

**COMPATIBILITY OF DIFFERENT PESTICIDES
AGAINST SUCKING PESTS OF COTTON**

THESIS

**Submitted to
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola
in partial fulfilment of the requirements
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**MASTER OF SCIENCE
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**By
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2019

DECLARATION OF STUDENT

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

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CERTIFICATE

This is to certify that thesis entitled "**COMPATIBILITY OF DIFFERENT PESTICIDES AGAINST SUCKING PESTS OF COTTON**" submitted in partial fulfilment of the requirements 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 **HEMALATHA D** under my guidance and supervision.

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

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(D) ABBREVIATIONS

% - Per cent

/ - Per

@ - at the rate of

AICRP- All India Coordinated Research project

Bt. - *Bacillus thuringensis*

CD - Critical difference

CS - Capsule suspension

CV - Coefficient of variation

DAS - Days after spraying

EC - Emulsifiable concentrate

ETL - Economic Threshold Level

et al. - et alia (and his associates)

etc. - Et cetera

Fig. - Figure

g/gm - gram (s)

GEAC - Genetic Engineering Approval Committee

ha - Hectare

HDPS - High density planting system

i.e. - id est (that is)

ICBR - Incremental Cost Benefit Ratio

kg - kilogram

Kg/ha - Kilogram per hectare

L	-	Litre
Ltd.	-	Limited.
M	-	meter
MgSO ₄	-	Magnesium sulphate
ml	-	millilitre
NAA	-	Naphthalene acetic acid
No.	-	Number
NS	-	Non significant
PDKV	-	Panjabrao Deshmukh Krishi Vidyapeeth
PPM	-	parts per million
q.	-	Quintal
RBD	-	Randomized Block Design
SC	-	Suspension concentration
SG	-	Soluble granule
SL	-	Soluble liquid
SP	-	Soluble powder
SE (m) $\pm$	-	Standard error of mean
Sig.	-	Significant
TNAU	-	Tamil Nadu Agricultural University
viz.,	-	Videlicet (Namely)
VNMKV-	-	Vasantrao Naik Marathwada Krishi Vidyapeeth
WDG	-	Water dispersible granule
WG	-	Wettable granules
WP	-	Wettable powder

(E) THESIS ABSTRACT

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ABSTRACT

An experiment was conducted to study the “Compatibility of different pesticides against sucking pests of cotton” at Department of Agricultural Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth,

Akola, during *kharif* season 2018-19. The experiment was laid in Randomized Block Design with twelve treatments, replicated thrice. The treatments included were, fipronil 5% SC, flonicamid 50% WG, spiromesifen 22.9% SC, diafenthiuron 50% WP, acephate 50% + imidacloprid 1.8% SP alone and in combination with copper oxychloride 50% WP along with untreated control. Three sprays of treatments were applied at 15 days interval to study the comparative efficacy and compatibility of pesticides alone and in combination against sucking pests of cotton. The observations were recorded at an interval of 3, 7, 10 and 14 days after spraying. Similarly, the observations on natural enemies i.e. predators like, coccinellids, chrysopids and spiders were also recorded. Besides, observation on phytotoxicity if any due to tank mixed insecticides and fungicide spray on cotton crop was recorded at 1, 3, 7, 10 and 14 days after each spray. Seed cotton yield data was also recorded from each of the net plot to find out most economical and effective treatment for the management of sucking pests of cotton.

Application of flonicamid 50% WG + copper oxychloride 50% WP proved effective in minimizing the aphid population. However, this treatment was found statistically equal with flonicamid 50% WG, diafenthiuron 50% WP, diafenthiuron 50% WP + copper oxychloride 50% WP, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, acephate 50% + imidacloprid 1.8% SP and spiromesifen 22.9% SC + copper oxychloride 50% WP. Whereas, the treatment of diafenthiuron 50% WP + copper oxychloride 50% WP recorded significantly minimum number of leafhoppers. This treatment was found at par with diafenthiuron 50% WP, flonicamid 50% WG + copper oxychloride 50% WP, flonicamid 50% WG, acephate 50% + imidacloprid 1.8% SP, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, spiromesifen 22.9% SC + copper oxychloride 50% WP and spiromesifen 22.9% SC.

The plots treated with diafenthiuron 50% WP + copper oxychloride 50% WP, diafenthiuron 50% WP, spiromesifen 22.9% SC, spiromesifen 22.9% SC + copper oxychloride 50% WP, flonicamid 50%

WG + copper oxychloride 50% WP and flonicamid 50% WG found equally effective in reducing the population of whiteflies. Significantly, minimum population of thrips was observed in treatment fipronil 5% SC + copper oxychloride 50% WP. However, this treatment was found at par with fipronil 5% SC, diafenthiuron 50% WP + copper oxychloride 50% WP, diafenthiuron 50% WP, flonicamid 50% WG, flonicamid 50% WG + copper oxychloride 50% WP, acephate 50% + imidacloprid 1.8% SP, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP and spiromesifen 22.9% SC.

Treatments under present investigation showed non significant effect on population of natural enemies and no deleterious effect of pesticides treatment was observed on population of natural enemies. Moreover, all the test chemicals viz., fipronil 5% SC, spiromesifen 22.9% SC, flonicamid 50% WG, diafenthiuron 50% WP, acephate 50% + imidacloprid 1.8% SP and their combination with copper oxychloride 50% WP had not caused any phytotoxic symptoms such as injury to leaf tip and leaf surface, wilting, vein clearing, necrosis and epinasty and hyponasty on cotton crop.

All the treatments recorded significant increase in the seed cotton yield compared to untreated control plots. The highest seed cotton yield was obtained in the plots sprayed with diafenthiuron 50% WP + copper oxychloride 50% WP and diafenthiuron 50% WP which were at par with each other. On the basis of economics, flonicamid 50% WG proved to be the most economically viable treatment followed by diafenthiuron 50% WP and acephate 50% + imidacloprid 1.8% SP.

The present findings indicated that the combination of test insecticides with copper oxychloride 50% WP can be suitably incorporated in an integrated pest management programme to protect the cotton crop from sucking pest complex without any negative effect on crops and natural enemies.

CHAPTER I

INTRODUCTION

1.1 Background Information

Cotton is the most important cash crop in India. It plays a dominant role in the industries and agricultural economy of the nation, contributes 1/3rd of total foreign exchange earning of India (Mayee and Rao, 2002).

India is the largest cotton growing country in the world with 35.29 per cent of world cotton area. In India, cotton is cultivated on an area of 122 lakh ha with a production of 377 lakh bales of seed cotton during 2017-18. Average productivity of cotton in India is 524 kg lint/ha. In Maharashtra, *Bt* cotton is cultivated in an area of 41.98 lakh hectares with total production 85 lakh bales with an average productivity of 344 Kg lint per hectare, which is low when compared to world average of 766 kg lint/ha (Anonymous, 2018).

In India, *Bt* cotton since its release in 2002 by Genetic Engineering Approval Committee (GEAC) replaced more and more conventional cotton area. There was an exponential increase in *Bt* cotton area from 29,000 ha in 2002 to 11.16 m ha in 2010 accounting for a staggering 92 per cent of the total cotton area in India. The insect pests are one of the major constraints in achieving optimum yield potential in cotton. In India 162 species of insect pest have been reported on the cotton from sowing to maturity in different cotton growing areas (Dhaliwal and Arora, 1998).

Due to assured protection of bollworms in *Bt* cotton hybrids the area under *Bt* cotton is increasing day by day but at the same time sucking pests has emerged as major threat for cotton growers causing heavy yield losses. Among the sucking pests, leafhopper, *Amrasca biguttula biguttula* (Ishida); thrips, *Thrips tabaci* (Linn); aphids, *Aphis gossypii* (Glover) and whiteflies, *Bemisia tabaci* (Genn.) are the important pests from seedling stage and cause heavy losses in tune of 21.20 to

22.86 per cent (Kulkarani et al. 2003). These sucking pests of cotton cause considerable direct damage such as loss of chlorophyll, stunting of growth, reduction in size of leaf and hence the photosynthetic area and severely affect yield (Jalaluddin et al. 1995).

Apart from this, the diseases like Grey mildew, Alternaria leaf spot and Bacterial blight are also posing threat to cotton cultivation. It requires large number of chemical sprays for managing insect pests and diseases. It is often economical and convenient to apply a mixture of two or more pesticides when a wide range of pests are to be managed.

Present day cotton crop consumes about half of the total pesticides, but does not result in desired control. This may be due to wrong choice of insecticides, improper timing and method of application and development of resistance in insect pests to insecticides. It is a common practice of farmers to use pesticides and their mixtures most frequently without consideration of compatibility and efficacy.

1.2 Importance and need of the study

Plant protection assumed a vital significance in increasing agricultural production. Mixture of two pesticides may produce greater insecticidal action than the sum of the individual components by synergism (Gera, 1973). In general farmers apply insecticides and fungicides together for the control of insect pests and diseases to reduce the cost of plant protection. When tank mixed insecticides and in combination it may be fungicides are applied at farmer level the compatibility may pose a problem.

Incompatibility of pesticide mixtures may occur due to chemical reaction between the individual components or their formulating agents. Physical properties may also likely to change, which affect the efficiency of application and uniform distribution and adherence on plants. Indiscriminate use, without proper understanding of such compatibility, may reduce the efficacy of the combinations in controlling the pests and diseases which results in phytotoxic effects (Kubendran et al. 2008).

Diafenthiuron in combination with carbendazim and copper oxychloride were found to be more effective in reducing the sucking pest

population and foliar diseases incidence in cotton (Bontha and Mallapur, 2017a). The information available on novel insecticides in combination with fungicides that are commonly used by farmers against insect pests and diseases is very scarce. If compatible insecticides and fungicides mixture is used in combination it may be cheaper to the farmer and such combination become useful for the control of both insect pests and diseases without losing their efficacy individually.

Keeping in view the above situation and need, the present investigation was carried out on “Compatibility of different pesticides against sucking pests of cotton” was planned with the following objectives.

1.3 Objectives of study

1. To test the efficacy of pesticides alone and in combination against sucking pests of cotton.
2. To know the phytotoxic effects of different pesticide mixtures.
3. To work out the economics of different treatments.

1.4 Scope

The use of insecticides and fungicides increases production costs considerably, especially if the needed pesticides are applied separately. The primary benefit of mixing pesticides together is a reduction in the number of applications required, which decreases labour costs (Blackshaw et al. 1995) and saves time which are the three major but scarce inputs in agricultural systems nowadays. Furthermore, pesticide mixtures may result in reduction in pest incidence than if either pesticide were applied separately (Warnock and Cloyd, 2005). It has been proposed that pesticide mixtures may delay the onset of resistance developing in pest populations (Bielza et al. 2009).

1.5 Limitations

1. The biological reaction among the components in the mixture may change according to the relative proportion used.

2. The most common problem affecting the spraying operation is physical incompatibility, which can block the nozzles and filters as well as causing separation in the tank.
3. Water temperature and quality may also influence the chemical compatibility of tank mixers.
4. Pesticides should never be mixed unless they are listed as compatible on the label.
5. Application of pesticide combinations at proper time has only given expected result.

1.6Hypothesis

The modern day alarming pest problem warrants immediate action to protect the crop. As there are no broad spectrum biocides that are effective against both pests and diseases, the farmers usually mix insecticides and fungicides. Such mixing of chemicals is technically feasible only when compounds are compatible with each other. Hence, there is every need to generate information on effective and economical combinations, so as to advise the farmers about compatible tank mix combination of insecticides and fungicides for the control of cotton insect pests.

CHAPTER II

REVIEW OF LITERATURE

The tank mix combination of insecticides and fungicides are usually practice by farmers against crop pest. The combined application of insecticides and fungicides helps the farmers to save time, labour, energy and equipment cost. These tank mixtures may affect the toxicity, physical properties of the chemicals or plant safety. Hence, it is necessary to evaluate the compatibility of tank mixed insecticides and fungicides before recommending combinations in the field. With this background, the review summarizes the results from several years of research on the compatibility of different insecticides and fungicides against various pests on different crops.

2.1 Efficacy and compatibility of pesticides alone and in combination against sucking pests

Patil et al. (2009) conducted field experiments to test the bio-efficacy of new molecule fipronil 5% SC @ 800 g/ha, fipronil 40% + imidacloprid 200 SL @ 200 ml/ha, acetamiprid 20 SP @ 100 g/ha and triazophos 40 EC @ 1500 ml/ha (standard checks) against sucking pests complex in *Bt* cotton. The result revealed that, all the insecticides were found effective in control of sucking pests. Significantly lower thrips, leafhopper and aphid populations were noticed in fipronil 5% SC @ 800 g/ha treatment (8.47, 1.62 and 3.45/3 leaves), respectively which was found to be quite effective and at par with standard check, acetamiprid @ 100 g/ha.

An experiment was conducted by Patel et al. (2010) by using novel insecticides for management of whitefly, *Bemisia tabaci* (Genn.) in cotton. They reported that, foliar application of thio-urea class, diafenthiuron 50 WP @ 400 g a.i./ha was found effective and recorded maximum reduction in population of whitefly, with maximum increase in

yield, net profit and relatively safer for potent predators. The results suggested that, diafenthiuron 50 WP, triazophos 40 EC and acetamiprid 20 SP were good substitutes to conventional insecticides in vogue, which could be used in formulating a successful management for *B. tabaci* in cotton.

Stanley et al. (2010) conducted an experiment on physical and biological compatibility of diafenthiuron with micro/macro nutrients, fungicides and bioagents against cardamom thrips. The experimental finding revealed that, diafenthiuron 50 WP alone has recorded 52.77 per cent reduction while, diafenthiuron 50 WP + carbendazim 50 WP with 55.80% against cardamom thrips. They concluded carbendazim shown synergistic effect with diafenthiuron.

Ramalakshmi et al. (2012) conducted an experiment to study the bioefficacy of novel insecticides against cotton leafhopper. Among the insecticides tested, fipronil 5 SC @ 50 g a.i./ha and fipronil 80 WG @ 50 g a.i./ha were effective in managing leafhopper at 10 days after treatment. Next best treatments were diafenthiuron 50 WP @ 375 g a.i./ha with 65.9% per cent reduction in leafhoppers.

Pachundkar et al. (2013) carried out an field experiment for evaluation of various synthetic insecticides against sucking pests of cluster bean. Experimental results showed that, plots treated with spiromesifen 240 SC registered lowest (1.61/3 leaves) population of *B. tabaci*. Whereas, fipronil 5 SC (0.005%) effectively managed thrips on cluster bean.

Bharpoda et al. (2014) conducted a research work to evaluate insecticides against sucking insect pests infesting *Bt* cotton. They reported that, among the different insecticides tested diafenthiuron 50 WP @ 0.05% was found most effective chemicals in reduction of aphid (3.03/leaf) and leafhopper population (1.66/ leaf) and thrips (1.43 thrips/ leaf).

Ghelani et al. (2014) studied the field efficacy of various insecticides against major sucking pests of *Bt* cotton. The result revealed that, among the insecticidal treatments, flonicamid 50 WG @ 0.02 per cent was found more effective against all major sucking pests. The treatments

with flonicamid 50 WG caused significantly maximum mortality of aphids and thrips after 3, 7 and 15 days of their applications. Moreover, at 3 and 15 days after application, flonicamid 50 WG was also found recording maximum mortality of jassids and it was statistically at par with dinotefuran 20 SG. Whereas, after 7 days of application, flonicamid 50 WG caused significantly maximum mortality of whitefly.

Halappa and Patil (2014) conducted an experiment on bioefficacy of different insecticides against cotton leafhopper, *Amarasca biguttula biguttula* (Ishada) under field condition. Experimental finding showed that, dinotefuran 20 SG (0.25g/l), fipronil 5 SC (1 ml/l), diafenthiuron 50 WP (0.75 g/l) and buprofeizin 25 EC (1ml/l) were found most effective against leafhopper with 79.57, 76.59, 76.23, and 73.69, per cent reduction over untreated check respectively.

Gaurkhede et al. (2015) conducted a field experiment at Department of Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeth, Akola during 2013-2014 to test the bio-efficacy of new chemistry molecules against sucking pests of *Bt* transgenic cotton. They reported that, at the end of third spray the application of flonicamid 50 WG @ 0.02 per cent proved effective in recording minimum aphid population i.e. 1.27 per leaf. Whereas, 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 within the range of 0.63 to 0.93 leafhoppers/leaf. 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 within the range of 2.59 to 3.60 thrips per leaf at the end of third spray. The treatment of 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) and fipronil 5SC @ 0.015 per cent (1.11 whiteflies/leaf).

Chandi et al. (2016) assessed the field efficacy of flonicamid 50 WG against sucking insect pests and predatory complex on *Bt* cotton. Based on pooled analysis of three years, per cent reduction of leafhopper over control in flonicamid @ 75 g a.i. /ha was found to be higher or at par with standard checks after 3 and 7 days of spray. Moreover, flonicamid @ 75 g a.i./ha also provided up to 73.4 per cent reduction in whitefly population. Whereas, per cent reduction of aphid was also found higher in flonicamid @ 75 g a.i./ha after 3, 7 and 10 days of spray.

Sathyan et al. (2016) conducted a research work on efficacy of synthetic insecticides against sucking pests in cotton, *Gossypium hirsutum* L. They revealed that, fipronil 5 SC was the most effective insecticide (3.15 thrips/3 leaves) with 83.06 per cent reduction in thrips population compared to the untreated check (18.60/3 leaves). Incidence of whitefly, *B. tabaci* was also found less on the plants treated with synthetic insecticide fipronil 5 SC (0.40 per three leaves). Whereas, leafhopper population was less in plots treated with diafenthiuron 50 WP (1.30 per three leaves). 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 chlorpyrifos 20 EC) over untreated check.

Boda and Ilyas (2017) conducted field experiment for evaluation of new insecticides against sucking pests of *Bt* cotton at Department of Agricultural Entomology, College of Agriculture, VNMKV, Parbhani during 2013. They reported that treatment fipronil 5 % SC was found most superior in reducing thrips population. Whereas, Spiromesifen 240 SC was found more superior in reducing whiteflies population on 3rd, 7th and 14th days after 1st and 2nd spray.

Bontha and Mallapur (2017a) studied the compatibility of diafenthiuron with selected agro-chemicals on *Bt* cotton. Experimental findings showed that, the lowest mean population of aphids (3.28 /3 leaves), leafhoppers (3.77 /3 leaves), thrips (1.97 /3 leaves) and whiteflies (0.77 /3 leaves) were recorded in diafenthiuron 50 WP @ 0.6 g +

carbendazim 50WP @ 1.0 g. This was followed by diafenthiuron 50 WP alone.

An experiment was conducted by Kalyan et al. (2017) for evaluation of new molecules against jassids and whiteflies of *Bt* cotton. They found maximum reduction in the jassid population with a mean of 64.68; 70.15; 74.72 and 66.44; 72.17; 78.05 per cent and population of whiteflies with mean of 66.28; 72.01; 78.13 and 68.86; 74.33; 80.14 per cent was recorded in difenthiuron 50 WP @ 300g a.i./ha and at 3rd, 5th and 7th days after first spray during both the years (2014 and 2015), respectively. It was found statistically at par with flonicamid 50 WP @ 100g a.i. and fipronil 5 SC @ 100g a.i./ha.

Kodandaram et al. (2017) carried out an experiment to study the bioefficacy, phytotoxicity and residue dynamics of sprays of flonicamid 50 WG in okra (*Abelmoschus esculenta* (L.) Moench) crops. Among the three doses (50, 75, 100 g a.i./ha) tested, applications of flonicamid 50 WG at 75 g a.i ha were equally effective in controlling both leafhoppers and whiteflies with a higher marketable fruit yield of okra under open field conditions. Flonicamid 50 WG also reduced population of leafhoppers and whiteflies by >85% when compared to untreated controls after three rounds of foliar application at an interval of 10 days.

Naik et al. (2017) studied the impact of newer pesticides and botanicals on sucking pest management in cotton under high density planting system (HDPS) in India. 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. Whereas, flonicamid 50% WG and acephate 75% SP were found effective treatments which were significantly superior to all other treatments with 2.19 and 2.59 Jassid nymphs/ 3 leaves/plant.

Nemade et al. (2017) reported that newer molecule flonicamid 50% WG (100 g a.i./ha) and diafenthiuron 50% WP were found promising and resulted into cent per cent control of aphids after second spray.

Furthermore, at the end of third spray flonicamid 50% WG (100 g a.i./ha) and diafenthiuron 50% WP were found most effective in checking the population leafhoppers, thrips and whiteflies. In which Aphids (0.87, 1.13 and 2.33/ 3 leaves), thrips (0.13, 0.21 and 0.20/ 3 leaves) and whiteflies (2.17, 2.47 and 3.13/ 3 leaves) as against untreated control.

Surwase et al. (2017) conducted field experiments to test the bio-efficacy of newer insecticides against major sucking pests of cotton. Among all the insecticides diafenthiuron 50% WP @ 300 g.a.i/ha was found most effective in reducing aphid population after 1st, 2nd and 3rd spray with 2.55, 3.32 and 1.22 aphids/three leaves, respectively. Moreover, buprofezin 25 EC @ 250 g.a.i/ha, fipronil 5% SC @ 50 g.a.i/ha and diafenthiuron 50% WP @ 300 g.a.i/ha were found effective against whiteflies. Insecticides fipronil 5%SC @ 50 g.a.i/ha effectively reduced the population of thrips after 1st, 2nd and 3rd spray with 3.71, 1.80 and 0.73/3 leaves followed by flonicamid 50 WG and dinotefuron 50 WP.

Halder et al. (2018) evaluated the comparative efficacy of different novel insecticides against whitefly (*Bemisia tabaci* Genn.) in cotton (*Gossypium spp.* L.) in new alluvial zone of West Bengal. They reported that, highest mean per cent reduction of whitefly in two years (2014 and 2015) was noted in spiromesifen 22.9% SC @ 1 gm/l (85.97%) followed by buprofezin 25% SC @ 1.6 ml/l (83.47%) treated plots.

Meghana et al. (2018) carried out an experiment to evaluate the efficacy of insecticides and bio pesticides against sucking pests on *Bt* cotton. They recorded significantly least population of aphids from treatments of flonicamid 50 WG, acetamiprid 20 SP, dinotefuran 20 SG and fipronil 5 SC. These treatments were significantly superior and equally effective against aphids (7.33, 7.83, 7.91 & 8.87 aphids / three leaves, respectively) over rest of the treatments at 3 days after 3rd spray and were on par with each other. With respect to jassids, whiteflies and thrips the least population were recorded from the plot treated with flonicamid 50 WG.

2.2 Efficacy and compatibility of pesticides alone and in combination against various insect pests on different crops

Prajapati et al. (2005) reported that the insecticide triazophos (20 EC @ 0.02%) alone or tank mixed with fungicides carbendazim (50 WP @ 0.05%) and tricyclazole (75 WP @ 0.04%) was found effective in controlling leaf folder damage as well as white backed plant hoppers as compared to untreated control. Triazophos applied either alone (27.6 hoppers per hill) or in combination with carbendazim (30.2 hoppers per hill) and with tricyclazole (29.7 hoppers per hill) registered more or less same level of hoppers and were at par. It indicated that the test chemicals can be mixed without any reduction in their efficacy. In none of the cases, the combinations of insecticides and fungicides, showed phytotoxic effect on foliage. It indicated positive compatibility of the chemicals evaluated.

