Eve.						
01 – 07	Jan 18	1	27.9	9.6	67.	29	00.0	0	-	1.6	2.4	
08 – 14		2	28.3	9.9	60	26	00.0	0	-	1.9	2.5	
15 – 21		3	29.4	11.2	57	22	00.0	0	-	2.0	2.9	
22 – 28		4	28.6	11.0	47	23	00.0	0	-	1.7	3.0	
29 – 04	Feb 18	5	31.6	10.3	50	16	00.0	0	-	2.0	3.0	
05 – 11		6	31.5	11.6	61	34	00.0	0	-	3.5	2.5	
12 – 18		7	28.2	12.8	71	37	00.0	0	-	1.9	3.7	
19 – 25		8	33.7	14.1	53	25	00.0	0	-	2.1	4.6	
26 -04	Mar 18	9	35.9	15.4	40	23	00.0	0	-	3.1	4.3	
05 – 11		10	34.7	16.1	40	23	00.2	0	-	3.2	4.1	
12 – 18		11	34.8	16.0	54	27	00.0	0	-	3.0	5.7	
19 -25		12	36.2	20.7	45	28	00.0	0	-	3.5	6.8	
26 – 01	Apr 18	13	38.4	22.8	37	22	00.0	0	-	3.5	6.3	
02 – 08		14	39.8	22.0	36	20	03.6	1	-	4.8	6.2	
09 – 15		15	37.1	22.0	49	29	10.2	1	-	4.1	5.4	
16 – 22		16	41.6	21.0	29	16	02.0	0	-	3.1	6.9	
23 – 29		17	42.1	25.4	30	19	00.0	0	-	6.5	7.9	
30 – 06	May18	18	42.2	22.9	37	23	00.0	0	-	4.7	9.5	
07 – 13		19	43.9	22.3	20	13	00.0	0	-	5.4	8.4	
14 – 20		20	43.5	24.8	24	13	00.0	0	-	6.8	9.1	
21 – 27		21	38.1	22.4	27	17	09.4	1	-	7.1	8.2	
28 – 03	Jun 18	22	36.6	21.9	40	23	00.0	0	-	5.1	8.7	
04 – 10		23	36.0	18.3	64	45	76.8	2	-	4.7	7.7	
11 – 17		24	31.5	20.3	55	39	73.8	2	-	4.8	6.2	
18 – 24		25	31.5	20.6	65	47	29.0	2	-	5.6	5.1	
25 – 01	Jul 18	26	31.5	19.6	79	66	107.6	3	-	5.7	7.4	
02 – 08		27	31.5	19.9	86	67	308	7	-	5.1	2.8	
09 – 15		28	29.6	19.7	83	76	31.8	4	-	6.6	3.1	
16 – 22		29	29.7	20.2	81	75	57.0	4	-	9.7	2.3	
23 – 29		30	29.0	21.9	82	96	45.4	2	-	5.6	3.9	
30 – 05	Aug18	31	32.9	22.5	69	51	00.0	0	-	5.7	2.7	
06 – 12		32	30.4	22.4	79	68	07.8	1	-	4.4	2.6	
13 – 19		33	30.3	21.7	85	67	35.0	2	-	5.3	1.0	
20 – 26		34	28.9	22.2	85	71	89.2	2	-	3.1	2.0	
27 – 02	Sep18	35	27.8	21.7	86	77	21.4	2	-	5.3	2.2	
03 – 09		36	29.6	21.1	81	69	25.6	2	-	2.2	3.9	
10 – 16		37	33.5	23.4	71	52	00.0	0	-	1.6	4.5	
17 – 23		38	33.5	23.6	77	67	44.6	1	-	3.0	3.9	
24 – 30		39	33.7	24.1	76	65	00.0	0	-	1.4	3.7	
01 – 07	Oct 18	40	34.7	23.8	72	49	00.0	0	-	1.6	3.7	
08 – 14		41	33.7	22.6	68	44	00.0	2	-	3.0	3.0	
15 – 21		42	34.6	23.2	69	40	00.0	0	-	1.9	2.4	
22 – 28		43	34.3	21.3	68	41	00.0	1	-	1.3	2.8	
29 – 04	Nov 18	44	31.4	20.8	67	43	00.0	0	-	1.5	2.5	
05 – 11		45	32.8	20.1	68	39	00.0	0	-	1.5	3.2	
12 – 18		46	33.0	18.9	67	46	00.0	0	-	1.7	2.8	
19 – 25		47	32.4	17.3	74	45	00.0	0	-	2.9	3.0	
26 – 02	Dec 18	48	30.0	16.2	70	32	00.0	0	-	3.4	2.1	
03 -09		49	28.1	15.4	76	43	16.6	1	-	3.3	1.6	
10 -16		50	27.3	14.9	78	67	3.2	1	-	2.9	2.2	
17 -23		51	25.0	12.8	78	66	00.0	0	-	2.9	2.5	
24 -31		52	25.5	11.2	71	69	00.0	0	-	3.0	2.5	