Mukherjee et al. (2009) conducted field experiment and confirmed the compatibility of two insecticides (imidacloprid and thiamethoxam) and two fungicides (propiconazole and validamycin) as tank mix in all possible insecticide and fungicide combinations against mixed population of planthoppers and sheath blight in rice. All the combination treatments involving insecticides and fungicides were effective against the mixed population of brown plant hopper, white backed plant hopper and sheath blight.

An experiment was conducted by Prasanna Kumar et al. (2011) on compatibility of pesticides against stem borer and leaf blast on deep water rice. They revealed that, the combination of flubendiamide + hexaconazole @ 85g a.i./ha was effective against all infestations which recorded 0.9% dead hearts and 0.4% white ears due to stem borer infestation, 2.9% damage due to leaf folder infestation in *kharif*, 2009 followed by tricyclozole + fipronil and kitazine + indoxacarb. Effect of these combination treatments was equal to the effect of fungicide and insecticide when sprayed alone at the same dosage.

Prasad and Gupta (2012) conducted experiment on compatibility of certain new insecticides and fungicides against stem borer and leaf blast in deep water rice. They reported that, insecticidal and fungicidal treatments alone were effective against stem borer and leaf

blast, respectively. Whereas, the combination treatments were effective against both stem borer and leaf blast. The combination of flubendiamide 20 WDG @ 0.25 g/l + isoprothiolane @ 1.5 ml/l was most effective against both stem borer 2.54 per cent infestation.

Pal et al. (2013) reported that the combination product RIL-060/F, 8.5% WG containing 3.5% flubendamide + 5% hexaconazole was tested for its efficacy against stem borer of rice during *kharif*, 2010 and 2011 at AICRP, Regional Research and Technology Transfer Station, Odisha. The combination product was found biologically as effective as individual treatments in controlling stem borer and increased the grain yield by 66.4% as compared to 35.3% in hexaconazole and 46.7% in flubendamide treated plots without any phytotoxic symptoms.

Suneel Kumara et al. (2016) evaluated the compatibility and bio-efficacy of newly released insecticides and fungicides alone and in combination against defoliator pests, *Aproaerema modicella* (Deventer); *Spodoptera litura* (Fabricius) and late leaf spot in groundnut. The results revealed that, spinosad 45 SC + mancozeb 75 WP, spinosad 45 SC + hexaconazole 5 EC, flubendiamide 20 WG + hexaconazole 5 EC and chlorfenapyr 10 SC + hexaconazole 5 EC combinations at recommended dose were found to be superior to the rest of tested combinations with a mean per cent *A. modicella* larval population reduction of 87.5 and comparable to that of insecticides alone. Whereas, it was evident that the little phytotoxic (chlorosis) symptom was seen in combination thiodicarb 75 WP + hexaconazole 5 EC and chlorfenapyr 10 SC + hexaconazole 5 EC with phytotoxicity score of 1 (0 to 10%) only at recommended dose.

Visalakshmi et al. (2016) assessed the efficacy and compatibility of five insecticides and two fungicides at recommended concentrations. The evaluation was done as a tank mix in various insecticide and fungicide combinations for their efficacy against stem borer, leaf folder and brown plant hopper of rice. Experimental finding showed that, flubendiamide @ 0.25mL/L in combination with trifloxystrobin 25% +

tebuconazole 50% (Nativo 75%) 0.4g/L recorded significant reduction of brown plant hopper (2.0/hill) and stem borer as white ears (2.8%) .

Jasrotia and katara (2018) evaluated the compatibility insecticides with propiconazole against foliar aphid *Rhopalosiphum maidis* and yellow rust in wheat. Experimental finding showed that, aphid population during 2014-15 after 15 days of spraying was observed to be least (2.5 aphids/earhead) in sole application of imidaclopride @ 100 ml/ha, while during 2015-16, the least population (1.9 aphids/earhead) was in combination treatment of propiconazole with thiamethoxam @ 50 ml/ha. The studies indicated that, mixing of broad spectrum fungicide, propiconazole did not influence the efficacy of two insecticides against foliar aphids.

Kumar (2018) carried out an experiment to evaluate the compatibility of insecticides with fungicides on lepidopterous pests and tikka leaf spot of groundnut. They found that, against tobacco caterpillar in combination and alone, chlorantraniliprole recorded minimum leaf minor and 80.6% by tobacco caterpillar after second application (55 DAS).

Jayasekharan et al. (2018) studied the compatibility of insecticide and fungicide mixture against *spodoptera litura* on virginia tobacco. Results revealed that, chlorfenapyr 10 SC @ 0.01% and chlorantraniliprole 18.5 SC @ 0.055% were the most effective. In combination with fungicides too, chlorfenapyr 10 SC @ 0.01% was the best demonstrating compatibility.

2.3 Effect of different pesticides alone and in combination on population of natural enemies

Bharpoda et al. (2014) carried out field experiments for evaluation of insecticides against sucking insect pests infesting *Bt* cotton. Experimental finding showed that, all insecticides relatively expressed more or less equal toxicity to the population of *Chrysoperla* (adult) and coccinellids (grubs and adult). In case of spider population, higher population of spider was observed when plots treated with difenthiuron 50

WP @ 0.05%, acetamiprid 20 SP @ 0.01% and carbosulfan 25 EC @ 0.025% and were comparatively less toxic.

Halappa and Patil (2014) conducted experiment on bioefficacy of different insecticides against cotton leafhopper, *Amarasca biguttula biguttula* (Ishada) under field condition. They reported that, fipronil 5 SC, dinotefuran 20 SG, diafenthiuron 50 WP, buprofeizin 25 EC, acetamiprid 20 SP, imidacloprid 17.8 SL and thiamethoxam 25 WDG, 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 (coccinelids, chrysopa, micromus and spiders).

Gaurkhede et al. (2015) who conducted an experiment to evaluate some new chemistry insecticide molecules for their bioefficacy against major sucking pests and toxicity against predators on *Bt* transgenic cotton at Department of Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeth, Akola, during 2013-2014. The result revealed that, insecticidal treatments flonicamid 50 WG @ 0.01 and 0.02 per cent, dinotefuran 20 SG @ 0.006 and 0.008 per cent, imidacloprid 30.5 SC @ 0.005 per cent, acetamiprid 20 SP @ 0.004 per cent and fipronil 5 SC @ 0.015 per cent found to have no deleterious effect on population of natural enemies (i.e. ladybird beetle, chrysopa larvae and spider).

Nemade et al. (2015) tested the newer insecticides against leafhopper on *Bt* cotton. They reported that newer molecule flonicamid 50% WG @ 100 g a.i./ha was found promising to managed the major sucking pests of *Bt* cotton. The treatments viz., imidacloprid 30.5 SL (0.005%), fipronil 5 SC (0.075%), acetamiprid 20 SP (0.008%), acephate 75 SP (0.15%), diafenthiuron 50 WP (0.08%), buprofezin 25 SC (0.05%), triazophos 40 EC (0.16%), azadirachtin 10000 PPM (1%) and dimethoate 30 EC (0.03%) (Std check) under trial did not showed any detrimental effect on predators population (i.e. ladybird beetle, chrysopa larvae and spider).

Visalakshmi et al. (2016) conducted experiment to test the compatibility and efficacy of insecticide and fungicide combinations against

major pests and sheath blight of paddy. They reported that, among different combinations tested during *kharif* 2012, the combination chlorpyrifos @ 2.5mL/L + trifloxystrobin 25% + Tebuconazole 50% (Nativo 75%) 0.4g/L followed by profenophos @2mL/L + propiconazole @1mL/L were the safest combinations for natural enemies in rice ecosystem.

Bontha and Mallapur (2017a) studied the compatibility of diafenthiuron with selected agrochemicals on *Bt* cotton. Results revealed that, diafenthiuron 50 WP in combination with carbendazim 50 WP and copper oxychloride 50 WP were found to be more effective in reducing the sucking pests population and foliar diseases incidence. Moreover, these combination proved safer to the three natural enemies in cotton ecosystem (coccinellids, chrysopids and spiders).

An experiment was conducted by Bontha and Mallapur (2017b) to test the compatibility of profenofos 50 EC with selected agrochemicals on *Bt* cotton. profenofos 50 EC in combination with carbendazim 50 WP and copper oxychloride 50 WP were found to be more effective in reducing the sucking pests population and foliar diseases incidence, but significantly lowest population of natural enemies *viz.*, coccinellids, chrysopids and spiders were recorded in profenofos 50 EC @ 2.0 ml alone as well as in combination with carbendazim 50 WP @ 1.0 g, copper oxychloride 50 WP @ 2 g, NAA @ 20 ppm and MgSO₄ @ 10 g with high level negative impact compared to the all other treatments.

Jeer et al. (2017) conducted field trial to evaluate the effect of pre-mix combination of acephate and imidacloprid on insect pests of rice and their natural enemies. Experimental finding showed that, all the tested doses of acephate 50%+ imidacloprid 1.8% SP (acephate 50% + imidacloprid 1.8% SP @ 414.4 g a.i /ha, acephate 50% + imidacloprid 1.8% SP @ 518 g a.i /ha, acephate 50% + imidacloprid 1.8% SP @ 621.6 g a.i /ha) were found safer to natural enemies(i.e. *Cyrtorhinus lividipennis* and spiders) in rice ecosystem.

Kodandaram et al. (2017) conducted an experiment for evaluating the bioefficacy, phytotoxicity and residue dynamics of sprays of flonicamid 50 WG in okra (*Abelmoschus esculenta* (L.) Moench) crops. They reported that, applications of flonicamid 50 WG did not cause any phytotoxic symptoms. It was also safe to the natural enemies (spiders and rove beetles) prevailing in the okra ecosystem.

Naik et al. (2017) studied the Impact of newer pesticides and botanicals on sucking pest management in cotton. Insecticides buprofezin 25% SC, fipronil 5% SC, imidacloprid 17.8% SL, diafenthiuron 50% WP, spiromesifen 22.9 % SC, flonicamid 50% WG and acephate 75% SP were found to be eco friendly and safe to the natural enemies (coccinellid, spiders and chrysopids). However, in second spray diafenthiuron 50 WP recorded highest population of coccinellid and the population of spider were significantly at high levels in fipronil 5 SC (0.89 spider/plant). Very residual population of chrysopids during second spray, irrespective of the treatments.

2.4. Phytotoxic effect of pesticides combination on cotton

Kalaiselvi et al. (2005) conducted field trail to evaluate the compatibility of lambda cyhalothrin 5 CS with nutrients and biocontrol agents in cotton. They observed that, none of the combinations of lambda cyhalothrin 5 CS at different doses with urea 2 per cent, magnesium sulphate 5 per cent and carbendazim 50 WP 0.1 per cent caused any phytotoxic effect and were not different symptomatically from untreated check. Lambda cyhalothrin 5 CS at the optimum and effective dose was biologically compatible with nutrients and carbendazim and could be used as tank mix.

Kubendran et al. (2008) conducted an experiment for the assessment of phytotoxicity and compatibility of flubendiamide 480 SC with other agrochemicals. They reported that combination treatments viz., flubendiamide 480 SC @ 100 ml/ha, 200 ml/ha and 400ml/ha with urea (5%), magnesium sulphate (5%) and carbendazim 50 WP (0.1%) this combination treatments did not cause any phytotoxic symptoms.

Shaila (2010) studied the compatibility of avermectins and chitin synthesis inhibitors with common fungicides. The results revealed that, the combinations of four insecticides viz., abamectin, emamectin benzoate, novaluron and lufenuron with three fungicides viz., mancozeb, chlorthalonil and carbendazim, showed no phytotoxic symptoms on one and half month old groundnut plants at recommended concentrations.

An experiment was conducted by Stanley et al. (2010) to test physical and biological compatibility of diafenthiuron with macro/micro nutrients, fungicides and biological control agents used in cardamom. Experimental finding showed that, diafenthiuron 50 WP alone and its combinations with carbendazim 50 WP, MgSO₄ and molybdenum did not cause any phototoxic symptoms such as injury to leaf tip and leaf surface, wilting, vein clearing, necrosis, epinasty and hyponasty on cardamom crop.

Suganthi et al. (2010) reported the phytotoxic effects of combination products (azoxystrobin, wettable sulphur, carbendazim, spiromesifen, dicofol, neem oil, neem seed kernel extract and emamectin with imidacloprid 17.8% SL at 25 g a.i./ha) on cotton, bhendi and chilli. Imidacloprid 17.8% SL at 25g a.i./ha with the above eight pesticides at recommended doses had not caused any phytotoxic symptoms such as injury to leaf tip and leaf surface, wilting, vein clearing, necrosis, epinasty and hyponasty.

Suneel Kumara et al. (2016) evaluated the compatibility and bio-efficacy of newly released insecticides and fungicides alone and in combination against defoliator pests, *Aproaerema modicella* (Deventer); *Spodoptera litura* (Fabricius) and late leaf spot in groundnut. The Slight phytotoxic symptoms (chlorosis) were seen in combination treatments of thiodicarb 75 WP + hexaconazole 5 EC and chlorfenapyr 10 SC + hexaconazole 5 EC with phytotoxicity score of 1 (0 to 10%) only at recommended dose.

Bontha and Mallapur (2017a) conducted an experiment to test the compatibility of diafenthiuron with selected agrochemicals on *Bt* cotton. They reported that, that diafenthiuron 50 WP in combination with

carbendazim 50 WP and copper oxychloride 50 WP had not caused any phytotoxic symptoms such as injury to leaf tip and leaf surface, wilting, vein clearing, necrosis, epinasty on 90 days old *Bt* cotton crop.

Bontha and Mallapur (2017b) evaluated the compatibility of profenofos 50 EC with selected agrochemicals on *Bt* cotton. Profenofos 50 EC in combination with carbendazim 50 WP and copper oxychloride 50 WP were found to be more effective in reducing the sucking pests population and foliar diseases incidence. All the tested treatments did not showed any phytotoxic symptoms on 90 days old *Bt* cotton crop.

Bontha and Mallapur (2017c) conducted an field trial to study the compatibility of thiamethoxam 25 WG with selected agro-chemicals on cotton. Thiamethoxam 25 WG in combination with carbendazim 50 WP, copper oxychloride 50 WP, NAA, and MgSO₄ at recommended doses had not caused any phytotoxic symptoms such as injury to leaf tip and leaf surface, wilting, vein clearing, necrosis, epinasty and hyponasty on cotton crop.

Raju et al. (2018) evaluated the phytotoxic effects of fifteen pesticidal combinations on rice crop under field conditions. They did not observed any phytotoxic symptoms such as injury to leaf tip, yellowing, wilting, necrosis, vein clearing, epinasty and hyponasty of leaves in the combinations of five insecticides (flubendiamide 480 SC, rynaxypyr 20 SC, cartap hydrochloride 50 SP, buprofezin 25 SC and profenophos 50 EC) with each of the three fungicides (tricyclazole 75 WP, hexaconazole 5 EC and propiconazole 25 EC).

2.5 Effect of different pesticides alone and in combination on seed cotton yield

Patil et al. (2009) evaluated the efficacy of fipronil 5% SC @ 880 g/ha, fipronil 40% + imidacloprid 200 SL @ 200 ml/ha, acetamiprid 20 SP @ 100 g/ha and triazophos 40 EC @ 1500 ml/ha (standard check) against sucking pests of cotton. Fipronil 5% SC @ 800 g/ha registered least number of thrips (8.47/3 leaves) and found to be on par with acetamiprid 20 SP @ 100g/ha (7.80/3 leaves). Significantly highest seed

cotton yield of 27.23 q/ha (2007) and 27.50 q/ha (2008) was harvested with higher dosage of fipronil 5% SC @ 800 g/ha, respectively providing it to be on par with acetamiprid 20 SP.

Prasadarao et al. (2011) conducted an field trial for the management of the cotton leafhopper by using fipronil 5 % SC. Studies revealed that, fipronil 5% SC @ 40 g a.i./ha was the best treatment in controlling the leafhoppers and it was on par with neonicotinoids viz., imidacloprid 17.8 SL @ 40 g a.i./ha (4.1/three leaves) and thiamethoxam 25 WG @ 25 g a.i./ha (5.2 leafhoppers/three leaves). They found that, maximum seed cotton yield (2693 kglha) was recorded in fipronil 5% SC 40 g a.i./ha which was significantly on par with imidacloprid 17.8 SL 40 g a.i./ha (2172 kglha).

Zanwar et al. (2012) conducted an experiment to evaluate the efficacy of certain chemicals against sucking pest of *Bt* cotton. The performance of neonecotinoids against natural enemies was found to be better in comparison with other treatments. Significantly highest seed cotton yield (14.35 q/ha) was recorded in fipronil 40% SC and imidacloprid 200 SL @ 100 ml/ha followed by fipronil 5% SC (12.58 q/ha).

Ghelani et al. (2014) conducted experiment on field efficacy of various insecticides against major sucking pests of *Bt* cotton. They recorded that, significantly higher yield of seed cotton was recorded in the treatments with flonicamid 0.02 per cent and acetamiprid 0.004 per cent. Further, it was also observed that acetamiprid 0.004 per cent was found most economic insecticidal treatment with C:B ratio of 1:42.59 followed by imidacloprid 0.0089 per cent, thiamethoxam 0.01 per cent and flonicamid 0.02 per cent for the control of major sucking pests of *Bt* cotton with high net return.

Gaurkhede et al. (2015) studied the bioefficacy of new chemistry molecules against sucking pests of *Bt* transgenic cotton. The result revealed the highest seed cotton yield was recorded in the plot sprayed with fipronil 0.015 per cent (2.86 kg/plot), which was closely followed by dinotefuran 0.008 per cent, flonicamid 0.02 per cent,

imidacloprid 0.005 per cent, acetamiprid 0.004 per cent and dinotefuran 0.006 per cent. On the basis of economics, imidacloprid 0.005 per cent proved to be the most economically viable treatment followed by acetamiprid 0.004 per cent, fipronil 0.015 per cent, dinotefuran 0.006 per cent and flonicamid 0.02 per cent.

An experiment was conducted by Suneel Kumara et al. (2016) to evaluate the compatibility and bio-efficacy of newly released insecticides and fungicides alone and in combination against defoliator pests, *Aproaerema modicella* (Deventer); *Spodoptera litura* (Fabricius) and late leaf spot in groundnut. The spinosad 45 SC + mancozeb 75 WP, spinosad 45 SC + hexaconazole 5 EC, flubendiamide 20 WG + hexaconazole 5 EC and chlorfenapyr 10 SC + hexaconazole 5 EC combinations at recommended dose were found to be superior to the rest of tested combinations and comparable to that of insecticides alone. The dry pod yields are highest in insecticide and fungicide combinations (1806 to 2590 Kg/ha) compared to insecticides (910 to 1155 Kg/ha) or fungicides (1259 to 1368 Kg/ha) alone and untreated control (764 Kg/ha).

Bontha and Mallapur (2017a) conducted field trial to test compatibility of diafenthiuron with selected agrochemicals on *Bt* cotton. The highest yield per hectare was recorded in diafenthiuron 50 WP @ 0.6 g + carbendazim 50WP @ 1.0 g (19.07 q/ ha) and diafenthiuron 50 WP @ 0.6 g + copper oxychloride 50WP @ 2g (18.18 q/ ha) found to be significantly superior over rest of the treatments but were on par among themselves. However, these treatments recorded 1.01 and 0.91 of benefit cost ratio's, respectively. Whereas, diafenthiuron 50 WP recorded 15.36 ka/ha seed cotton yield with benefit cost ratio of 0.67.

Kalyan et al. (2017) conducted an experiment to evaluate the new molecules against jassids and whiteflies of *Bt* cotton. The experimental finding showed that, Seven days after spray, the maximum per cent reduction in jassids and whitefly population was recorded in difenthiuron 50 WP. This treatment also seed cotton yield of 3101 kg/ha with highest net profit of Rs.51,381/ha.

Nemade et al. (2017) evaluated the efficacy of new molecules against major sucking pests of cotton, during 2015-2016. The experimental finding showed that, 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. 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).

CHAPTER III

MATERIAL AND METHODS

The present investigation entitled “Compatibility of different pesticides against sucking pests of cotton” was carried out at research farm of Department of Agricultural Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *kharif* 2018-19. The material used and methods adopted during the course of investigation are described below.

Table 1: List of pesticides included in the trial

Sr. No	Common name	Trade name	Source/ Manufacturer
1.	Fipronil 5% SC	Regent	Bayer Crop Sci. Ltd., Mumbai
2.	Spiromesifen 22.9% SC	Oberon	Bayer Crop Sci. Ltd., Mumbai
3.	Flonicamid 50% WG	Ulala	UPL India Ltd., Mumbai
4.	Diafenthiuron 50% WP	Pegasus	Syngenta India Ltd., Pune.
5.	Acephate 50% + Imidacloprid 1.8% SP	Lancer gold	UPL India Ltd., Mumbai
6.	Copper oxychloride 50% WP	Blitox	Rallis India Ltd., Mumbai

3.1 Materials

Materials like cotton seed (AJEET 155 BGII), agricultural implements, bullock pair, marker, rope, measuring tape, manures and fertilizers, labels, pegs, insecticides, fungicide, knapsack sprayer, weighing balance etc. were used while conducting field experiment.

3.2 Methods

3.2.1 Details of experiment

1. Year of experiment : 2018 (*Kharif*)
2. Design of experiment : Randomized Block Design (RBD)
3. Number of treatments : 12 (twelve)
4. Number of replication : 3 (Three)

5. Crop : Cotton (*Bt*)
6. Variety : AJEET 155 BGII
7. Spacing : Row to row : 90 cm
: Plant to plant : 60 cm
8. Plot size : Gross 6.00 m X 5.40 m
Net 4.80 m X 3.60 m
9. Spacing between replication : 1.2 m
10. Spacing between treatments : 0.9 m
11. Fertilizer dose : 60: 30: 30 N: P: K kg/ha
12. Date of Sowing : 01 July 2018

3.2.2 Treatment details

Tr. no.	Pesticides	Dose (ml or g/lit)
T1	Fipronil 5% SC	3.0ml
T2	Spiromesifen 22.9% SC	1.2ml
T3	Flonicamid 50% WG	0.3g
T4	Diafenthiuron 50% WP	1.2g
T5	Acephate 50% + Imidacloprid 1.8% SP	2.0g
T6	Copper oxychloride 50% WP	2.5g
T7	Fipronil 5% SC + Copper oxychloride 50% WP	3.0ml+2.5g
T8	Spiromesifen 22.9% SC + Copper oxychloride 50% WP	1.2ml+2.5g
T9	Flonicamid 50% WG + Copper oxychloride 50% WP	0.3g+2.5g
T10	Diafenthiuron 50% WP + Copper oxychloride 50% WP	1.2g+2.5g
T11	(Acephate 50% + Imidacloprid 1.8% SP) + Copper oxychloride 50% WP	2.0g+2.5g
T12	Untreated control	-

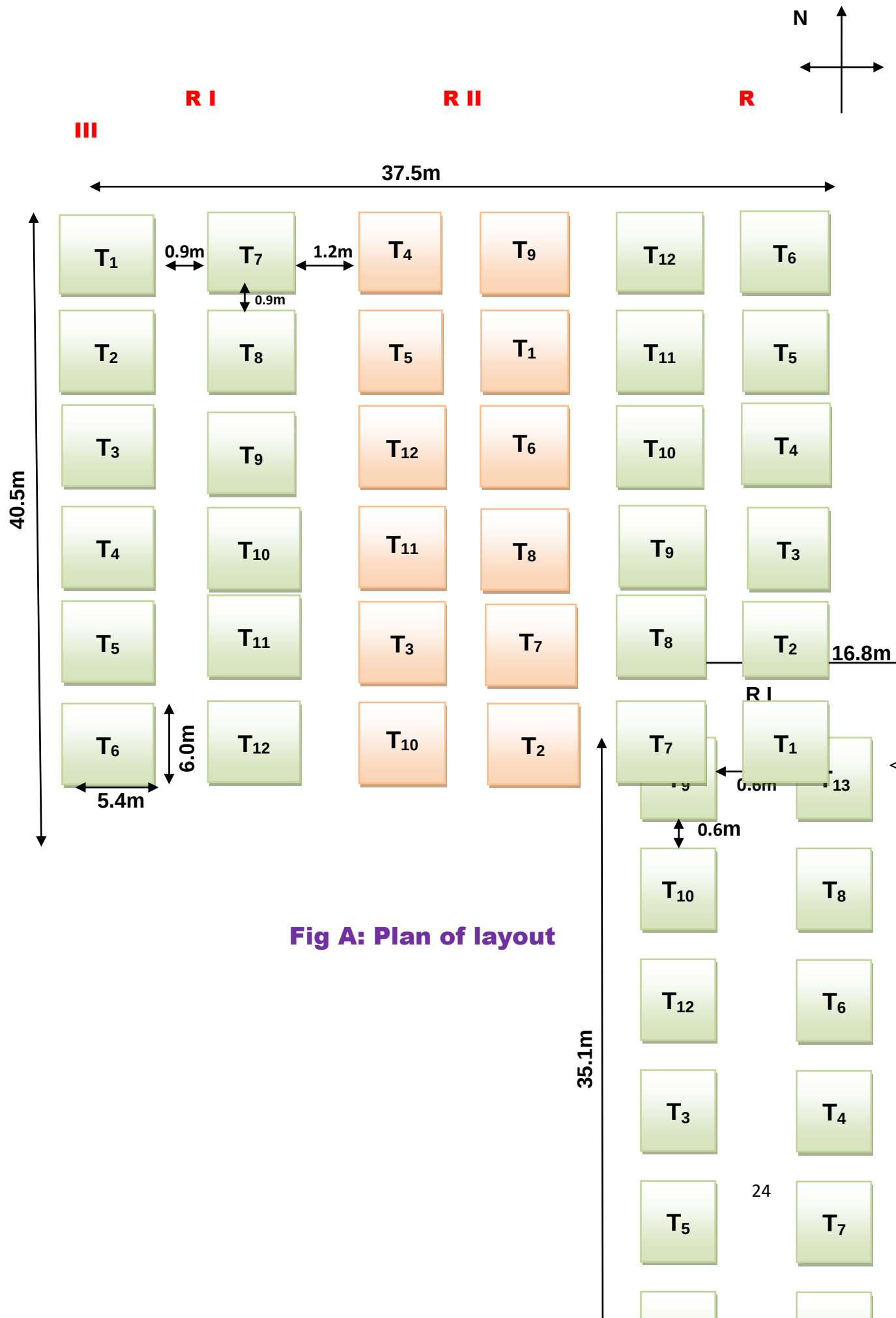


Fig A: Plan of layout



Plate 1. General view of experimental plot

3.2.3 Experimental site

The present investigation was conducted on the research farm of Department of Agricultural Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *Kharif* season of 2018. The selected site was uniform with medium black cotton soil having fairly good drainage.

3.2.4 Cultural operations

3.2.4.1 Preparatory tillage

The soil was thoroughly prepared by ploughing, followed by repeated harrowing. The field was cleaned by picking stubbles of previous crop. Before sowing one harrowing was given and the experimental plot was laid out as per statistical design.

3.2.4.2 Layout of experiment

Field experiment was laid out in Randomized Block Design with twelve treatments replicated thrice. The gross plot size was 6.00 m X 5.40 m and spacing was 90 x 60 cm.

3.2.4.3 Sowing

Marking of lines was done by wooden marker at spacing of 90 cm. Sowing of experimental plot was done on 01 July 2018 by dibbling 1 seed per hill at the depth of about 3-4 cm at a distance of 60 cm and then covered with soil carefully.

3.2.4.4 Gap filling

Gap filling was done within 5-7th day after emergence of crop.

3.2.4.5 Application of fertilizers

The recommended dose of fertilizers was applied at the rate of 60:30:30 kg of N, P₂O₅ and K₂O per hectare, respectively. The half dose of nitrogen and full dose of phosphorus and potassium was applied at the time of sowing. The remaining half dose of nitrogen was given one month after the basal dose.

3.2.4.6 Hoeing and weeding

Timely hoeing and weeding operations were carried out to remove weeds to improve the soil aeration and conserve the soil moisture. In all three hoeing and three weeding were undertaken during the crop season.

3.2.5 Preparation and application of pesticidal spray

The measured quantity of pesticide was added in small quantity of water and thoroughly mixed with a stick and then remaining quantity of clean water was added to get the desired concentration. The desired concentration of spray solution was prepared by using formula,

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

Where,

V= Volume of commercial insecticides in ml.

C= Concentration of spray required.

A= Quantity of spray solution required in ml.

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

The insecticidal spray mixture for respective treatments was freshly prepared every time at the site of experiment just before spraying. Spraying were undertaken with knapsack sprayer. The sprayer was thoroughly cleaned and again flushed with fresh water after each treatment. Care was taken to avoid the drift on surrounding plots at the time of sprayings. The treatment spray was initiated at the time of incidence of sucking pests. In all three spray were undertaken at an interval of 15 days.

Sr. No.	Spraying	Date
1	1 st spray	23/ 08/ 2018
2	2 nd spray	08/ 09/ 2018
3	3 rd spray	24/ 09/ 2018

3.2.6 Method of recording observations

3.2.6.1 Observations on the sucking pest population

Periodical observations were undertaken to record the incidence of sucking pests viz., aphids, leafhoppers, whiteflies and thrips on three leaves selected from top, middle and bottom canopy of five randomly selected plants per each of the net plot to monitor the build up of sucking pest population for effective treatment spray. The treatment spray was initiated at the time of incidence of sucking pests. In all three sprays were undertaken at 15 days interval. The pre treatment observations were recorded at 24 hours before the application of spray. Whereas, the post treatment observations were recorded at 3, 7, 10 and 14 days after each treatment spray.

3.2.6.2 Observations on the natural enemies

The observations on predators viz., coccinellids, chrysopids and spider were recorded on randomly selected five plants from each of the net plot on whole plant basis at 3, 7, 10 and 14 days after each treatment spray to assess the effect of different treatments on population of natural enemies.

3.2.6.3 Seed cotton yield

Seed cotton yield obtained at each picking from each net plot was recorded. Total yield was worked out. Yield of seed cotton in q/ha was calculated in order to compare the effect of different treatments. In all total four pickings were done at following dates.

Sr. No.	Picking	Date
1	1 st	25/ 10/ 2018
2	2 nd	08/ 11/ 2018
3	3 rd	15/ 11/ 2018
4	4 th	23/ 11/ 2018

3.2.6.4 Assessment of phytotoxicity

The observations on phytotoxicity symptoms like leaf tip burn, wilting, vein clearing, necrosis, epinasty and hyponasty were recorded at 1, 3, 7, 10 and 14 days after each treatment spray in each plot. These observations on phytotoxicity were recorded by following phytotoxicity rating scale given by Rajeshwaran et al. 2004.

Phytotoxicity rating

Sr. No.	Scale	Per cent Phytotoxicity
1	0	No phytotoxicity
2	1	1-10
3	2	11-20
4	3	21-30
5	4	31-40
6	5	41-50
7	6	51-60
8	7	61-70
9	8	71-80
10	9	81-90
11	10	91-100

3.3 Statistical Analysis

As per Gomez and Gomez (1984), the data obtained during the present course of investigation was converted to appropriate transformations and was subjected to statistical analysis to test the level of significance.

At the end “Incremental Cost Benefit Ratio” based on total seed cotton yield in terms of rupees, cost of treatments, labour charges and cost of application was calculated at the prevailing market rates during the period of experimentation in order to evolve cost effective treatment against sucking pest complex of cotton.

3.4 Meteorological data

The weekly Meteorological data on maximum and minimum temperature, relative humidity, rainfall, rainy days and sunshine hours, during the crop season of 2018-19 recorded at Agricultural Meteorological Observatory, Dr. PDKV, Akola are presented in Appendix-I.

CHAPTER IV

RESULTS AND DISCUSSION

The present investigation was conducted with a view to study the compatibility of different pesticides in comparison with individual pesticides against sucking pest of cotton. The experiment was carried out at research farm of Department of Agricultural Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *kharif* 2018-19.

The data obtained during the present investigation were subjected to statistical analysis by following standard procedures and are discussed as under.

4.1 Efficacy of pesticides alone and in combination against cotton aphids after first spray

The data on population of aphids recorded a day before the spray in different plots was found statistically non significant indicating the uniform distribution of the pest on the experimental plots. The population in the different treatment plots ranged from 7.00 to 9.87 aphids per leaf.

4.1.1 Three days after first spray

The data presented in Table 2 (Fig.1) pertaining to population of aphids at three days after first spray revealed that, all the treatments found significantly effective except copper oxychloride 50% WP over untreated control. The lowest population of aphid (1.16/leaf) was recorded in plot treated with flonicamid 50% WG which was found at par with flonicamid 50% WG + copper oxychloride 50% WP and diafenthiuron 50% WP with 1.21 and 1.47 aphids/leaf, respectively. The latter two treatments were also found at par with diafenthiuron 50% WP + copper oxychloride 50% WP (2.10) and spiromesifen 22.9% SC + copper oxychloride 50% WP (2.13). The next effective treatments were in the order viz., spiromesifen 22.9% SC, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, acephate 50% + imidacloprid 1.8% SP, fipronil 5% SC + copper oxychloride 50% WP and fipronil 5% SC, in which



Aphids



Leafhopper



whitefly



Thrips

Plate 2. Different sucking pests observed during experimentation

aphid population was ranged between 2.44 to 3.27 aphids/leaf. The highest population of aphids were observed in untreated control (6.48/leaf) and copper oxychloride 50% WP treated plots (6.72/leaf).

4.1.2 Seven days after first spray

The data tabulated in Table 2 (Fig.1) revealed that, all the treatments were significantly superior except copper oxychloride 50% WP over untreated control. Among the different treatments flonicamid 50% WG + copper oxychloride 50% WP recorded minimum population of aphids (0.97/leaf). This treatment was found at par with diafenthiuron 50% WP, diafenthiuron 50% WP + copper oxychloride 50% WP, flonicamid 50% WG, spiromesifen 22.9% SC + copper oxychloride 50% WP and spiromesifen 22.9% SC in which aphid population ranged between 1.24 to 1.82 aphids/ leaf. The next best treatments were in order of following ways, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.93), acephate 50% + imidacloprid 1.8% SP (2.27), fipronil 5% SC + copper oxychloride 50% WP (2.27) and fipronil 5% SC (2.69). The maximum population of aphids was recorded in copper oxychloride 50% WP (6.15) treated plots which was found at par with untreated control (6.40).

4.1.3 Ten days after first spray

It is evident from Table 2 (Fig.1) that, all the treatments were significantly effective except copper oxychloride 50% WP over untreated control in reducing population of aphids at ten days after first spray. Particularly, the treatment with flonicamid 50% WG + copper oxychloride 50 WP (0.84/leaf) recorded minimum population of aphids. However, this treatment was found at par with with flonicamid 50% WG, diafenthiuron 50% WP + copper oxychloride 50% WP and diafenthiuron 50% WP with population of 0.91, 1.12 and 1.33 aphids per leaf , respectively. The treatments viz., spiromesifen 22.9% SC + copper oxychloride 50% WP, spiromesifen 22.9% SC, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, fipronil 5% SC + copper oxychloride 50% WP, acephate 50% + imidacloprid 1.8% SP and fipronil 5% SC showed the efficacy in the descending order in which aphid population ranged between

Table 2: Efficacy of pesticides alone and in combination against cotton aphids after first spray

Tr. No	Treatments	Number of aphids /leaf at					
		Pre count	3DAS	7DAS	10DAS	14DAS	Mean
1	Fipronil 5% SC	7.41 (2.89)	3.27 (2.06)	2.69 (1.86)	2.48 (1.85)	3.68 (2.15)	3.03 (1.98)
2	Spiromesifen 22.9% SC	7.40 (2.90)	2.44 (1.85)	1.82 (1.65)	1.99 (1.69)	3.55 (2.12)	2.45 (1.83)
3	Flonicamid 50% WG	8.59 (3.09)	1.16 (1.46)	1.38 (1.53)	0.91 (1.38)	1.52 (1.58)	1.24 (1.49)
4	Diafenthiuron 50% WP	7.00 (2.82)	1.47 (1.56)	1.24 (1.48)	1.33 (1.52)	1.47 (1.56)	1.38 (1.53)
5	Acephate 50% + Imidacloprid 1.8% SP	9.32 (3.20)	3.03 (2.01)	2.27 (1.76)	2.30 (1.79)	1.97 (1.71)	2.39 (1.81)
6	Copper oxychloride 50% WP	7.36 (2.89)	6.72 (2.78)	6.15 (2.67)	5.97 (2.61)	7.41 (2.90)	6.56 (2.74)
7	Fipronil 5% SC + Copper oxychloride 50% WP	8.59 (3.10)	3.13 (2.03)	2.27 (1.76)	2.30 (1.77)	3.58 (2.13)	2.82 (1.92)
8	Spiromesifen 22.9% SC + Copper oxychloride 50% WP	7.97 (2.99)	2.13 (1.76)	1.42 (1.54)	1.69 (1.61)	2.71 (1.91)	1.99 (1.71)
9	Flonicamid 50% WG + Copper oxychloride 50% WP	8.00 (3.66)	1.21 (1.49)	0.97 (1.39)	0.84 (1.36)	1.49 (1.57)	1.13 (1.45)
10	Diafenthiuron 50% WP+ Copper oxychloride 50% WP	9.87 (3.29)	2.10 (1.76)	1.33 (1.52)	1.12 (1.45)	1.36 (1.53)	1.48 (1.56)
11	(Acephate 50% +Imidacloprid 1.8% SP) + Copper oxychloride 50% WP	7.94 (2.99)	2.44 (1.85)	1.93 (1.69)	2.71 (1.70)	1.83 (1.67)	2.23 (1.73)
12	Untreated control	8.11 (3.01)	6.48 (2.73)	6.40 (2.71)	6.47 (2.72)	8.20 (3.01)	6.89 (2.80)
	F test	NS	Sig	Sig	Sig	Sig	Sig
	SE (m) $\pm$	0.13	0.09	0.10	0.08	0.11	0.10
	CD at 5 %	0.38	0.28	0.29	0.24	0.34	0.29
	CV %	7.44	8.37	9.68	8.05	9.97	9.02

Note: Figures in parentheses are corresponding square root transformation values., DAS- Days After Spraying

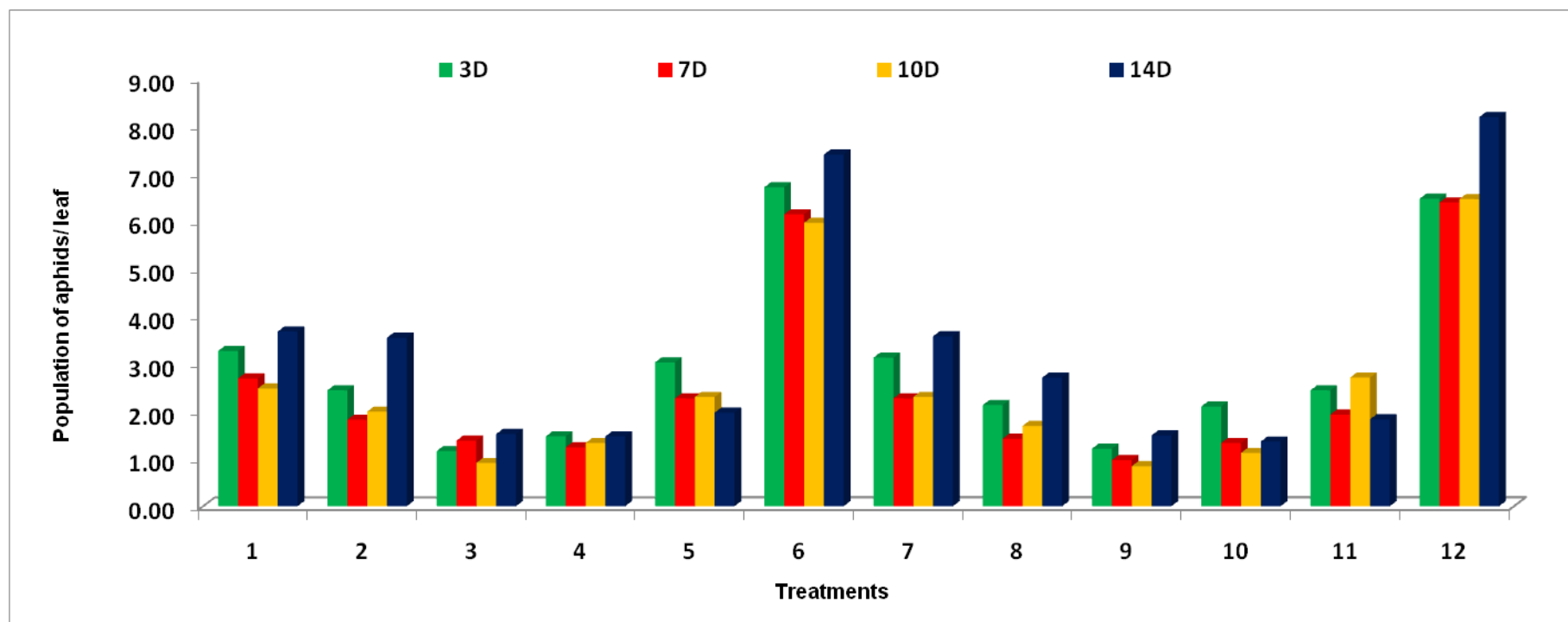


Fig 1. Efficacy of pesticides alone and in combination against cotton aphids after first spray

T₁ : Fipronil 5% SC

T₄: Diafenthiuron 50% WP

T₇ :Fipronil 5% SC + Copper oxychloride 50% WP

T₁₀: Diafenthiuron 50% WP+ Copper oxychloride 50% WP

T₂ : Spiromesifen 22.9% SC

T₅:Acephate 50% + Imidacloprid 1.8% SP

T₈: Spiromesifen 22.9%SC + Copper oxychloride 50% WP

T₁₁: (Acephate 50% + Imidacloprid 1.8% SP) + Copper oxychloride 50% WP

T₃: Flonicamid 50% WG

T₆:Copper oxychloride 50% WP

T₉ :Flonicamid 50% WG + Copper oxychloride 50% WP

T₁₂: Untreated control

1.69 to 2.48/leaf and were found superior to the treatment of copper oxychloride 50% WP (5.97) and untreated control (6.47).

4.1.4 Fourteen days after first spray

The data (Table 2 and Fig.1) in respect of population of aphids at fourteen days after first spray showed that, all the treatments were significantly effective except copper oxychloride 50% WP over untreated control in recording minimum population of aphids. The plots treated with diafenthiuron 50% WP + copper oxychloride 50% WP recorded minimum population of aphids (1.36/leaf) and this treatment was found at par with with diafenthiuron 50% WP (1.47), flonicamid 50% WG + copper oxychloride 50% (1.49), flonicamid 50% WG (1.52), (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.83) and acephate 50% + imidacloprid 1.8% SP (1.97). However, the latter four treatments were also found at par with spiromesifen 22.9% SC + copper oxychloride 50% WP (2.71). The next effective treatments were in the order *viz.*, spiromesifen 22.9% SC (3.55), fipronil 5% SC + copper oxychloride 50% WP (3.58) and Fipronil 5% SC (3.68) which are found at par with each other. The copper chloride 50% WP treated plots and untreated control recorded highest aphid population of 7.41 and 8.20, respectively.

4.1.5 Mean

All the treatments found significantly effective in recording minimum population of aphids in comparison to plots treated with copper oxychloride 50% WP and untreated control (Table 2 and Fig.1). Amongst the various treatments, flonicamid 50% WG + copper oxychloride 50% WP (1.13/leaf) recorded the minimum population of aphids. This treatment was found at par with flonicamid 50% WG (1.24), diafenthiuron 50% WP (1.38), diafenthiuron 50% WP + copper oxychloride 50% WP (1.48), spiromesifen 22.9% SC + copper oxychloride 50% WP (1.99) and (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (2.23). Whereas, the treatments acephate 50% + imidacloprid 1.8% SP (2.39), spiromesifen 22.9% SC (2.45), fipronil 5% SC + copper oxychloride 50% WP (2.82) were found statistically at par with fipronil 5% SC (3.03). The maximum

population of aphids was recorded in copper oxychloride 50% WP (6.56) treated plots which was found at par with untreated control (6.89).

4.2. Efficacy of pesticides alone and in combination against cotton aphids after second spray

4.2.1 Three days after second spray

Among the treatments, population of aphids recorded at three days after second spray (Table 3 and Fig.2) was minimum in the plots treated with flonicamid 50% WG + copper oxychloride 50% WP (0.26 aphids/leaf)) and was found at par with flonicamid 50% WG (0.54), diafenthiuron 50% WP + copper oxychloride 50% WP (0.88), diafenthiuron 50% WP (0.97), acephate 50% + imidacloprid 1.8% SP (0.99) and spiromesifen 22.9% SC (1.15). The remaining treatments showed their efficacy against aphids in descending order i.e. (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.40), fipronil 5% SC (1.40), fipronil 5% SC + copper oxychloride 50% WP (1.78) and spiromesifen 22.9% SC + copper oxychloride 50% WP (2.91). Whereas, the plots treated with copper oxychloride 50% WP recorded maximum population of aphids (5.84) and was found at par with untreated control (5.33).

4.2.2 seven days after second spray

The data on effect of different treatments against aphids at seven days after second spray (Table 3 and Fig.2) revealed that, application of diafenthiuron 50% WP + copper oxychloride 50% WP recorded the minimum population of aphids (0.16 aphid/leaf). This treatment was found at par with flonicamid 50% WG (0.34), flonicamid 50% WG + copper oxychloride 50% WP (0.44), diafenthiuron 50% WP (0.45) and spiromesifen 22.9%SC + copper oxychloride 50% WP (0.56). The next effective treatments in order of efficacy were viz., (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.05), fipronil 5% SC + copper oxychloride 50% WP (1.30), acephate 50% + imidacloprid 1.8% SP (1.39), fipronil 5% SC (1.39) and spiromesifen 22.9% SC (1.71) which were found at par with each other. The highest population of aphids

was observed in copper oxychloride 50% WP (4.60) and untreated control (4.93).

4.2.3 Ten days after second spray

Minimum aphid population was recorded in the treatment flonicamid 50% WG (0.20 aphids/leaf) at ten days after second spray (Table 3 and Fig.2). However, this treatment was found at par with flonicamid 50% WG + copper oxychloride 50% WP, acephate 50% + imidacloprid 1.8% SP, diafenthiuron 50% WP + copper oxychloride 50% WP, diafenthiuron 50% WP, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, fipronil 5% SC and spiromesifen 22.9% SC + copper oxychloride 50% WP with 0.29, 0.33, 0.40, 0.43, 0.47, 0.53 and 0.77 aphids/leaf, respectively. This treatments were followed by spiromesifen 22.9% SC (0.89) and fipronil 5% SC + copper oxychloride 50% WP (1.01) whereas, copper oxychloride 50 %WP and untreated control recorded 3.83 and 4.17 aphids/leaf and found at par with each other.

Table 3: Efficacy of pesticides alone and in combination against cotton aphids after second spray

Tr. No	Treatments	Number of aphids /leaf at				
		3DAS	7DAS	10DAS	14DAS	Mean
1	Fipronil 5% SC	1.40 (1.54)	1.39 (1.54)	0.53 (1.23)	0.73 (1.31)	1.01 (1.41)
2	Spiromesifen 22.9% SC	1.15 (1.46)	1.71 (1.65)	0.89 (1.37)	0.67 (1.28)	1.10 (1.42)
3	Flonicamid 50% WG	0.54 (1.24)	0.34 (1.16)	0.20 (1.09)	0.42 (1.19)	0.37 (1.17)
4	Diafenthiuron 50% WP	0.97 (1.40)	0.45 (1.20)	0.43 (1.19)	0.30 (1.14)	0.54 (1.23)
5	Acephate 50% + Imidacloprid 1.8% SP	0.99 (1.40)	1.39 (1.54)	0.33 (1.15)	0.47 (1.21)	0.79 (1.33)
6	Copper oxychloride 50% WP	5.84 (2.59)	4.60 (2.36)	3.83 (2.19)	3.71 (2.17)	4.50 (2.33)
7	Fipronil 5% SC + Copper oxychloride 50% WP	1.78 (1.67)	1.30 (1.51)	1.01 (1.42)	0.53 (1.23)	1.16 (1.45)
8	Spiromesifen 22.9% SC + Copper oxychloride 50% WP	2.91 (1.98)	0.56 (1.25)	0.77 (1.32)	0.64 (1.27)	1.22 (1.46)
9	Flonicamid 50% WG + Copper oxychloride 50% WP	0.26 (1.12)	0.44 (1.20)	0.29 (1.14)	0.33 (1.15)	0.33 (1.15)
10	Diafenthiuron 50% WP+ Copper oxychloride 50% WP	0.88 (1.36)	0.16 (1.08)	0.40 (1.18)	0.50 (1.22)	0.49 (1.21)
11	(Acephate 50% +Imidacloprid 1.8% SP) + Copper oxychloride 50% WP	1.40 (1.54)	1.05 (1.42)	0.47 (1.21)	0.60 (1.26)	0.88 (1.36)
12	Untreated control	5.33 (2.51)	4.93 (2.42)	4.17 (2.27)	4.27 (2.29)	4.68 (2.37)
	F test	Sig	Sig	Sig	Sig	Sig
	SE (m) ±	0.12	0.08	0.08	0.09	0.09
	CD at 5 %	0.35	0.25	0.23	0.26	0.27
	CV %	12.58	9.51	9.84	10.90	10.70

Note: Figures in parentheses are corresponding square root transformation values.

DAS- Days After Spraying

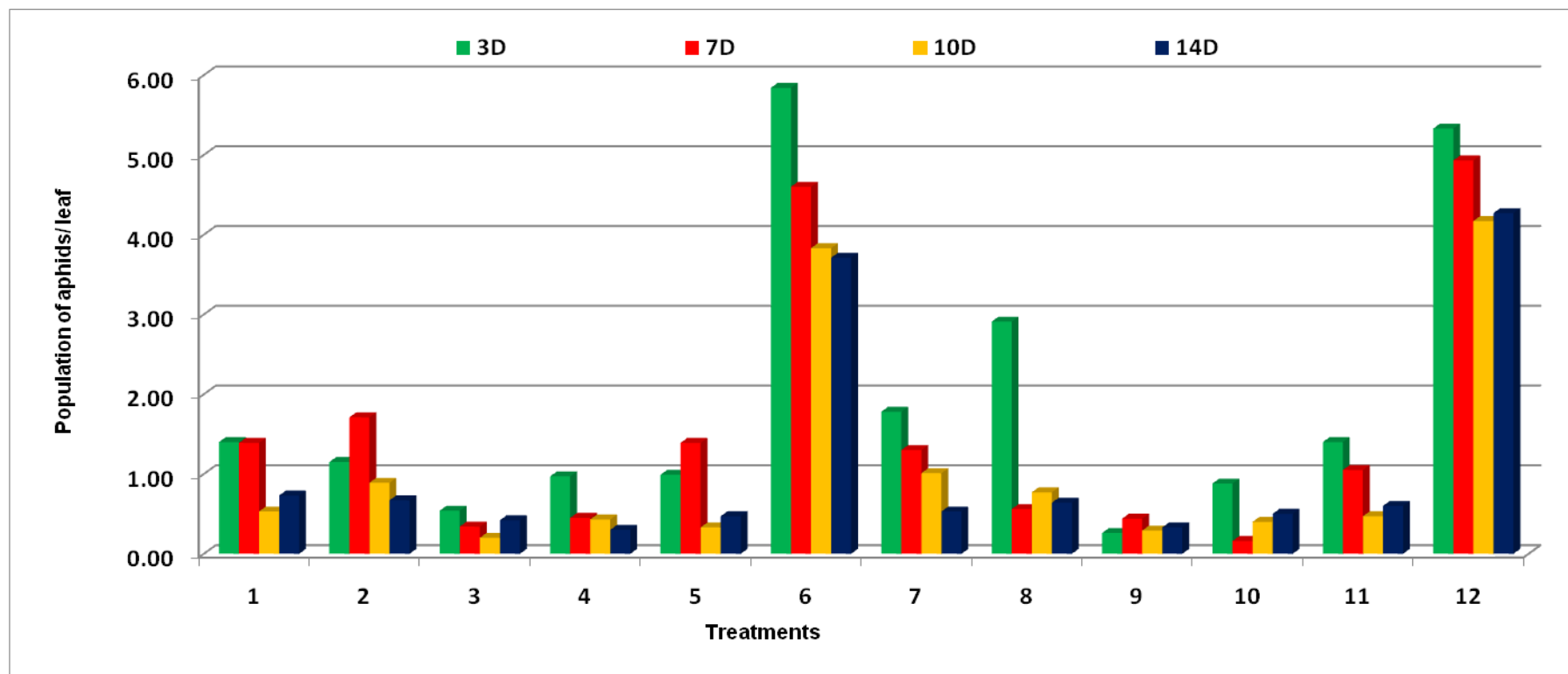


Fig 2. Efficacy of pesticides alone and in combination against cotton aphids after second spray

T₁ : Fipronil 5% SC

T₄: Diafenthiuron 50% WP

T₇ :Fipronil 5% SC + Copper oxychloride 50% WP

T₁₀: Diafenthiuron 50% WP+ Copper oxychloride 50% WP

T₂ : Spiromesifen 22.9% SC

T₅:Acephate 50% + Imidacloprid 1.8% SP

T₈: Spiromesifen 22.9%SC + Copper oxychloride 50% WP

T₁₁: (Acephate 50% + Imidacloprid 1.8% SP) + Copper oxychloride 50% WP

T₃: Flonicamid 50% WG

T₆:Copper oxychloride 50% WP

T₉ :Flonicamid 50% WG + Copper oxychloride 50% WP

T₁₂: Untreated control

4.2.4 Fourteen days after second spray

The data presented in Table 3 (Fig.2) revealed that, significantly less number of aphids were recorded in all the treatments except copper oxychloride 50% WP as against untreated control. Among the treatments minimum population of aphids (0.30/leaf) was observed in diafenthiuron 50% WP at fourteen days after second spray. However, this treatment was found at par with flonicamid 50% WG + copper oxychloride 50% WP, flonicamid 50% WG, acephate 50% + imidacloprid 1.8% SP, diafenthiuron 50% WP + copper oxychloride 50% WP, fipronil 5% SC + copper oxychloride 50% WP, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, spiromesifen 22.9% SC + copper oxychloride 50% WP, spiromesifen 22.9% SC and fipronil 5% SC in which 0.33, 0.42, 0.47, 0.50, 0.53, 0.60, 0.64, 0.67 and 0.73 aphids/leaf, respectively were recorded. Whereas, maximum number of aphids were observed in untreated control (4.27) which was found with copper oxychloride 50% WP (3.71).

4.2.5 Mean

The data on mean population of aphids after second spray displayed in Table 3 (Fig.2) revealed that, treatments viz., flonicamid 50% WG + copper oxychloride 50% WP (0.33), flonicamid 50% WG (0.37), diafenthiuron 50% WP + copper oxychloride 50% WP (0.49), diafenthiuron 50% WP (0.54), acephate 50% + imidacloprid 1.8% SP (0.79), (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (0.88) and fipronil 5% SC (1.01) proved equally effective in recording minimum population of aphids. Whereas, the treatment with spiromesifen 22.9% SC (1.10), fipronil 5% SC + copper oxychloride 50% WP (1.16) and spiromesifen 22.9% SC + copper oxychloride 50% WP (1.22) were found moderately effective. The treatment of copper oxychloride 50% WP showed relatively more number of aphids (4.50) and was found at par with untreated control (4.68).

4.3 Cumulative effect of pesticides alone and in combination against cotton aphids

4.3.1 Three days after spray

The data displayed in Table 4 (Fig.3) indicated that, all the treatments are significantly superior except copper oxychloride 50% WP over untreated control in recording minimum number of aphids at three days after spray. Among them, flonicamid 50% WG + copper oxychloride 50% WP, flonicamid 50% WG, diafenthiuron 50% WP and diafenthiuron 50% WP + copper oxychloride 50% WP were found statistically equal in reducing the population of aphids in which 0.74, 0.85, 1.22 and 1.49 aphids/leaf, respectively were recorded. The remaining treatments showed efficacy in descending order viz., spiromesifen 22.9% SC (1.80), (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.92), acephate 50% + imidacloprid 1.8% SP (2.01), fipronil 5% SC (2.34), fipronil 5% SC + copper oxychloride 50% WP (2.46) and spiromesifen 22.9% SC + copper oxychloride 50% WP (2.52). The plots treated with copper oxychloride 50% WP (6.28) and untreated control (5.91) recorded highest number of aphids per leaf.

4.3.2 Seven days after spray

The data on effect of different treatments against aphids at seven days after each spray (Table 4 and Fig.3) showed that, application of flonicamid 50% WG + copper oxychloride 50% WP recorded lower aphid population (0.71/leaf). This treatment was closely followed by diafenthiuron 50% WP + copper oxychloride 50% WP (0.75), diafenthiuron 50% WP (0.85), flonicamid 50% WG (0.86), spiromesifen 22.9% SC + copper oxychloride 50% WP (0.99) and (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.49). All these treatments found at par with each other. Whereas, spiromesifen 22.9% SC (1.77), fipronil 5% SC + copper oxychloride 50% WP (1.79), acephate 50% + imidacloprid 1.8% SP (1.83) and fipronil 5% SC (2.04) appeared as next better treatments. Highest number of aphids was recorded in copper oxychloride 50% WP (5.38) and found at par with untreated control (5.67).

Table 4: Cumulative effect of pesticides alone and in combination against cotton aphids

Tr. No	Treatments	Number of aphids /leaf at				
		3DAS	7DAS	10DAS	14DAS	Mean
1	Fipronil 5% SC	2.34 (1.80)	2.04 (1.70)	1.51 (1.53)	2.21 (1.73)	2.02 (1.69)
2	Spiromesifen 22.9% SC	1.80 (1.66)	1.77 (1.64)	1.44 (1.47)	2.11 (1.70)	1.78 (1.63)
3	Flonicamid 50% WG	0.85 (1.35)	0.86 (1.35)	0.56 (1.24)	0.97 (1.39)	0.81 (1.33)
4	Diafenthiuron 50% WP	1.22 (1.48)	0.85 (1.34)	0.88 (1.36)	0.89 (1.35)	0.96 (1.39)
5	Acephate 50% + Imidacloprid 1.8% SP	2.01 (1.71)	1.83 (1.65)	1.32 (1.47)	1.22 (1.46)	1.59 (1.57)
6	Copper oxychloride 50% WP	6.28 (2.69)	5.38 (2.52)	4.90 (2.40)	5.56 (2.54)	5.53 (2.53)
7	Fipronil 5% SC + Copper oxychloride 50% WP	2.46 (1.85)	1.79 (1.65)	1.66 (1.60)	2.06 (1.68)	1.99 (1.69)
8	Spiromesifen 22.9% SC + Copper oxychloride 50% WP	2.52 (1.87)	0.99 (1.40)	1.23 (1.46)	1.68 (1.59)	1.60 (1.58)
9	Flonicamid 50% WG + Copper oxychloride 50% WP	0.74 (1.31)	0.71 (1.30)	0.57 (1.25)	0.91 (1.36)	0.73 (1.30)
10	Diafenthiuron 50% WP+ Copper oxychloride 50% WP	1.49 (1.56)	0.75 (1.30)	0.76 (1.32)	0.93 (1.38)	0.98 (1.39)
11	(Acephate 50% +Imidacloprid 1.8% SP) + Copper oxychloride 50% WP	1.92 (1.70)	1.49 (1.56)	1.59 (1.54)	1.22 (1.47)	1.55 (1.54)
12	Untreated control	5.91 (2.62)	5.67 (2.57)	5.32 (2.50)	6.24 (2.65)	5.78 (2.58)
	F test	Sig	Sig	Sig	Sig	Sig
	SE (m) ±	0.10	0.09	0.08	0.10	0.09
	CD at 5 %	0.31	0.27	0.24	0.30	0.28
	CV %	10.48	9.60	8.95	10.44	9.87

Note: Figures in parentheses are corresponding square root transformation values.

DAS- Days After Spraying

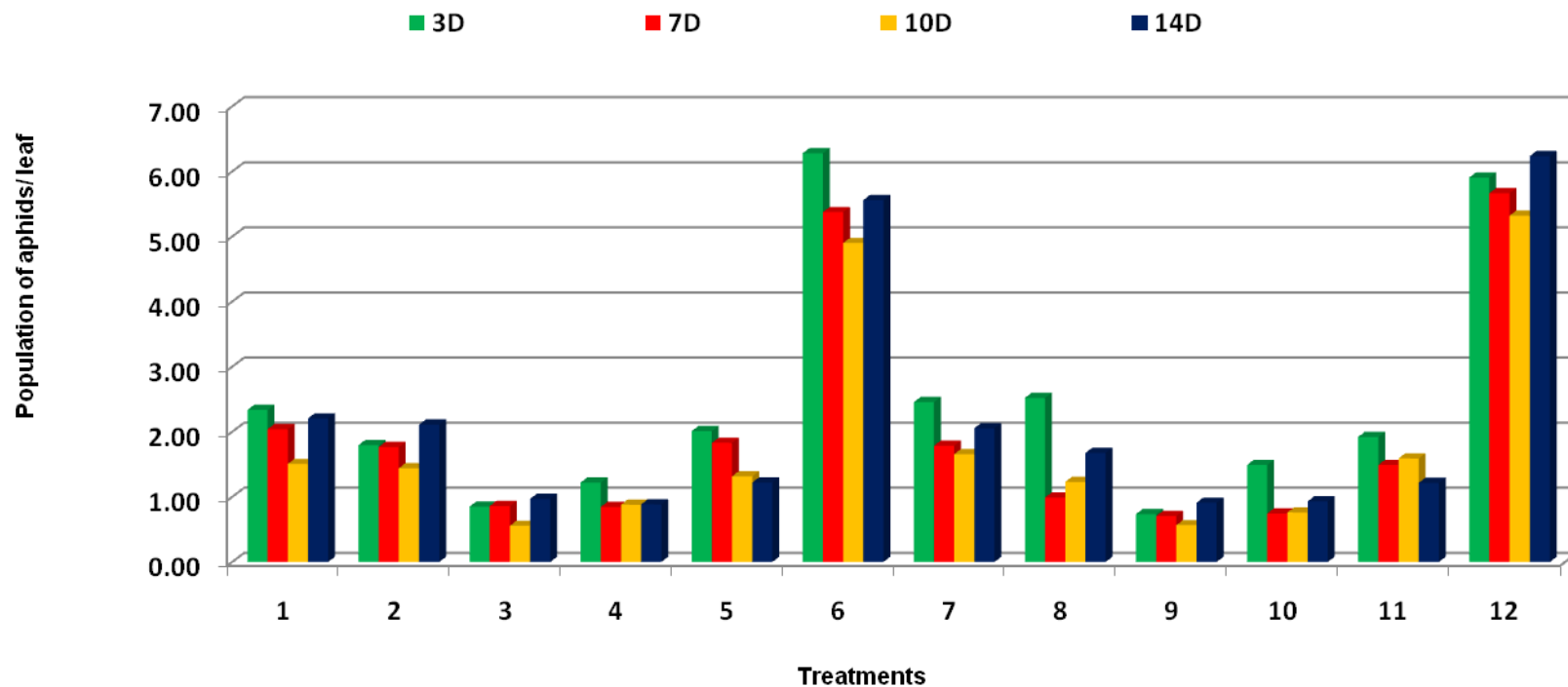


Fig 3. Cumulative effect of pesticides alone and in combination against cotton aphids

T₁ : Fipronil 5% SC

T₄: Diafenthiuron 50% WP

T₇ :Fipronil 5% SC + Copper oxychloride 50% WP

T₁₀: Diafenthiuron 50% WP+ Copper oxychloride 50% WP

T₂ : Spiromesifen 22.9% SC

T₅:Acephate 50% + Imidacloprid 1.8% SP

T₈: Spiromesifen 22.9%SC + Copper oxychloride 50% WP

T₁₁: (Acephate 50% + Imidacloprid 1.8% SP) + Copper oxychloride 50% WP

T₃: Flonicamid 50% WG

T₆:Copper oxychloride 50% WP

T₉ :Flonicamid 50% WG + Copper oxychloride 50% WP

T₁₂: Untreated control

4.3.3 Ten days after spray

Among the different treatments population of aphids recorded at ten days after each spray (Table 4 and Fig.3) was minimum in the plots treated with flonicamid 50% WG (i.e. 0.56 aphids/leaf). This treatment was found at par with flonicamid 50% WG + copper oxychloride 50% WP, diafenthiuron 50% WP + copper oxychloride 50% WP, diafenthiuron 50% WP, spiromesifen 22.9% SC + copper oxychloride 50% WP, acephate 50% + imidacloprid 1.8% SP and spiromesifen 22.9% SC with 0.57, 0.76, 0.88, 1.23, 1.32 and 1.44 aphids/leaf, respectively were recorded. The next effective treatments were viz., fipronil 5% SC (1.51), (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.59) and fipronil 5% SC + copper oxychloride 50% WP (1.66). Maximum number of aphids recorded in treatment copper oxychloride 50% WP and untreated control with 4.90 and 5.32 aphids/leaf, respectively.

4.3.4 Fourteen days after spray

The data pertaining to the efficacy of pesticides combination against aphids at fourteen days after each spray presented in Table 4 (Fig.3) revealed that, minimum population of aphids (i.e. 0.89 aphids/leaf) was recorded in plots treated with diafenthiuron 50% WP. This treatment was found at par with flonicamid 50% WG + copper oxychloride 50% WP (0.91), diafenthiuron 50% WP + copper oxychloride 50% WP (0.93), flonicamid 50% WG (0.97), acephate 50% + imidacloprid 1.8% SP (1.22), (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.22) and spiromesifen 22.9% SC + copper oxychloride 50% WP (1.68). Next in the order of efficacy were fipronil 5% SC + copper oxychloride 50% WP, spiromesifen 22.9% SC and fipronil 5% SC with population of 2.06, 2.11 and 2.21 aphids/leaf, respectively and found at par with each other. The treatment with copper oxychloride 50% WP (5.56) showed relatively more number of aphids and found at par with untreated control (6.24).

4.3.5 Mean

It is evident from the mean data presented in Table 4 and illustrated under Fig.3 that, after each treatment spray flonicamid 50% WG +

copper oxychloride 50% WP proved effective with minimum number of aphids (0.73/leaf). This treatment was found at par with flonicamid 50% WG (0.81), diafenthiuron 50% WP (0.96), diafenthiuron 50% WP + copper oxychloride 50% WP (0.98), (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.55), acephate 50% + imidacloprid 1.8% SP (1.59) and spiromesifen 22.9% SC + copper oxychloride 50% WP (1.60). Whereas, spiromesifen 22.9% SC (1.78), fipronil 5% SC + copper oxychloride 50% WP (1.99) and fipronil 5% SC (2.02) appeared as next better treatments in this respect. Maximum population of aphids was recorded in copper oxychloride 50% WP (5.53) and untreated control (5.78).

The present findings are in agreement with the studies of Meghana et al. (2018) evaluated the efficacy of insecticides and bio pesticides against sucking pests on *Bt* cotton. Their results revealed that, significantly least population of aphids (7.33 aphids /three leaves) was observed from the plots which received flonicamid 50 WG spray. This was followed by fipronil 5% SC (8.87) and diafenthiuron 50%WP (9.26) as against untreated control. Similarly, Nemade et al. (2017) reported that, among the newer insecticides tested flonicamid 50% WG @ 100g and 50g a.i./ha were found promising to managed the cotton aphids followed by diafenthiuron 50%WP @ 300g a.i./ha.

Moreover, Surwase et al. (2017) studied the bioefficacy of newer insecticides against major sucking pests of transgenic cotton. Results indicated that, among all insecticides diafenthiuron 50% WP @ 300 g.a.i/ha was found most effective in reducing aphid population (1.22 aphids /3 leaves) at the end of the third spray, as against untreated control (9.16). Whereas, Boda and Ilyas (2017) tested nine insecticides against sucking pests of *Bt* cotton, they reported Spiromesifen 240 SC and fipronil 5 SC found effective in reducing population of aphids (3.37 aphids /3 leaves) at 14 days after spray as against untreated control (25.57 aphids /3 leaves).

The present findings regarding efficacy of diafenthiuron 50% WP in combination with copper oxychloride 50 WP are in accordance with results of earlier worker Bontha and Mallapur (2017a) who reported lower mean population of aphids in diafenthiuron 50%WP and diafenthiuron 50% WP +

copper oxychloride 50 WP i.e. 3.57 and 3.70 aphids /3 leaves, respectively as against untreated control 11.22 /3 leaves. Similarly, Chandi et al. (2016) assessed the field efficacy of flonicamid 50 WG against sucking insect pests on *Bt* cotton. Based on pooled analysis of three years, Per cent reduction of aphid was higher in flonicamid @ 75 g a.i./ha after 3, 7 and 10 days of spray. The earlier worker Gaurkhede et al. (2015) noticed that, at the end of third spray the application of flonicamid 50 WG@ 0.02 per cent proved effective in recording minimum aphid population i.e. 1.27 aphids per leaf.

4.4 Efficacy of pesticides alone and in combination against cotton leafhoppers after first spray

The data on population of leafhoppers recorded a day before the spray in different plots was found statistically non significant indicating the uniform distribution of the pest on the experimental plots. The population in the different treatment plots ranged from 2.09 to 3.51 leafhoppers per leaf.

4.4.1 Three days after first spray

It is evident from Table 5 (Fig.4) that, all the treatments were significantly effective over copper oxychloride 50% WP and untreated control in reducing population of leafhoppers, at three days after first spray. The treatment with diafenthiuron 50% WP (0.50/leaf) recorded the lowest population leafhoppers. This treatment was found at par with diafenthiuron 50% WP + copper oxychloride 50% WP, flonicamid 50% WG + copper oxychloride 50% WP, flonicamid 50% WG , acephate 50% + imidacloprid 1.8% SP, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, spiromesifen 22.9% SC + copper oxychloride 50% WP, spiromesifen 22.9% SC, fipronil 5% SC and fipronil 5% SC + copper oxychloride 50% WP statistically equal in reducing the population of leafhoppers. In these treatments population ranged between 0.52 to 1.10 leafhoppers per leaf. Whereas, the plots treated with copper oxychloride 50% WP (3.58) and untreated control (3.69) recorded highest number of leafhoppers.

4.4.2 seven days after first spray

The data displayed in Table 5 (Fig.4) indicated that, all the treatments were significantly superior except copper oxychloride 50% WP over untreated control in reaching the minimum population of leafhoppers, at seven days after first spray. The plots sprayed with diafenthiuron 50% WP + copper oxychloride 50% WP (0.79/leaf) recorded the minimum population of leafhoppers. The treatment with, diafenthiuron 50% WP, flonicamid 50% WG, spiromesifen 22.9% SC + copper oxychloride 50% WP, flonicamid 50% WG + copper oxychloride 50% WP, spiromesifen 22.9% SC, acephate 50% + imidacloprid 1.8% SP, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, fipronil 5% SC and fipronil 5% SC + copper oxychloride 50 WP were found statistically equal in reducing the number of leafhoppers in which 0.81, 0.95, 1.02, 1.02, 1.04, 1.07, 1.11, 1.12 and 1.14 leafhoppers/leaf, respectively were recorded. The maximum number of leafhoppers were observed in copper oxychloride 50% WP (3.42) which was found at par with untreated control (3.33).

4.4.3 Ten days after first spray

The data tabulated in Table 5 (Fig.4) revealed that, all the treatments were significantly superior over copper oxychloride 50% WP and untreated control. Among the different treatments flonicamid 50% WG recorded minimum population of leafhoppers (0.31/leaf) .This treatment was found at par with flonicamid 50% WG + copper oxychloride 50% WP, diafenthiuron 50% WP + copper oxychloride 50% WP, diafenthiuron 50% WP, spiromesifen 22.9% SC + copper oxychloride 50% WP (0.89), spiromesifen 22.9% SC and (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP with the population of leafhoppers ranged between 0.48 to 0.89 per leaf. The next effective treatments were in the order viz., acephate 50% + imidacloprid 1.8% SP (0.97), fipronil 5% SC (1.30) and fipronil 5% SC + copper oxychloride 50% WP (2.03) which were found at par with each other. The highest population of leafhoppers was observed in copper oxychloride 50% WP (3.36) and untreated control (3.60).

Table 5: Efficacy of pesticides alone and in combination against cotton leafhoppers after first spray

Tr. No	Treatments	Number of leafhoppers /leaf at					
		Pre count	3DAS	7DAS	10DAS	14DAS	Mean
1	Fipronil 5% SC	3.41 (2.10)	1.09 (1.43)	1.12 (1.44)	1.30 (1.52)	2.46 (1.86)	1.49 (1.56)
2	Spiromesifen 22.9% SC	3.51 (2.11)	1.08 (1.42)	1.04 (1.42)	0.93 (1.39)	1.71 (1.65)	1.19 (1.46)
3	Flonicamid 50% WG	2.61 (1.89)	0.59 (1.26)	0.95 (1.39)	0.31 (1.14)	1.48 (1.57)	0.83 (1.34)
4	Diafenthuron 50% WP	3.47 (2.11)	0.50 (1.22)	0.81 (1.34)	0.84 (1.35)	1.15 (1.46)	0.82 (1.34)
5	Acephate 50% + Imidacloprid 1.8% SP	2.09 (1.76)	0.63 (1.27)	1.07 (1.43)	0.97 (1.49)	2.19 (1.77)	1.22 (1.49)
6	Copper oxychloride 50% WP	3.40 (2.10)	3.58 (2.15)	3.42 (2.12)	3.36 (2.10)	3.75 (2.17)	3.53 (2.16)
7	Fipronil 5% SC + Copper oxychloride 50% WP	3.36 (2.09)	1.10 (1.44)	1.14 (1.46)	2.03 (1.70)	2.37 (1.81)	1.66 (1.60)
8	Spiromesifen 22.9% SC + Copper oxychloride 50% WP	3.10 (2.02)	1.03 (1.41)	1.02 (1.41)	0.89 (1.37)	1.77 (1.66)	1.18 (1.46)
9	Flonicamid 50% WG + Copper oxychloride 50% WP	3.07 (2.02)	0.57 (1.25)	1.02 (1.41)	0.48 (1.22)	1.60 (1.61)	0.92 (1.37)
10	Diafenthuron 50% WP+ Copper oxychloride 50% WP	2.37 (1.83)	0.52 (1.23)	0.79 (1.34)	0.63 (1.28)	1.01 (1.41)	0.74 (1.31)
11	(Acephate 50% +Imidacloprid 1.8% SP) + Copper oxychloride 50% WP	2.30 (1.82)	0.90 (1.39)	1.11 (1.44)	0.89 (1.40)	1.81 (1.68)	1.20 (1.48)
12	Untreated control	2.76 (1.94)	3.69 (2.17)	3.33 (2.08)	3.60 (2.14)	4.13 (2.23)	3.69 (2.15)
	F test	NS	Sig	Sig	Sig	Sig	Sig
	SE (m) ±	0.08	0.09	0.09	0.09	0.10	0.09
	CD at 5 %	0.25	0.27	0.25	0.26	0.29	0.27
	CV %	7.40	11.26	10.09	10.40	9.92	10.42

Note: Figures in parentheses are corresponding square root transformation values.,

DAS- Days After Spraying

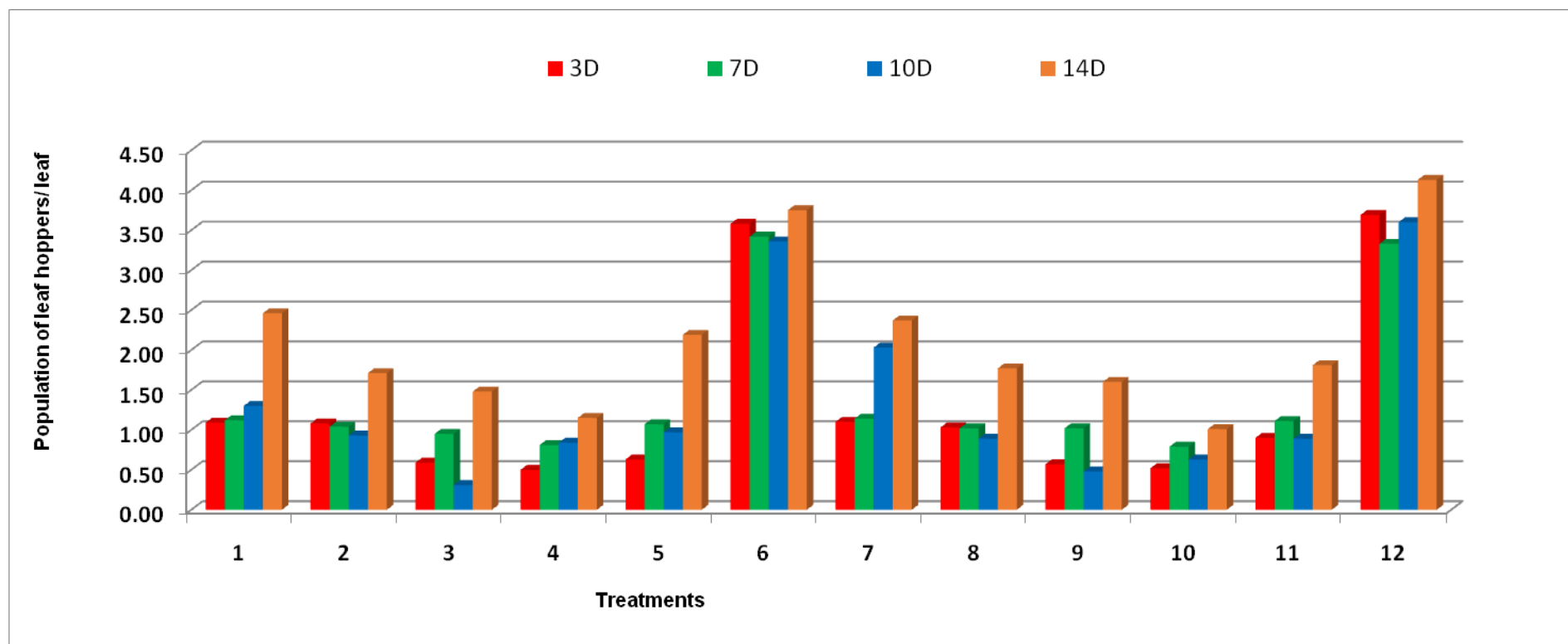


Fig 4. Efficacy of pesticides alone and in combination against cotton leafhoppers after first spray

T ₁ : Fipronil 5% SC	T ₄ : Diafenthiuron 50% WP	T ₇ :Fipronil 5% SC + Copper oxychloride 50% WP	T ₁₀ : Diafenthiuron 50% WP+ Copper oxychloride 50% WP
T ₂ : Spiromesifen 22.9% SC	T ₅ :Acephate 50% + Imidacloprid 1.8% SP	T ₈ : Spiromesifen 22.9%SC + Copper oxychloride 50% WP	T ₁₁ : (Acephate 50% + Imidacloprid 1.8% SP) + Copper oxychloride 50% WP
T ₃ : Flonicamid 50% WG	T ₆ :Copper oxychloride 50% WP	T ₉ :Flonicamid 50% WG + Copper oxychloride 50% WP	T ₁₂ : Untreated control

4.4.4 Fourteen days after first spray.

The data depicted in Table 5 and illustrated in Fig.4 showed the significant results pertaining to population of leafhoppers at fourteen days after first spray. Among the treatments, minimum number of leafhoppers were observed in the plots treated with diafenthiuron 50% WP + copper oxychloride 50% WP (1.01/leaf). This treatment in turn found at par with diafenthiuron 50% WP (1.15), flonicamid 50% WG (1.48), flonicamid 50% WG + copper oxychloride 50% WP (1.60), spiromesifen 22.9% SC (1.71), spiromesifen 22.9% SC + copper oxychloride 50% WP (1.77) and (acephate 50% + Imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.81). The other treatment showed the efficacy in descending order viz., acephate 50% + imidacloprid 1.8% SP (2.19), fipronil 5% SC + copper oxychloride 50% WP (2.37), fipronil 5% SC (2.46) which were found at par with each other. Whereas maximum population of leafhoppers was observed in untreated control (4.13/leaf) which is found at par with copper oxychloride 50% WP (3.75).

4.4.5 Mean

The data displayed in Table 5 (Fig.4) regarding mean population of leafhoppers after first spray showed that, all the treatments were significantly superior except copper oxychloride 50% WP over untreated control in recording minimum population of leafhoppers. Among the different treatments diafenthiuron 50% WP + copper oxychloride 50% WP recorded the lowest population leafhoppers (0.74/leaf). This was followed diafenthiuron 50% WP (0.82), flonicamid 50% WP (0.83), flonicamid 50% WG + copper oxychloride 50% WP (0.92), spiromesifen 22.9% SC + copper oxychloride 50% WP (1.18), spiromesifen 22.9% SC (1.19), (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.20), acephate 50% + imidacloprid 1.8% SP (1.22), fipronil 5% SC (1.49) and fipronil 5% SC+ copper oxychloride 50% WP (1.66). All these treatments were found statistically equal in recording minimum population of leafhoppers as against copper oxychloride 50% WP (3.53) and untreated control (3.69).

4.5 Efficacy of pesticides alone and in combination against cotton leafhoppers after second spray

4.5.1 Three days after second spray

The data pertaining to efficacy of pesticide combination against leafhoppers at three days after second spray presented in Table 6 (Fig.5) revealed that minimum population of leafhoppers (0.27/leaf) was recorded in plots treated with diafenthiuron 50% WP + copper oxychloride 50% WP. This treatment was found at par with diafenthiuron 50% WP, flonicamid 50% WG + copper oxychloride 50% WP, flonicamid 50% WG, spiromesifen 22.9% SC + copper oxychloride 50% WP, acephate 50% + imidacloprid 1.8% SP and (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP in which population ranged between 0.45 to 0.64 leafhoppers/leaf. Next in order of efficacy was fipronil 5% SC + copper oxychloride 50% WP which recorded 0.85 leafhoppers/leaf and found at par with spiromesifen 22.9% SC (1.30). Whereas, the treatment with fipronil 5% SC was found moderately effective with population of 1.65 leafhoppers/leaf. The highest population of leafhoppers was observed in copper oxychloride 50% WP (4.25) and untreated control (4.88) which were found at par with each other.

4.5.2 Seven days after second spray

Among the different treatments the leafhopper population recorded at seven days after second spray (Table 6 and Fig.5) was minimum in the plots treated with flonicamid 50% WG + copper oxychloride 50% WP i.e. 0.84 leafhoppers/leaf. This treatment was found at par with diafenthiuron 50% WP (0.93), diafenthiuron 50% WP + copper oxychloride 50% WP (0.94), flonicamid 50% WG (1.30), acephate 50% + Imidacloprid 1.8% SP (1.35) and (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.52). Next in order, the treatment with spiromesifen 22.9% SC, spiromesifen 22.9% SC + copper oxychloride 50% WP, fipronil 5% SC + copper oxychloride 50% WP and fipronil 5% SC recorded population of leafhoppers ranged between 1.70 to 1.91/leaf. Whereas, significantly maximum population of leafhoppers was observed in treatment with copper oxychloride 50% WP (4.30) which was found at par with untreated control (4.26).

Table 6: Efficacy of pesticides alone and in combination against cotton leafhoppers after second spray

Tr. No	Treatments	Number of leafhoppers /leaf at				
		3DAS	7DAS	10DAS	14DAS	Mean
1	Fipronil 5% SC	1.65 (1.64)	1.91 (1.71)	1.98 (1.72)	1.86 (1.69)	1.85 (1.69)
2	Spiromesifen 22.9% SC	1.30 (1.51)	1.70 (1.64)	1.86 (1.69)	1.64 (1.62)	1.63 (1.62)
3	Flonicamid 50% WG	0.53 (1.24)	1.30 (1.51)	1.32 (1.52)	1.22 (1.49)	1.10 (1.44)
4	Diafenthiuron 50% WP	0.45 (1.20)	0.93 (1.39)	0.73 (1.32)	1.10 (1.45)	0.80 (1.34)
5	Acephate 50% + Imidacloprid 1.8% SP	0.59 (1.26)	1.35 (1.53)	0.99 (1.41)	1.12 (1.45)	1.01 (1.41)
6	Copper oxychloride 50% WP	4.25 (2.25)	4.30 (2.28)	4.44 (2.33)	3.67 (2.14)	4.25 (2.25)
7	Fipronil 5% SC + Copper oxychloride 50% WP	0.85 (1.36)	1.86 (1.69)	1.69 (1.63)	1.79 (1.64)	1.55 (1.58)
8	Spiromesifen 22.9% SC + Copper oxychloride 50% WP	0.55 (1.24)	1.85 (1.69)	1.55 (1.59)	1.56 (1.59)	1.38 (1.53)
9	Flonicamid 50% WG + Copper oxychloride 50% WP	0.52 (1.23)	0.84 (1.36)	1.23 (1.49)	1.40 (1.55)	1.00 (1.41)
10	Diafenthiuron 50% WP+ Copper oxychloride 50% WP	0.27 (1.13)	0.94 (1.39)	0.76 (1.33)	1.07 (1.43)	0.76 (1.32)
11	(Acephate 50% +Imidacloprid 1.8% SP) + Copper oxychloride 50% WP	0.64 (1.28)	1.52 (1.59)	1.38 (1.54)	1.16 (1.46)	1.18 (1.47)
12	Untreated control	4.88 (2.44)	4.26 (2.27)	4.16 (2.26)	4.07 (2.25)	4.34 (2.31)
	F test	Sig	Sig	Sig	Sig	Sig
	SE (m) ±	0.07	0.08	0.08	0.10	0.08
	CD at 5 %	0.21	0.23	0.25	0.28	0.24
	CV %	8.75	8.13	8.72	9.86	8.87

Note: Figures in parentheses are corresponding square root transformation values.

DAS- Days After Spraying

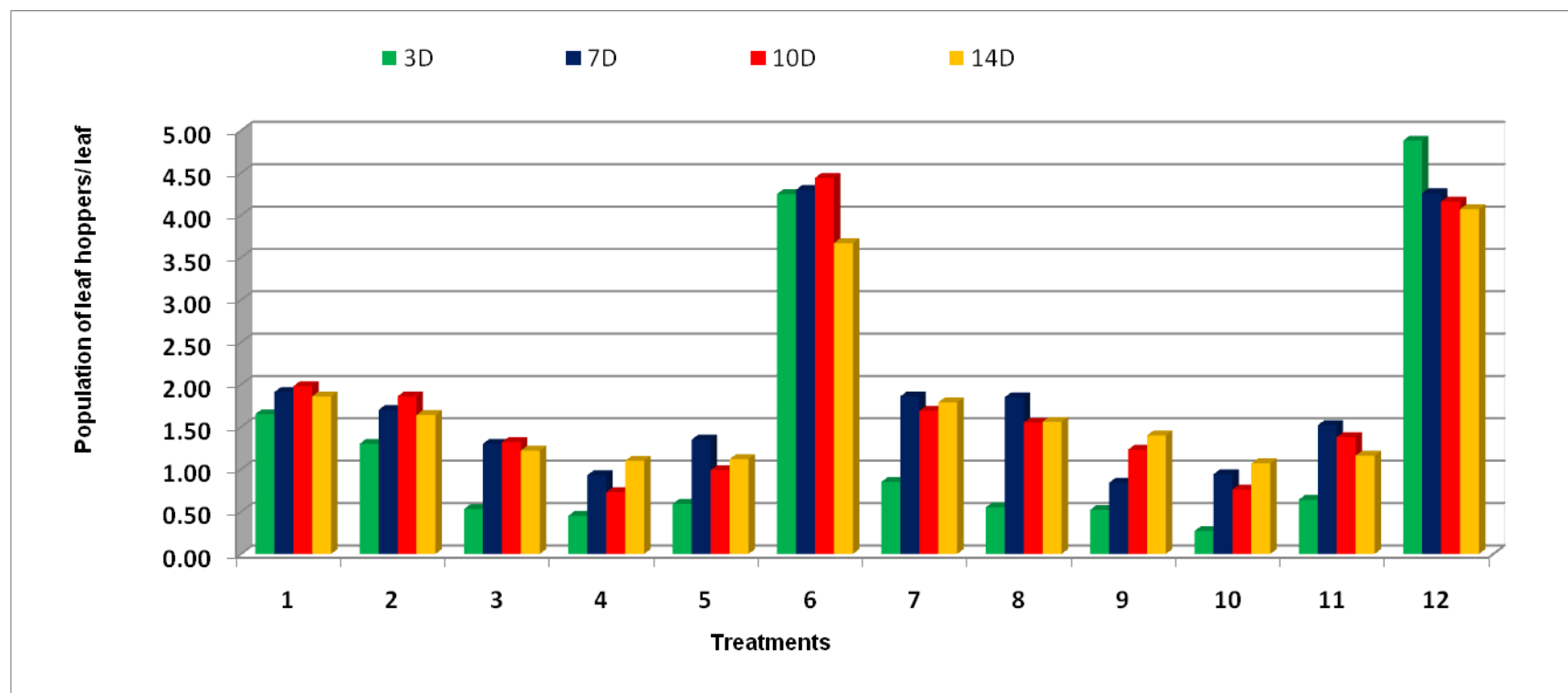


Fig 5. Efficacy of pesticides alone and in combination against cotton leafhoppers after second spray

T₁ : Fipronil 5% SC

T₄: Diafenthiuron 50% WP

T₇ :Fipronil 5% SC + Copper oxychloride 50% WP

T₁₀: Diafenthiuron 50% WP + Copper oxychloride 50% WP

T₂ : Spiromesifen 22.9% SC

T₅:Acephate 50% + Imidacloprid 1.8% SP

T₈: Spiromesifen 22.9%SC + Copper oxychloride 50% WP

T₁₁: (Acephate 50% + Imidacloprid 1.8% SP) + Copper oxychloride 50% WP

T₃: Flonicamid 50% WG

T₆:Copper oxychloride 50% WP

T₉ :Flonicamid 50% WG + Copper oxychloride 50% WP

T₁₂: Untreated control

4.5.3 Ten days after second spray

The data on the efficacy of various treatments against leafhoppers at ten days after second spray (Table 6 and Fig.5) revealed that diafenthiuron 50% WP, diafenthiuron 50% WP + copper oxychloride 50% WP, acephate 50% + imidacloprid 1.8% SP, flonicamid 50% WG + copper oxychloride 50% WP, flonicamid 50% WG and (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP proved equally effective in recording minimum population of leafhoppers ranged between 0.73 to 1.38/leaf, respectively. The treatment spiromesifen 22.9% SC + copper oxychloride 50% WP (1.55), fipronil 5% SC + copper oxychloride 50% WP (1.69), spiromesifen 22.9% SC (1.86) and fipronil 5% SC (1.98) were found moderately effective. Whereas, copper oxychloride 50% WP and untreated control recorded 4.44 and 4.16 leafhoppers/leaf.

4.5.4 Fourteen days after second spray

The data depicted in Table 6 (Fig.5) regarding leafhopper population at fourteen days after second spray showed that, treatment with diafenthiuron 50% WP + copper oxychloride 50% WP recorded minimum population of leafhoppers (i.e. 1.07 leafhoppers/leaf). However, this treatment was found at par with diafenthiuron 50% WP (1.10), acephate 50% + Imidacloprid 1.8% SP (1.12), (acephate 50% + Imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.16), flonicamid 50% WG(1.22), flonicamid 50% WG + copper oxychloride 50% WP (1.40), spiromesifen 22.9%SC + copper oxychloride 50% WP (1.56), spiromesifen 22.9% SC (1.64), fipronil 5% SC + copper oxychloride 50% WP (1.79) and fipronil 5% SC (1.86). Maximum population of leafhoppers were recorded in untreated control (4.07) and found at par with copper oxychloride 50% WP (3.67).

4.5.5 Mean

It is evident from the mean data presented in Table 6 and illustrated under Fig.5 that, after second spray treatment with diafenthiuron 50% WP + copper oxychloride 50% WP proved effective with minimum number of leafhoppers (0.76). This treatment was found at par with

diafenthiuron 50% WP (0.80), flonicamid 50% WG + copper oxychloride 50% WP (1.00), acephate 50% + imidacloprid 1.8% SP (1.01), flonicamid 50% WG (1.10), (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.18) and spiromesifen 22.9% SC + copper oxychloride 50% WP (1.38). Whereas, fipronil 5% SC + copper oxychloride 50% WP (1.55), spiromesifen 22.9% SC (1.63) and fipronil 5% SC (1.85) appeared as next better treatments in this respect. Highest number of leafhopper population was recorded in untreated control (4.34) and was at par with copper oxychloride 50% WP (4.25).

4.6 Efficacy of pesticides alone and in combination against cotton leafhoppers after third spray

4.6.1 Three days after third spray

Leafhopper population recorded at three days after third spray presented in Table 7 (Fig.6) revealed that all the treatment except copper oxychloride 50% WP found significantly effective in reducing the leafhoppers as against untreated control. Among the treatments, diafenthiuron 50% WP + copper oxychloride 50% WP recorded minimum leafhoppers (0.31/leaf) found statistically equal to flonicamid 50% WG + copper oxychloride 50% WP (0.43), diafenthiuron 50% WP (0.44), flonicamid 50% WG (0.46), acephate 50% + imidacloprid 1.8% SP (0.52), fipronil 5% SC + copper oxychloride 50% WP (0.54) and (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (0.77). Whereas, fipronil 5% SC, spiromesifen 22.9% SC and spiromesifen 22.9% SC + copper oxychloride 50% WP appeared as next better treatments with population of 1.18, 1.28 and 1.87 leafhoppers/leaf, respectively. However, highest number of leafhoppers were recorded in copper oxychloride 50% WP and untreated control with population of 3.52 and 3.40/leaf, respectively and found at par with each other.

4.6.2 Seven days after third spray

The Table 7 (Fig.6) pertaining to leafhopper population recorded at seven days after third spray showed that the minimum number of leafhoppers were observed in plots treated with diafenthiuron 50% WP

(0.43/leaf). This treatment was found at par with diafenthiuron 50% WP + copper oxychloride 50% WP, acephate 50% + imidacloprid 1.8% SP, flonicamid 50% WG + copper oxychloride 50% WP, flonicamid 50% WG and (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP in which leafhopper population ranged between 0.56 to 1.02 /leaf. These treatments were followed by the treatments spiromesifen 22.9%SC + copper oxychloride 50% WP (1.12), spiromesifen 22.9% SC (1.17), fipronil 5% SC (1.33) and fipronil 5% SC + copper oxychloride 50% WP (1.43) proved moderately effective. Maximum population of leafhoppers were recorded in plots treated with copper oxychloride 50% WP (3.04) and untreated control (3.90).

4.6.3 Ten days after third spray

The data displayed in Table 7 (Fig.6) indicated that all the treatments except copper oxychloride 50% WP significantly superior over untreated control in recording minimum population of leafhoppers, at ten days after third spray. The treatment with diafenthiuron 50% WP + copper oxychloride 50% WP, flonicamid 50% WG, diafenthiuron 50% WP, flonicamid 50% WG + copper oxychloride 50% WP, acephate 50% + imidacloprid 1.8% SP, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, spiromesifen 22.9% SC + copper oxychloride 50% WP, fipronil 5% SC + copper oxychloride 50% WP and spiromesifen 22.9% SC were found statistically equal in reducing the population leafhoppers in which 0.84, 0.92, 1.14, 1.15, 1.22, 1.28, 1.37, 1.47 and 1.60 leafhoppers/leaf, respectively were recorded. The latter treatments were also in turn found at par with fipronil 5% SC (1.87). Plots treated with copper oxychloride 50% WP (4.14) and untreated control (3.96) recorded highest number of leafhoppers per leaf.

4.6.4 Fourteen days after third spray

The data presented in Table 7 (Fig.6) revealed that the treatment with diafenthiuron 50% WP + copper oxychloride 50% WP, found significantly superior over other treatments with minimum population of leafhoppers (0.51/leaf) at fourteen days after third spray. However, this treatment was found at par with diafenthiuron 50% WP (1.04) and acephate

Table 7: Efficacy of pesticides alone and in combination against cotton leafhoppers after third spray

Tr. No	Treatments	Number of leafhoppers /leaf at				
		3DAS	7DAS	10DAS	14DAS	Mean
1	Fipronil 5% SC	1.18 (1.46)	1.33 (1.53)	1.87 (1.69)	1.81 (1.68)	1.55 (1.59)
2	Spiromesifen 22.9% SC	1.28 (1.50)	1.17 (1.46)	1.60 (1.61)	1.69 (1.63)	1.43 (1.55)
3	Flonicamid 50% WG	0.46 (1.21)	1.01 (1.41)	0.92 (1.39)	1.57 (1.60)	0.99 (1.40)
4	Diafenthiuron 50% WP	0.44 (1.20)	0.43 (1.20)	1.14 (1.45)	1.04 (1.42)	0.76 (1.32)
5	Acephate 50% + Imidacloprid 1.8% SP	0.52 (1.23)	0.71 (1.31)	1.22 (1.48)	1.21 (1.47)	0.91 (1.37)
6	Copper oxychloride 50% WP	3.52 (2.12)	3.04 (2.01)	4.14 (2.26)	3.93 (2.21)	3.66 (2.15)
7	Fipronil 5% SC + Copper oxychloride 50% WP	0.54 (1.24)	1.43 (1.56)	1.47 (1.54)	2.11 (1.76)	1.39 (1.52)
8	Spiromesifen 22.9% SC + Copper oxychloride 50% WP	1.87 (1.68)	1.12 (1.45)	1.37 (1.53)	1.87 (1.69)	1.56 (1.59)
9	Flonicamid 50% WG + Copper oxychloride 50% WP	0.43 (1.19)	0.80 (1.34)	1.15 (1.46)	1.42 (1.56)	0.95 (1.39)
10	Diafenthiuron 50% WP+ Copper oxychloride 50% WP	0.31 (1.14)	0.56 (1.25)	0.84 (1.36)	0.51 (1.23)	0.56 (1.24)
11	(Acephate 50% +Imidacloprid 1.8% SP) + Copper oxychloride 50% WP	0.77 (1.33)	1.02 (1.42)	1.28 (1.51)	1.56 (1.59)	1.16 (1.46)
12	Untreated control	3.40 (2.08)	3.90 (2.20)	3.96 (2.22)	4.04 (2.23)	3.83 (2.18)
	F test	Sig	Sig	Sig	Sig	Sig
	SE (m) ±	0.09	0.08	0.09	0.10	0.09
	CD at 5 %	0.28	0.24	0.25	0.29	0.27
	CV %	11.44	9.22	9.09	10.31	10.02

Note: Figures in parentheses are corresponding square root transformation values. DAS- Days After Spraying

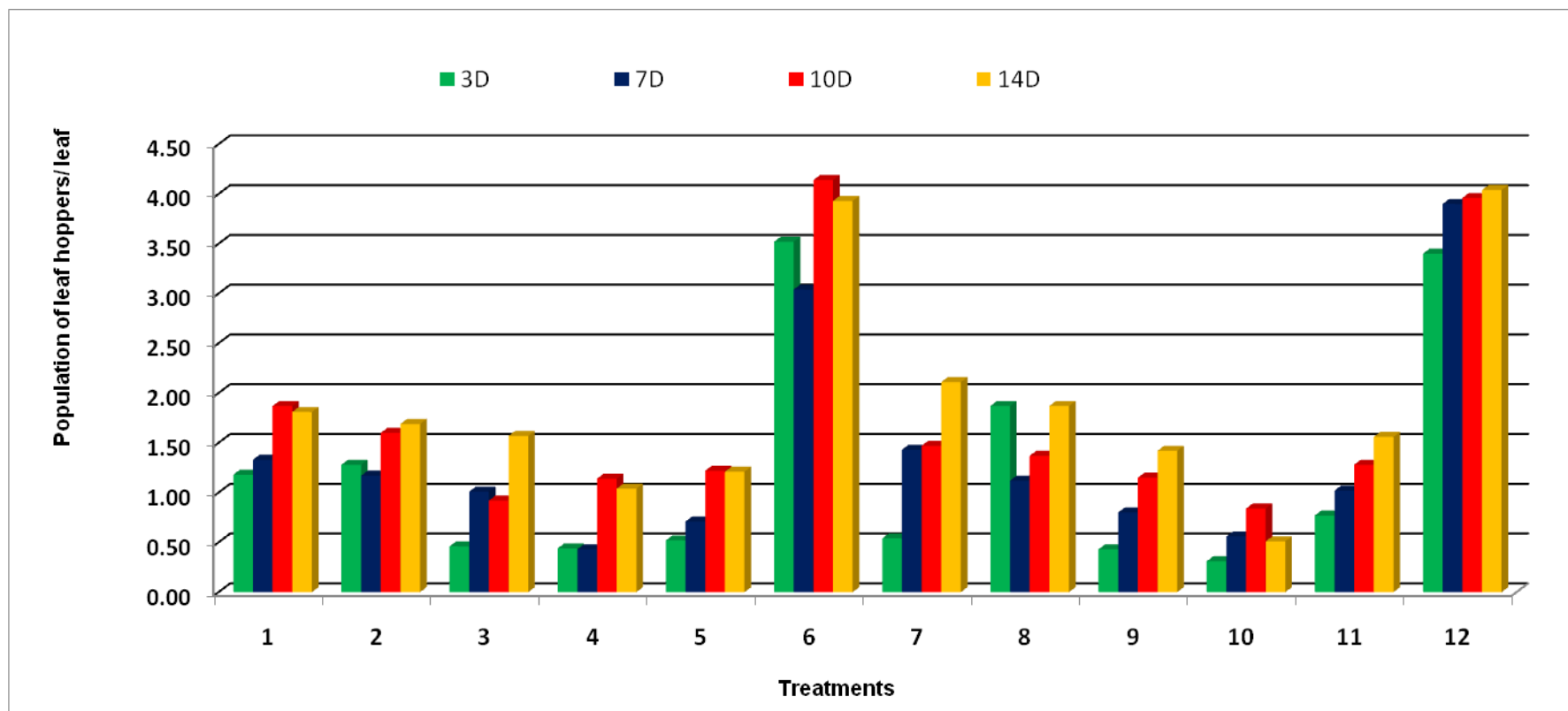


Fig 6. Efficacy of pesticides alone and in combination against cotton leafhoppers after third spray

T₁ : Fipronil 5% SC

T₄: Diafenthiuron 50% WP

T₇ :Fipronil 5% SC + Copper oxychloride 50% WP

T₁₀: Diafenthiuron 50% WP + Copper oxychloride 50% WP

T₂ : Spiromesifen 22.9% SC

T₅:Acephate 50% + Imidacloprid 1.8% SP

T₈: Spiromesifen 22.9%SC + Copper oxychloride 50% WP

T₁₁: (Acephate 50% + Imidacloprid 1.8 % SP) + Copper oxychloride 50% WP

T₃: Flonicamid 50% WG

T₆:Copper oxychloride 50% WP

T₉ :Flonicamid 50% WG + Copper oxychloride 50% WP

T₁₂: Untreated control

50% + imidacloprid 1.8% SP (1.21). The remaining treatments showed efficacy in descending order viz., flonicamid 50% WG + copper oxychloride 50% WP, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, flonicamid 50% WG, spiromesifen 22.9% SC, fipronil 5% SC, spiromesifen 22.9% SC + copper oxychloride 50% WP, fipronil 5% SC + copper oxychloride 50% WP and copper oxychloride 50% WP with 1.42, 1.56, 1.57, 1.69, 1.81, 1.87, 2.11 and 3.93 leafhoppers/leaf, respectively. Maximum number of leafhoppers were observed in untreated control (4.04/leaf).

4.6.5 Mean

Data on the mean number of leafhopper population after third spray (Table 7 and Fig.6) revealed that treatment with diafenthiuron 50% WP + copper oxychloride 50% WP recorded minimum leafhopper population (0.56/leaf). However, this treatment proved statistically equal with diafenthiuron 50% WP (0.77), acephate 50% + imidacloprid 1.8% SP (0.91), flonicamid 50% WG + copper oxychloride 50% WP (0.95), flonicamid 50% WG (0.99) and (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.16) in reducing the leaf hoper population at different intervals after third spray. Whereas, Fipronil 5% SC + copper oxychloride 50% WP (1.39), spiromesifen 22.9% SC (1.43), fipronil 5% SC (1.55) and spiromesifen 22.9% SC + copper oxychloride 50% WP (1.56) appeared as next better treatments in this respect. Significantly highest number of leafhoppers was recorded in untreated control (3.83) which was found at par with copper oxychloride 50% WP (3.66).

4.7 Cumulative effect of pesticides alone and in combination against cotton leafhoppers

4.7.1 Three days after spray

The data depicted in Table 8 (Fig.7) regarding leafhopper population at three days after spray showed that, treatment with diafenthiuron 50% WP + copper oxychloride 50% WP recorded minimum population of leafhoppers (i.e. 0.37 leafhoppers/leaf). However, this treatment was found at par with diafenthiuron 50% WP, flonicamid 50% WG + copper oxychloride 50% WP, flonicamid 50% WG, acephate 50% + imidacloprid 1.8% SP,

(acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP and fipronil 5% SC + copper oxychloride 50% WP in which population ranged between 0.46 to 0.83 leafhoppers/leaf. These were followed by the treatments spiromesifen 22.9% SC + copper oxychloride 50% WP, spiromesifen 22.9% SC and fipronil 5% SC proved moderately effective with 1.5, 1.22 and 1.31 leafhoppers per leaf, respectively. However, highest number of leafhoppers were recorded in copper oxychloride 50% WP and untreated control with population of 3.78 and 3.99/leaf, respectively.

4.7.2 Seven days after spray

The data presented in Table 8 (Fig.7) revealed that, all the treatments except copper oxychloride 50% WP found statistically superior over untreated control in reducing the population of leafhoppers at seven days after treatment. Among the different treatments plots treated with diafenthiuron 50% WP recorded minimum number of leafhoppers i.e. 0.72/leaf. However, this treatment was closely followed by diafenthiuron 50% WP + copper oxychloride 50% WP (0.76), flonicamid 50% WG + copper oxychloride 50% WP (0.89), acephate 50% + imidacloprid 1.8 % SP (1.04), Flonicamid 50% WG (1.09), (Acephate 50% + Imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.22), spiromesifen 22.9% SC (1.30) and spiromesifen 22.9% SC + copper oxychloride 50% WP (1.33). The latter treatments in turn found at par with fipronil 5% SC (1.45) and fipronil 5% SC + copper oxychloride 50% WP (1.48). Plots treated with copper oxychloride 50% WP (3.59) and untreated control (3.83) recorded maximum number of leafhoppers.

4.7.3 Ten days after spray

The data pertaining to leafhopper population recorded at ten days after each spray (Table 8 and Fig.7) was found statistically significant. Among the treatments minimum leafhoppers (0.74/leaf) were observed in the plots treated with diafenthiuron 50% WP + copper oxychloride 50% WP. However, this treatment found statistically equal to flonicamid 50% WG, diafenthiuron 50% WP, flonicamid 50% WG + copper oxychloride 50% WP, acephate 50% + imidacloprid 1.8% SP, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, spiromesifen 22.9% SC + copper

Table 8: Cumulative effect of pesticides alone and in combination against cotton leafhoppers

Tr. No	Treatments	Number of leafhoppers /leaf at				
		3DAS	7DAS	10DAS	14DAS	Mean
1	Fipronil 5% SC	1.31 (1.51)	1.45 (1.56)	1.72 (1.62)	2.04 (1.74)	1.63 (1.61)
2	Spiromesifen 22.9% SC	1.22 (1.48)	1.30 (1.51)	1.46 (1.56)	1.68 (1.63)	1.42 (1.55)
3	Flonicamid 50% WG	0.53 (1.24)	1.09 (1.44)	0.85 (1.35)	1.42 (1.55)	0.97 (1.39)
4	Diafenthiuron 50% WP	0.46 (1.21)	0.72 (1.31)	0.90 (1.37)	1.10 (1.44)	0.80 (1.33)
5	Acephate 50% + Imidacloprid 1.8% SP	0.58 (1.25)	1.04 (1.42)	1.06 (1.46)	1.51 (1.57)	1.05 (1.43)
6	Copper oxychloride 50% WP	3.78 (2.17)	3.59 (2.14)	3.98 (2.23)	3.78 (2.17)	3.78 (2.18)
7	Fipronil 5% SC + Copper oxychloride 50% WP	0.83 (1.35)	1.48 (1.57)	1.73 (1.64)	2.09 (1.74)	1.53 (1.57)
8	Spiromesifen 22.9% SC + Copper oxychloride 50% WP	1.15 (1.44)	1.33 (1.52)	1.27 (1.50)	1.73 (1.65)	1.37 (1.53)
9	Flonicamid 50% WG + Copper oxychloride 50% WP	0.51 (1.22)	0.89 (1.37)	0.95 (1.39)	1.47 (1.56)	0.96 (1.39)
10	Diafenthiuron 50% WP+ Copper oxychloride 50% WP	0.37 (1.17)	0.76 (1.33)	0.74 (1.32)	0.86 (1.36)	0.68 (1.29)
11	(Acephate 50% +Imidacloprid 1.8% SP) + Copper oxychloride 50% WP	0.77 (1.33)	1.22 (1.48)	1.18 (1.48)	1.51 (1.58)	1.17 (1.47)
12	Untreated control	3.99 (2.23)	3.83 (2.18)	3.91 (2.21)	4.08 (2.24)	3.95 (2.21)
	F test	Sig	Sig	Sig	Sig	Sig
	SE (m) ±	0.08	0.08	0.09	0.10	0.09
	CD at 5 %	0.25	0.24	0.25	0.29	0.26
	CV %	10.48	9.15	9.40	10.03	9.77

Note: Figures in parentheses are corresponding square root transformation values.

DAS- Days After Spraying

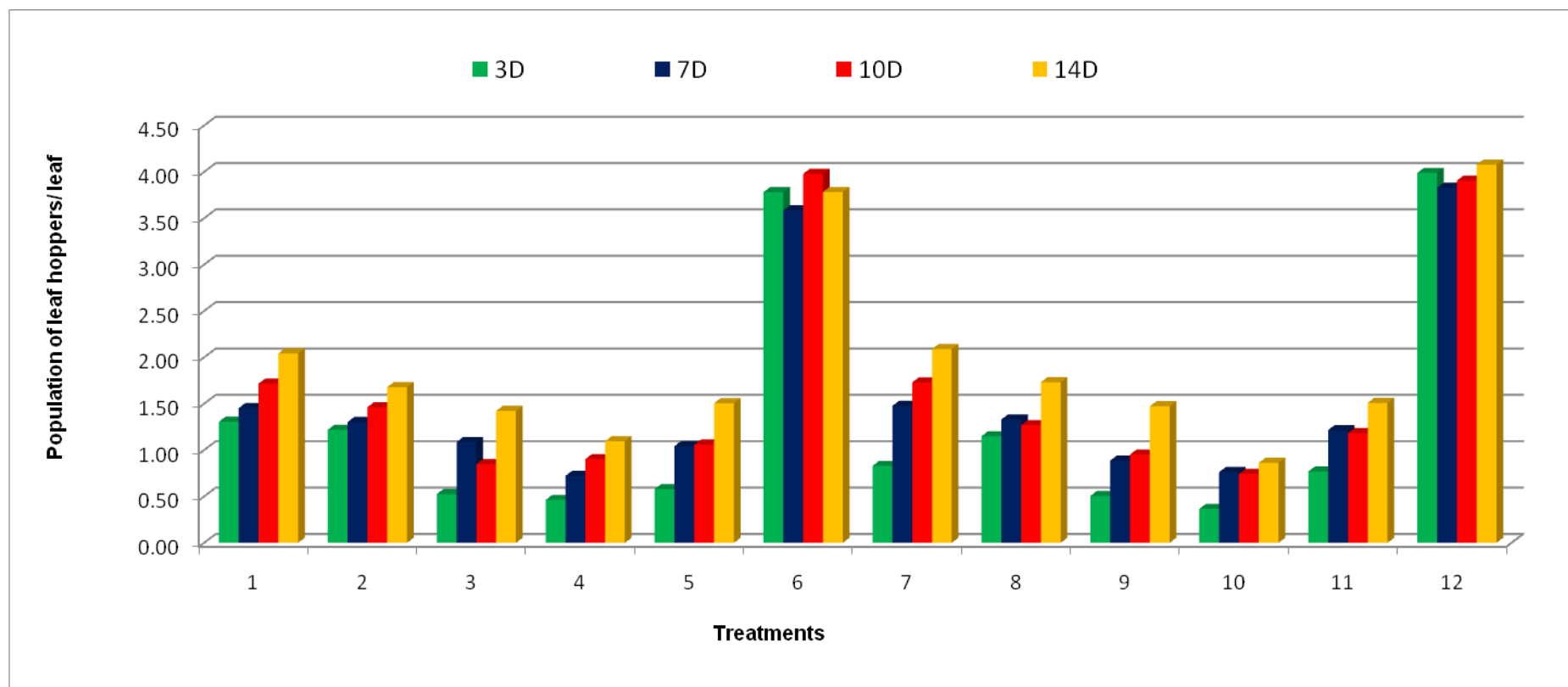


Fig 7. Cumulative effect of pesticides alone and in combination against cotton leafhoppers

T₁ : Fipronil 5% SC

T₄: Diafenthiuron 50% WP

T₇ :Fipronil 5% SC + Copper oxychloride 50% WP

T₁₀: Diafenthiuron 50% WP + Copper oxychloride 50% WP

T₂ : Spiromesifen 22.9% SC

T₅:Acephate 50% + Imidacloprid 1.8% SP

T₈: Spiromesifen 22.9% SC + Copper oxychloride 50% WP

T₁₁: (Acephate 50% + Imidacloprid 1.8% SP) + Copper oxychloride 50% WP

T₃: Flonicamid 50% WG

T₆:Copper oxychloride 50% WP

T₉ :Flonicamid 50% WG + Copper oxychloride 50% WP

T₁₂: Untreated control

oxychloride 50% WP and spiromesifen 22.9% SC in which 0.85, 0.90, 0.95, 1.06, 1.18, 1.27 and 1.46 leafhoppers/leaf were recorded, respectively. All these treatments found at par with each other. The treatment fipronil 5% SC (1.72) and fipronil 5% SC + copper oxychloride 50% WP (1.73) found moderately effective in reducing population of leafhoppers. Maximum population of leafhoppers were recorded in copper oxychloride 50% WP (3.98) and found at par with untreated control (3.91).

4.7.4 Fourteen days after spray

The population of leafhoppers recorded during fourteen days after each spray (Table 8 and Fig.7) revealed that plots treated with diafenthiuron 50% WP + copper oxychloride 50% WP recorded minimum population of leafhoppers (0.86/leaf). This treatment was found at par with diafenthiuron 50% WP (1.10), flonicamid 50% WG (1.42), flonicamid 50% WG + copper oxychloride 50% WP (1.47), acephate 50% + Imidacloprid 1.8% SP (1.51), (acephate 50% + Imidacloprid (1.8% SP) + copper oxychloride 50% WP (1.51), spiromesifen 22.9% SC (1.68) and spiromesifen 22.9% SC + copper oxychloride 50% WP (1.73). These were followed by fipronil 5% SC and fipronil 5% SC + copper oxychloride 50% WP with 2.04 and 2.09 leafhoppers/leaf, respectively. The treatment copper oxychloride 50% WP (3.78) and untreated control (4.08) recorded highest number of leafhoppers and found at par with each other.

4.7.5 Mean

The mean data (Table 8 and Fig.7) regarding the population of leafhoppers after each spray revealed that, all the treatments except copper oxychloride 50% WP proved significantly effective over untreated control in recording minimum number of leafhoppers. Amongst the various treatments, diafenthiuron 50% WP + copper oxychloride 50% WP recorded minimum population of leafhoppers (0.68/leaf). However, this treatment was found statistically equal with diafenthiuron 50% WP (0.80), flonicamid 50% WG + copper oxychloride 50% WP (0.96), flonicamid 50% WG (0.97), acephate 50% + imidacloprid 1.8% SP (1.05), (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.17), spiromesifen

22.9% SC + copper oxychloride 50% WP (1.37) and spiromesifen 22.9% SC (1.42). The treatments fipronil 5% SC + copper oxychloride 50% WP and fipronil 5% SC proved moderately effective with population of 1.53 and 1.63 leafhoppers/leaf, respectively. Maximum number of leafhoppers was observed in plots treated with copper oxychloride 50% WP (3.78) and untreated control (3.95).

The present finding regarding efficacy of diafenthiuron 50 WP against leafhoppers carried out by Kalyan et al. (2017). Evaluate the efficacy of new molecule and reported that out of ten treatments, the maximum per cent reduction in cotton jassids population with a mean of 77.80 and 79.13 was recorded in diafenthiuron 50 WP at seven days after second spray during both the year of experimentation, respectively and it was found statistically at par with flonicamid 50 WG @ 100g a.i./ha and fipronil 5 SC @ 100G a.i./ha. Similarly in field experiment conducted by Sathyan et al. (2016) reported that, the leafhopper population on the plants treated with difenthiuron 50 WP was significantly lower than all other treatments and found statistically equal to fipronil SC (2.60 leafhoppers /3 leaves). Further they reported that, in addition to these treatments flonicamid 50 WG and Spiromesifen 22.9% SC was also able to reduce the leafhopper population by more than 50 per cent compared to untreated check.

Similar findings were also reported by Halappa and Patil (2014) who recorded 76.59, 76.23 per cent reduction in cotton leafhopper population over untreated check, in fipronil 5 SC and diafenthiuron 50 WP treated plots, respectively. Boda and Ilyas (2017) in their field experiment reported efficacy of spiromesifen 240 SC and fipronil 5 SC against cotton jassids over untreated check. Moreover, the earlier workers Bontha and Mallapur (2017a) evaluated the biological compatibility of diafenthiuron 50 WP with fungicides. The result of field trial showed that diafenthiuron 50 WP when sprayed in combination with copper oxychloride 50 WP exhibited additive action, found effective against leafhoppers with higher pest reduction values over untreated check. Similarly, Kodandaram et al. (2017) carried out an experiment to study the bioefficacy, phytotoxicity, and residue dynamics of sprays of flonicamid 50 WG in okra (*Abelmoschus esculenta* (L.) Moench) crops. They found that,

applications of flonicamid 50 WG at 75 g a.i./ha were equally effective in controlling both leafhoppers after three rounds of foliar application at an interval of 10 days.

4.8 Efficacy of pesticides alone and in combination against cotton whiteflies after first spray

The data on whitefly population recorded a day before the spray in different plots was found statistically non significant indicating the uniform distribution of the pest on the experimental plots. The population in the different treatment plots ranged from 3.03 to 4.17 whiteflies per leaf.

4.8.1 Three days after first spray

The data presented in Table 9 (Fig.8) revealed that minimum population of whiteflies was recorded in the plots treated with diafenthiuron 50% WP + copper oxychloride 50% WP (0.42/leaf) at three days after first spray. However, this treatment was found at par with spiromesifen 22.9% SC (0.44), spiromesifen 22.9% SC + copper oxychloride 50% WP (0.50), diafenthiuron 50% WP (0.59) and (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (0.83). The next best treatments in the order were viz., acephate 50% + imidacloprid 1.8% SP (1.24), flonicamid 50% WG + copper oxychloride 50% WP (1.43), flonicamid 50% WG (1.62), fipronil 5% SC (1.63) and fipronil 5% SC+ copper oxychloride 50% WP (1.65). All these treatments were found at par with each other but are superior to plots treated with copper oxychloride 50% WP (2.69) and untreated control (2.83).

4.8.2 Seven days after first spray

The data tabulated in Table 9 illustrated under Fig.8 pertaining to whitefly population seven days after first spray was significant. Among the treatments, diafenthiuron 50% WP + copper oxychloride 50% WP recorded less number of whiteflies (0.62/leaf). However, this treatment was found at par with spiromesifen 22.9% SC, diafenthiuron 50% WP, flonicamid 50% WG + copper oxychloride 50% WP, spiromesifen 22.9% SC + copper oxychloride 50% WP, flonicamid 50% WG, acephate 50% + imidacloprid 1.8% SP, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, fipronil 5% SC + copper oxychloride 50% WP and fipronil 5% SC in which the

Table 9: Efficacy of pesticides alone and in combination against cotton whiteflies after first spray

Tr. No	Treatments	Number of whiteflies /leaf at					
		Pre count	3DAS	7DAS	10DAS	14DAS	Mean
1	Fipronil 5% SC	3.37 (2.07)	1.63 (1.62)	1.29 (1.51)	1.52 (1.58)	1.32 (1.52)	1.44 (1.56)
2	Spiromesifen 22.9% SC	3.24 (2.06)	0.44 (1.20)	0.68 (1.29)	0.71 (1.31)	0.61 (1.27)	0.61 (1.27)
3	Flonicamid 50% WG	3.03 (2.00)	1.62 (1.61)	0.91 (1.38)	1.22 (1.48)	0.70 (1.30)	1.11 (1.44)
4	Diafenthiuron 50% WP	3.75 (2.18)	0.59 (1.26)	0.75 (1.31)	0.77 (1.32)	0.59 (1.25)	0.67 (1.29)
5	Acephate 50% + Imidacloprid 1.8% SP	3.17 (2.04)	1.24 (1.49)	1.02 (1.41)	0.81 (1.34)	0.70 (1.30)	0.94 (1.38)
6	Copper oxychloride 50% WP	3.13 (2.03)	2.69 (1.91)	3.13 (2.03)	3.10 (2.01)	3.33 (2.07)	3.06 (2.01)
7	Fipronil 5% SC + Copper oxychloride 50% WP	4.17 (2.26)	1.65 (1.62)	1.17 (1.46)	1.24 (1.49)	0.71 (1.30)	1.19 (1.47)
8	Spiromesifen 22.9% SC + Copper oxychloride 50% WP	3.33 (2.06)	0.50 (1.22)	0.77 (1.32)	0.75 (1.32)	0.64 (1.28)	0.67 (1.29)
9	Flonicamid 50% WG + Copper oxychloride 50% WP	3.32 (2.07)	1.43 (1.55)	0.75 (1.31)	1.02 (1.41)	0.74 (1.30)	0.98 (1.39)
10	Diafenthiuron 50% WP+ Copper oxychloride 50% WP	3.37 (2.09)	0.42 (1.19)	0.62 (1.27)	0.58 (1.27)	0.51 (1.23)	0.54 (1.24)
11	(Acephate 50% +Imidacloprid 1.8% SP) + Copper oxychloride 50% WP	3.08 (2.01)	0.83 (1.35)	1.08 (1.43)	1.01 (1.41)	0.68 (1.29)	0.90 (1.37)
12	Untreated control	3.70 (2.17)	2.83 (1.95)	3.11 (2.02)	3.30 (2.06)	3.69 (2.16)	3.23 (2.05)
	F test	NS	Sig	Sig	Sig	Sig	Sig
	SE (m) ±	0.10	0.07	0.08	0.09	0.07	0.08
	CD at 5 %	0.29	0.24	0.24	0.27	0.21	0.24
	CV %	8.32	9.55	9.64	10.54	8.33	9.52

Note: Figures in parentheses are corresponding square root transformation values.

DAS- Days After Spraying

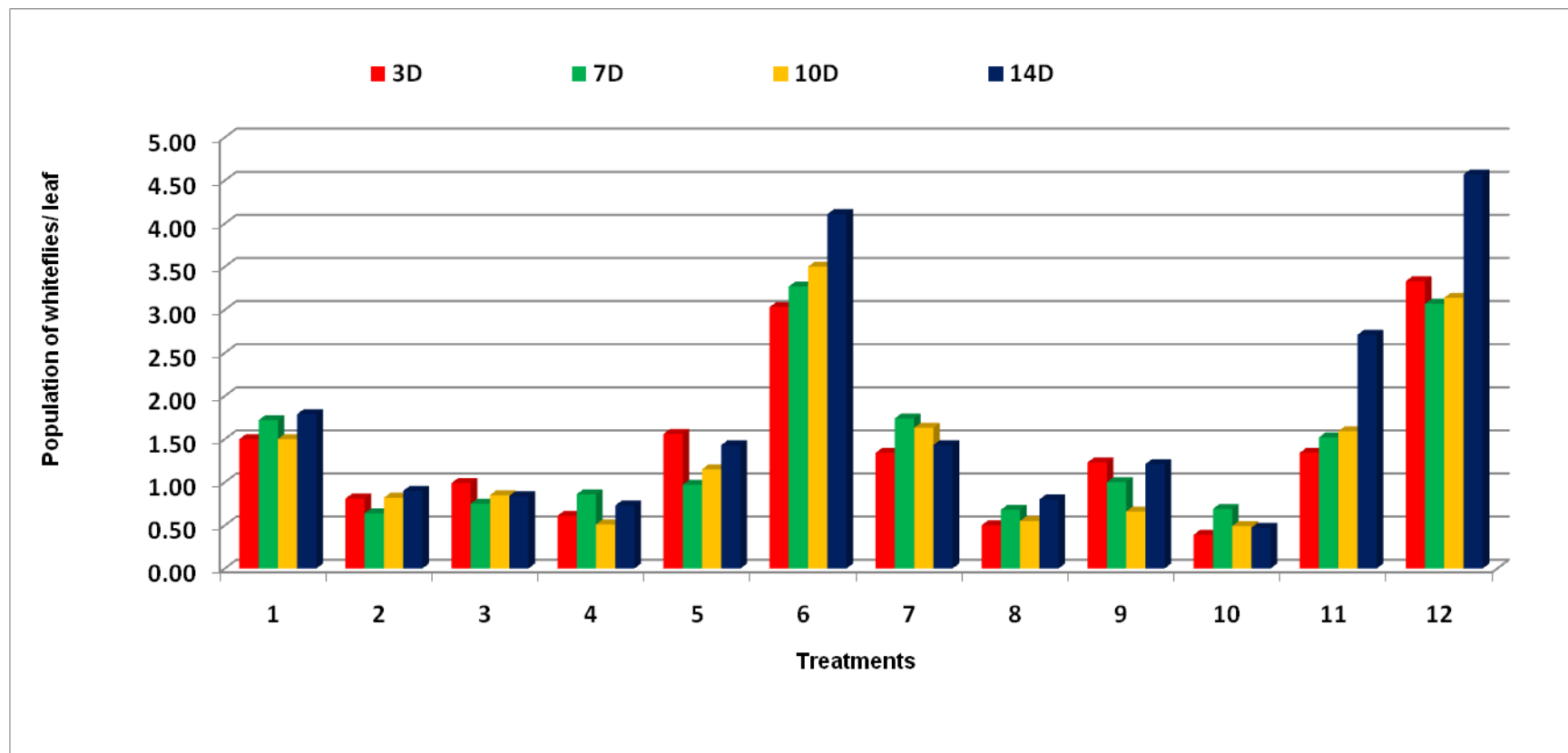


Fig 8. Efficacy of pesticides alone and in combination against cotton whiteflies after first spray

T₁ : Fipronil 5% SC	T₄: Diafenthiuron 50% WP	T₇ :Fipronil 5% SC + Copper oxychloride 50% WP	T₁₀: Diafenthiuron 50% WP + Copper oxychloride 50% WP
T₂ : Spiromesifen 22.9% SC	T₅:Acephate 50% + Imidacloprid 1.8% SP	T₈: Spiromesifen 22.9%SC + Copper oxychloride 50% WP	T₁₁: (Acephate 50% + Imidacloprid 1.8% SP) + Copper oxychloride 50% WP
T₃: Flonicamid 50% WG	T₆:Copper oxychloride 50% WP	T₉ :Flonicamid 50% WG + Copper oxychloride 50% WP	T₁₂: Untreated control

population of whiteflies ranged between 0.68 to 1.29/leaf. The highest population of whiteflies observed in plots treated with copper oxychloride 50% WP (3.13) which was found at par with untreated control (3.11).

4.8.3 Ten days after first spray

It is evident from the presented in Table 9 (Fig.8) that all the treatments except copper oxychloride 50% WP were found significantly superior over untreated control in recording lowest number of whitefly population at ten days after first spray. Among the different treatment under the trail the treatment with diafenthiuron 50% WP + copper oxychloride 50% WP recorded the minimum number of whiteflies (0.58/leaf). This treatment was closely followed by spiromesifen 22.9% SC (0.71), spiromesifen 22.9% SC + copper oxychloride 50% WP (0.75), diafenthiuron 50% WP (0.77), acephate 50% + imidacloprid 1.8% SP (0.81), (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.01), Flonicamid 50% WG + copper oxychloride 50% WP (1.02) and fipronil 5% SC+ copper oxychloride 50% WP (1.24). The latter treatments found at par with fipronil 5% SC (1.52). The plots treated with copper oxychloride 50% WP and untreated control recorded highest population of whiteflies i.e. 3.10 and 3.30 whiteflies pre leaf, respectively and found at par with each other.

4.8.4 Fourteen days after first spray

The data depicted in Table 9 (Fig.8) revealed that all the treatments except copper oxychloride 50% WP were found significantly superior over untreated control in reducing population of whiteflies at fourteen days after first spray. The treatment with diafenthiuron 50% WP + copper oxychloride 50% WP recorded minimum number of whiteflies (0.51/leaf). This treatment was found at par with diafenthiuron 50% WP (0.59), spiromesifen 22.9% SC (0.61), spiromesifen 22.9% SC + copper oxychloride 50% WP (0.64), (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (0.68), acephate 50% + imidacloprid 1.8% SP (0.70), flonicamid 50% WG (0.70), fipronil 5% SC + copper oxychloride 50% WP (0.71) and flonicamid 50% WG + copper oxychloride 50% WP (0.74). Whereas, 1.32 whiteflies/ leaf were observed in plots treated with fipronil 5% SC. The highest population of

whiteflies was recorded in copper oxychloride 50% WP (3.33) which was found at par with untreated control (3.69).

4.8.5 Mean

The mean data pertaining to population whiteflies after first spray depicted in Table 9 (Fig.8) showed that, data was significant. Amongst the various treatments, diafenthiuron 50% WP + copper oxychloride 50% WP recorded minimum population of whiteflies (0.54/leaf). This treatment was closely followed by spiromesifen 22.9% SC, spiromesifen 22.9% SC + copper oxychloride 50% WP, diafenthiuron 50% WP, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, acephate 50% + imidacloprid 1.8% SP, flonicamid 50% WG + copper oxychloride 50% WP, flonicamid 50% WG and fipronil 5% SC + copper oxychloride 50% WP. In this treatments the population of whiteflies ranged between 0.61 to 1.19/leaf. Whereas treatments of fipronil 5% SC recorded 1.44 whiteflies/leaf. Maximum population of whiteflies were observed in plots treated with copper oxychloride 50% WP (3.06/leaf) found at par with untreated control (3.23/leaf).

4.9 Efficacy of pesticides alone and in combination against cotton whiteflies after second spray

4.9.1 Three days after second spray

The data presented in Table 10 (Fig.9) revealed that, all the treatments except copper oxychloride 50% WP proved significantly effective over untreated control in reducing the population whiteflies. Among the different treatments plots treated with diafenthiuron 50% WP + copper oxychloride 50% WP, spiromesifen 22.9% SC + copper oxychloride 50% WP, diafenthiuron 50% WP, spiromesifen 22.9% SC and flonicamid 50% WG proved statistically equal in recording minimum population i.e. 0.39, 0.50, 0.61, 0.81 and 0.99 whiteflies/leaf, respectively. Next in order of efficacy were flonicamid 50% WG + copper oxychloride 50% WP, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, fipronil 5% SC + copper oxychloride 50% WP, fipronil 5% SC and acephate 50% + imidacloprid 1.8% SP which showed efficacy in descending order with population range between 1.23 to 1.56 whiteflies/leaf. Whereas, Maximum population of

Table 10: Efficacy of pesticides alone and in combination against cotton whiteflies after second spray

Tr. No	Treatments	Number of whiteflies /leaf at				
		3DAS	7DAS	10DAS	14DAS	Mean
1	Fipronil 5% SC	1.50 (1.56)	1.72 (1.65)	1.50 (1.58)	1.79 (1.67)	1.63 (1.61)
2	Spiromesifen 22.9% SC	0.81 (1.34)	0.64 (1.28)	0.82 (1.34)	0.90 (1.38)	0.79 (1.34)
3	Flonicamid 50% WG	0.99 (1.40)	0.75 (1.32)	0.85 (1.36)	0.84 (1.36)	0.86 (1.36)
4	Diafenthiuron 50% WP	0.61 (1.27)	0.86 (1.36)	0.51 (1.23)	0.73 (1.31)	0.68 (1.29)
5	Acephate 50% + Imidacloprid 1.8% SP	1.56 (1.60)	0.97 (1.40)	1.15 (1.45)	1.43 (1.56)	1.28 (1.50)
6	Copper oxychloride 50% WP	3.03 (2.00)	3.27 (2.07)	3.50 (2.12)	4.11 (2.26)	3.48 (2.11)
7	Fipronil 5% SC + Copper oxychloride 50% WP	1.34 (1.53)	1.74 (1.65)	1.63 (1.62)	1.43 (1.56)	1.54 (1.59)
8	Spiromesifen 22.9% SC + Copper oxychloride 50% WP	0.50 (1.22)	0.68 (1.29)	0.55 (1.24)	0.80 (1.34)	0.63 (1.27)
9	Flonicamid 50% WG + Copper oxychloride 50% WP	1.23 (1.49)	1.00 (1.40)	0.66 (1.28)	1.21 (1.48)	1.03 (1.42)
10	Diafenthiuron 50% WP+ Copper oxychloride 50% WP	0.39 (1.18)	0.69 (1.30)	0.49 (1.22)	0.47 (1.21)	0.51 (1.23)
11	(Acephate 50% +Imidacloprid 1.8% SP) + Copper oxychloride 50% WP	1.34 (1.53)	1.52 (1.58)	1.59 (1.60)	2.71 (1.93)	1.79 (1.66)
12	Untreated control	3.33 (2.10)	3.07 (2.01)	3.14 (2.03)	4.57 (2.43)	3.53 (2.14)
	F test	Sig	Sig	Sig	Sig	Sig
	SE (m) $\pm$	0.08	0.07	0.08	0.10	0.08
	CD at 5 %	0.25	0.22	0.24	0.29	0.25
	CV %	9.78	8.34	9.41	10.58	9.52

Note: Figures in parentheses are corresponding square root transformation values.

DAS- Days After Spraying

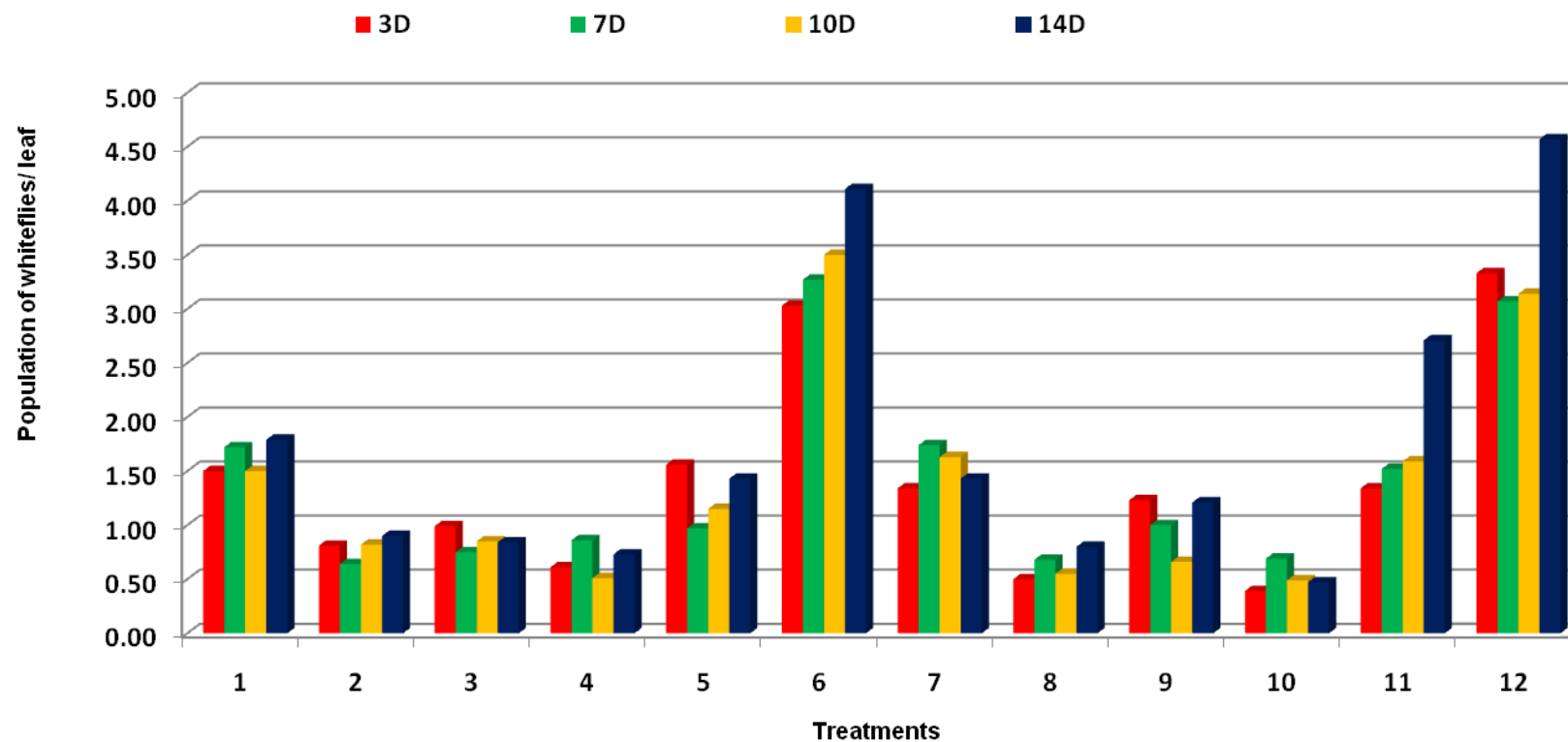


Fig 9. Efficacy of pesticides alone and in combination against cotton whiteflies after second spray

T₁ : Fipronil 5% SC

T₄: Diafenthiuron 50% WP

T₇ :Fipronil 5% SC + Copper oxychloride 50% WP

T₁₀: Diafenthiuron 50% WP + Copper oxychloride 50% WP

T₂ : Spiromesifen 22.9% SC

T₅:Acephate 50% + Imidacloprid 1.8% SP

T₈: Spiromesifen 22.9%SC + Copper oxychloride 50% WP

T₁₁: (Acephate 50% + Imidacloprid 1.8 % SP) + Copper oxychloride 50% WP

T₃: Flonicamid 50% WG

T₆:Copper oxychloride 50% WP

T₉ :Flonicamid 50% WG + Copper oxychloride 50% WP

T₁₂: Untreated control

whiteflies was recorded in copper oxychloride 50% WP (3.03) found at par with untreated control (3.33).

4.9.2 Seven days after second spray

The data on number of whitefly population at seven days after second spray given in Table 10 (Fig.9) revealed that treatment spiromesifen 22.9% SC recorded minimum whitefly population (0.64/leaf). However, this treatment found at par with spiromesifen 22.9% SC + copper oxychloride 50% WP, diafenthiuron 50% WP + copper oxychloride 50% WP, flonicamid 50% WG, diafenthiuron 50% WP, acephate 50% + imidacloprid 1.8% SP and flonicamid 50% WG + copper oxychloride 50% WP in which 0.68, 0.69, 0.75, 0.85, 0.97 and 1.00 whiteflies/leaf, respectively were recorded. Latter three treatments in turn found at par with (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.52). The treatment of (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP was in turn also found at par with fipronil 5% SC (1.72) and fipronil 5% SC + copper oxychloride 50% WP (1.74). Highest number of whiteflies was recorded in copper oxychloride 50% WP (3.27) which was at par with untreated control (3.07).

4.9.3 Ten days after second spray

The data recorded on whitefly population at ten days after second spray presented in Table 10 and illustrated under Fig.9 was found statistically significant. Minimum whitefly population was seen due to application of diafenthiuron 50% WP + copper oxychloride 50% WP (0.49 /leaf) and was found at par with diafenthiuron 50% WP (0.51), spiromesifen 22.9% SC + copper oxychloride 50% WP (0.55), flonicamid 50% WG + copper oxychloride 50% WP (0.66), spiromesifen 22.9% SC (0.82), flonicamid 50% WG (0.85) and acephate 50% + imidacloprid 1.8% SP (1.15). These were followed by treatments fipronil 5% SC, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP and fipronil 5% SC + copper oxychloride 50% in which 1.50, 1.59 and 1.63 whiteflies/leaf were recorded, respectively. Whereas, maximum population of whiteflies was recorded in copper oxychloride 50% WP (3.50) and untreated control (3.14).

4.9.4 Fourteen days after second spray

The data pertaining to whitefly population at fourteen days after second spray displayed in Table 10 and illustrated under Fig.9 revealed that, plots treated with diafenthiuron 50% WP + copper oxychloride 50% WP recorded the minimum population of whiteflies (0.47/leaf). This treatment was found at par with diafenthiuron 50% WP (0.73), spiromesifen 22.9% SC + copper oxychloride 50% WP (0.80), flonicamid 50% WG (0.84), spiromesifen 22.9% SC (0.90) and flonicamid 50% WG + copper oxychloride 50% WP (1.21). The other treatments viz., fipronil 5% SC + copper oxychloride 50% WP (1.43), acephate 50% + imidacloprid 1.8% SP (1.43), fipronil 5% SC (1.79) and (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (2.71) showed efficacy in descending order. Maximum population of whiteflies was observed in plots of copper oxychloride 50% WP (4.11) and untreated control (4.57) and are at par with each other.

4.9.5 Mean

The results on mean population of whiteflies after second spray (Table 10 and Fig.9) revealed that, all the treatments except copper oxychloride 50% WP were found statistically significant recorded minimum population of whiteflies as against untreated control. Among the different treatments application of diafenthiuron 50% WP+ copper oxychloride 50% WP (0.51), spiromesifen 22.9% SC + copper oxychloride 50% WP (0.63), diafenthiuron 50% WP (0.68), spiromesifen 22.9% SC (0.79), flonicamid 50% WG (0.86) and flonicamid 50% WG + copper oxychloride 50% WP (1.03) were the most promising treatments in recording lower whitefly population. Whereas, acephate 50% + imidacloprid 1.8% SP (1.28), fipronil 5% SC + copper oxychloride 50% WP (1.54), fipronil 5% SC (1.63) and (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.79) and appeared as next better treatments and are at par with each other. Plots treated with copper oxychloride 50% WP and untreated control recorded maximum population of whiteflies with 3.48 and 3.53/leaf, respectively.

4.10. Efficacy of pesticides alone and in combination against cotton whiteflies after third spray

4.10.1 Three days after third spray

The population of whiteflies recorded at three days after third spray revealed that, (Table 11 and Fig.10), plots treated with diafenthiuron 50% WP and diafenthiuron 50% WP + copper oxychloride 50% WP proved significantly effective over other treatments in recording minimum population of whiteflies i.e., 0.54 and 1.20/leaf. However, the latter treatment in turn was also found at par with spiromesifen 22.9% SC + copper oxychloride 50% WP (1.35), spiromesifen 22.9% SC (1.55), flonicamid 50% WG + copper oxychloride 50% WP (1.57) and flonicamid 50% WG (1.91). However, fipronil 5% SC, fipronil 5% SC + copper oxychloride 50% WP, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP and acephate 50% + imidacloprid 1.8% SP recorded 2.40, 2.57, 2.83 and 2.93 whiteflies/leaf, respectively and proved moderately effective in this respect. Whereas, treatment of copper oxychloride 50% WP recorded 5.37 whiteflies/leaf and found at par with untreated control (5.70).

4.10.2 Seven days after third spray

The data on effect of different treatments against whiteflies at seven days after third spray (Table 11 and Fig.10) showed that, application of diafenthiuron 50% WP + copper oxychloride 50% WP, diafenthiuron 50% WP and spiromesifen 22.9% SC recording significantly lower whitefly population of 1.33, 1.84 and 1.88/leaf, respectively and found at par with each other. The latter two treatments were also found at par with treatments in order spiromesifen 22.9% SC + copper oxychloride 50% WP (2.63), acephate 50% + imidacloprid 1.8 % SP (2.65), flonicamid 50% WG + copper oxychloride 50% WP (2.67). These were followed by treatments viz., flonicamid 50% WG, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, fipronil 5% SC and fipronil 5% SC + copper oxychloride 50% WP which recorded 3.23, 3.31, 3.47 and 3.55 whiteflies/leaf, respectively and found superior over copper oxychloride 50% WP (6.10) and untreated control (7.54).

4.10.3 Ten days after third spray

The data presented in Table 11 (Fig.10) revealed that, all the treatment except copper oxychloride 50% WP found statistically superior over untreated control. Among the different treatments plots treated with spiromesifen 22.9% SC + copper oxychloride 50% WP recorded minimum population of whiteflies (1.40/leaf). However, this treatment were found at par with diafenthiuron 50% WP + copper oxychloride 50% WP (1.42), diafenthiuron 50% WP (1.44), spiromesifen 22.9% SC (1.57), flonicamid 50% WG (2.01) and flonicamid 50% WG + copper oxychloride 50% WP (2.41). Whereas, the treatment Fipronil 5% SC + copper oxychloride 50% WP (2.58), (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (2.60), fipronil 5% SC (2.65) and acephate 50% + imidacloprid 1.8% SP (2.90) were found moderately effective in this respect. Highest number of whitefly population was recorded in copper oxychloride 50% WP (6.97) which was found at par with untreated control (6.63).

4.10.4 Fourteen days after third spray

The data pertaining to population of whiteflies recorded at fourteen days after third spray (Table 11 and Fig.10) was found statistically significant. Among the treatments the minimum whiteflies (0.47/leaf) were observed in the plots treated with diafenthiuron 50% WP+ copper oxychloride 50% WP. However, this treatment found statistically equal to diafenthiuron 50% WP (0.70), spiromesifen 22.9% SC (0.84), spiromesifen 22.9% SC + copper oxychloride 50% WP (0.92) and flonicamid 50% WG + copper oxychloride 50% WP (0.97). Whereas, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.36), flonicamid 50% WG (1.39), acephate 50% + imidacloprid 1.8 % SP (1.41), fipronil 5% SC + copper oxychloride 50% WP (1.62) and fipronil 5% SC (1.93) appeared as next better treatments and are at par with each other. The plots treated with copper oxychloride 50% WP recorded the maximum population of whiteflies (4.53) which was found at par with untreated control (4.13).

Table 11: Efficacy of pesticides alone and in combination against cotton whiteflies after third spray

Tr. No	Treatments	Number of whiteflies /leaf at				
		3DAS	7DAS	10DAS	14DAS	Mean
1	Fipronil 5% SC	2.40 (1.84)	3.47 (2.10)	2.65 (1.90)	1.93 (1.71)	2.61 (1.89)
2	Spiromesifen 22.9% SC	1.55 (1.59)	1.88 (1.69)	1.57 (1.60)	0.84 (1.35)	1.46 (1.56)
3	Flonicamid 50% WG	1.91 (1.70)	3.23 (2.05)	2.01 (1.73)	1.39 (1.54)	2.13 (1.76)
4	Diafenthiuron 50% WP	0.54 (1.24)	1.84 (1.68)	1.44 (1.56)	0.70 (1.30)	1.13 (1.45)
5	Acephate 50% + Imidacloprid 1.8% SP	2.93 (1.98)	2.65 (1.91)	2.90 (1.97)	1.41 (1.54)	2.47 (1.85)
6	Copper oxychloride 50% WP	5.37 (2.44)	6.10 (2.67)	6.97 (2.78)	4.53 (2.35)	5.74 (2.56)
7	Fipronil 5% SC + Copper oxychloride 50% WP	2.57 (1.88)	3.55 (2.13)	2.58 (1.89)	1.62 (1.62)	2.58 (1.88)
8	Spiromesifen 22.9% SC + Copper oxychloride 50% WP	1.35 (1.53)	2.63 (1.90)	1.40 (1.54)	0.92 (1.39)	1.58 (1.59)
9	Flonicamid 50% WG + Copper oxychloride 50% WP	1.57 (1.60)	2.67 (1.91)	2.41 (1.84)	0.97 (1.40)	1.90 (1.69)
10	Diafenthiuron 50% WP+ Copper oxychloride 50% WP	1.20 (1.48)	1.33 (1.53)	1.42 (1.55)	0.47 (1.21)	1.11 (1.44)
11	(Acephate 50% +Imidacloprid 1.8% SP) + Copper oxychloride 50% WP	2.83 (1.95)	3.31 (2.07)	2.60 (1.90)	1.36 (1.53)	2.53 (1.86)
12	Untreated control	5.70 (2.56)	7.54 (2.95)	6.63 (2.76)	4.13 (2.26)	6.00 (2.63)
	F test	Sig	Sig	Sig	Sig	Sig
	SE (m) ±	0.09	0.10	0.10	0.08	0.09
	CD at 5 %	0.27	0.29	0.30	0.22	0.27
	CV %	8.74	8.41	9.46	8.23	8.71

Note: Figures in parentheses are corresponding square root transformation values.

DAS- Days After Spraying

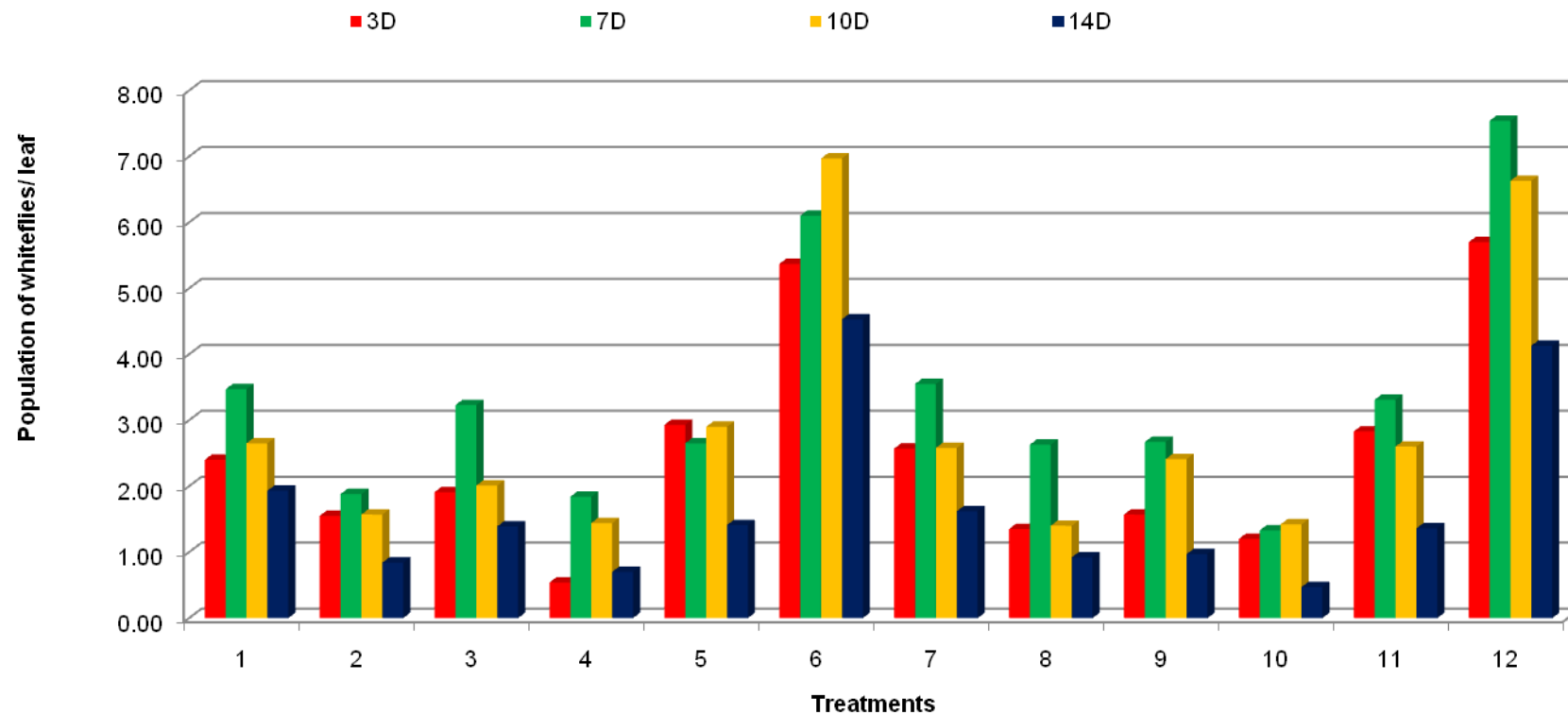


Fig 10. Efficacy of pesticides alone and in combination against cotton whiteflies after third spray

T₁ : Fipronil 5% SC

T₄: Diafenthiuron 50% WP

T₇ :Fipronil 5% SC + Copper oxychloride 50% WP

T₁₀: Diafenthiuron 50% WP+ Copper oxychloride 50% WP

T₂ : Spiromesifen 22.9% SC

T₅: Acephate 50% + Imidacloprid 1.8 % SP

T₈: Spiromesifen 22.9%SC + Copper oxychloride 50% WP

T₁₁: (Acephate 50% + Imidacloprid 1.8% SP) + Copper oxychloride 50% WP

T₃: Flonicamid 50% WG

T₆: Copper oxychloride 50% WP

T₉ :Flonicamid 50% WG + Copper oxychloride 50% WP

T₁₂: Untreated control

4.10.5 Mean

Results on the efficacy of various treatments against population of whiteflies after third spray (Table 11 and Fig.10) showed that, diafenthiuron 50% WP + copper oxychloride 50% WP (1.11), as well as diafenthiuron 50% WP (1.13), spiromesifen 22.9% SC (1.46), spiromesifen 22.9% SC + copper oxychloride 50% WP (1.58) and flonicamid 50% WG + copper oxychloride 50% WP (1.90) proved equally effective in recording minimum population of whiteflies at different intervals of observations. Whereas, the treatment with flonicamid 50% WG (2.13), acephate 50% + Imidacloprid 1.8% SP (2.47), (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (2.53), fipronil 5% SC + copper oxychloride 50% WP (2.58) and fipronil 5% SC (2.61) showed efficacy in descending order proved moderately effective. Significantly highest number of whiteflies were recorded in treatment copper oxychloride 50% WP and untreated control with population of 5.74 and 6.00 whiteflies/leaf, respectively.

4.11 Cumulative effect of pesticides alone and in combination against cotton whiteflies

4.11.1 Three days after spray

The data tabulated in Table 12 (Fig.11) revealed that, all the treatments except copper oxychloride 50% WP were found significantly superior over untreated control. The treatments with diafenthiuron 50% WP, diafenthiuron 50% WP + copper oxychloride 50% WP, spiromesifen 22.9% SC + copper oxychloride 50% WP and spiromesifen 22.9% SC proved equally effective in recording less number of whiteflies ranged between 0.58 to 0.93/leaf at three days after spray. The treatment flonicamid 50% WG + copper oxychloride 50% WP (1.41), flonicamid 50% WG (1.51), (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.67), fipronil 5% SC (1.84), fipronil 5% SC + copper oxychloride 50% WP (1.85) and acephate 50% + imidacloprid 1.8% SP (1.91) showed efficacy in descending order. Whereas, maximum population of whiteflies was recorded in copper oxychloride 50% WP (3.70) and untreated control (3.95).

4.11.2 Seven days after spray

It is evident from the Table 12 (Fig.11) that minimum population of whiteflies was recorded in the treatment diafenthiuron 50% WP + copper oxychloride 50% WP (0.88/leaf) at seven days after spray. However, this treatment was found at par with spiromesifen 22.9% SC (1.07), diafenthiuron 50% WP (1.15), spiromesifen 22.9% SC + copper oxychloride 50% WP (1.36), flonicamid 50% WG + copper oxychloride 50% WP (1.47), acephate 50% + imidacloprid 1.8% SP (1.55) and flonicamid 50% WG (1.63). The next in order of efficacy were treatments, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.97), fipronil 5% SC + copper oxychloride 50% WP (2.15) and Fipronil 5% SC (2.16). Plots treated with copper oxychloride 50% WP (4.17) and untreated control (4.57) recorded maximum population of whiteflies.

4.11.3 Ten days after spray

The data pertaining to population of whiteflies recorded at ten days after spray (Table 12 and Fig.11) was found statistically significant. Among the treatments minimum whiteflies (0.83/leaf) were observed in the plots treated with diafenthiuron 50% WP + copper oxychloride 50% WP. However, this treatment found statistically equal to spiromesifen 22.9% SC + copper oxychloride 50% WP, diafenthiuron 50% WP, spiromesifen 22.9% SC, flonicamid 50% WG + copper oxychloride 50% WP, flonicamid 50% WG and acephate 50% + Imidacloprid 1.8% SP in which population of whiteflies ranged between 0.90 to 1.62/leaf. Whereas, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.73), fipronil 5% SC + copper oxychloride 50% WP (1.82) and fipronil 5% SC (1.89) appeared as next better treatments in this respect. Highest number of whiteflies recorded in copper oxychloride 50% WP (4.52) and found at par with untreated control (4.36).

4.11.4 Fourteen days after spray

The Table 12 (Fig.11) pertaining to population of whiteflies recorded at fourteen days after spray showed that the minimum number of whiteflies were observed in plots treated with diafenthiuron 50% WP + copper oxychloride 50% WP (0.48/leaf).

Table 12: Cumulative effect of pesticides alone and in combination against cotton whiteflies

Tr. No	Treatments	Number of whiteflies /leaf at				
		3DAS	7DAS	10DAS	14DAS	Mean
1	Fipronil 5% SC	1.84 (1.67)	2.16 (1.75)	1.89 (1.69)	1.68 (1.63)	1.89 (1.69)
2	Spiromesifen 22.9% SC	0.93 (1.38)	1.07 (1.42)	1.03 (1.42)	0.78 (1.33)	0.95 (1.38)
3	Flonicamid 50% WG	1.51 (1.57)	1.63 (1.58)	1.36 (1.52)	0.98 (1.40)	1.37 (1.52)
4	Diafenthiuron 50% WP	0.58 (1.26)	1.15 (1.45)	0.91 (1.37)	0.67 (1.29)	0.83 (1.34)
5	Acephate 50% + Imidacloprid 1.8% SP	1.91 (1.69)	1.55 (1.57)	1.62 (1.59)	1.18 (1.47)	1.56 (1.58)
6	Copper oxychloride 50% WP	3.70 (2.12)	4.17 (2.26)	4.52 (2.30)	3.99 (2.23)	4.09 (2.23)
7	Fipronil 5% SC + Copper oxychloride 50% WP	1.85 (1.68)	2.15 (1.75)	1.82 (1.67)	1.25 (1.49)	1.77 (1.65)
8	Spiromesifen 22.9% SC + Copper oxychloride 50% WP	0.78 (1.32)	1.36 (1.50)	0.90 (1.37)	0.79 (1.34)	0.96 (1.39)
9	Flonicamid 50% WG + Copper oxychloride 50% WP	1.41 (1.55)	1.47 (1.54)	1.36 (1.51)	0.97 (1.39)	1.31 (1.50)
10	Diafenthiuron 50% WP+ Copper oxychloride 50% WP	0.67 (1.28)	0.88 (1.37)	0.83 (1.35)	0.48 (1.22)	0.72 (1.30)
11	(Acephate 50% +Imidacloprid 1.8% SP) + Copper oxychloride 50% WP	1.67 (1.61)	1.97 (1.69)	1.73 (1.64)	1.58 (1.58)	1.74 (1.63)
12	Untreated control	3.95 (2.20)	4.57 (2.33)	4.36 (2.28)	4.13 (2.28)	4.25 (2.27)
	F test	Sig	Sig	Sig	Sig	Sig
	SE (m) ±	0.08	0.08	0.09	0.08	0.08
	CD at 5 %	0.25	0.25	0.27	0.24	0.25
	CV %	9.36	8.80	9.80	9.05	9.25

Note: Figures in parentheses are corresponding square root transformation values.

DAS- Days After Spraying

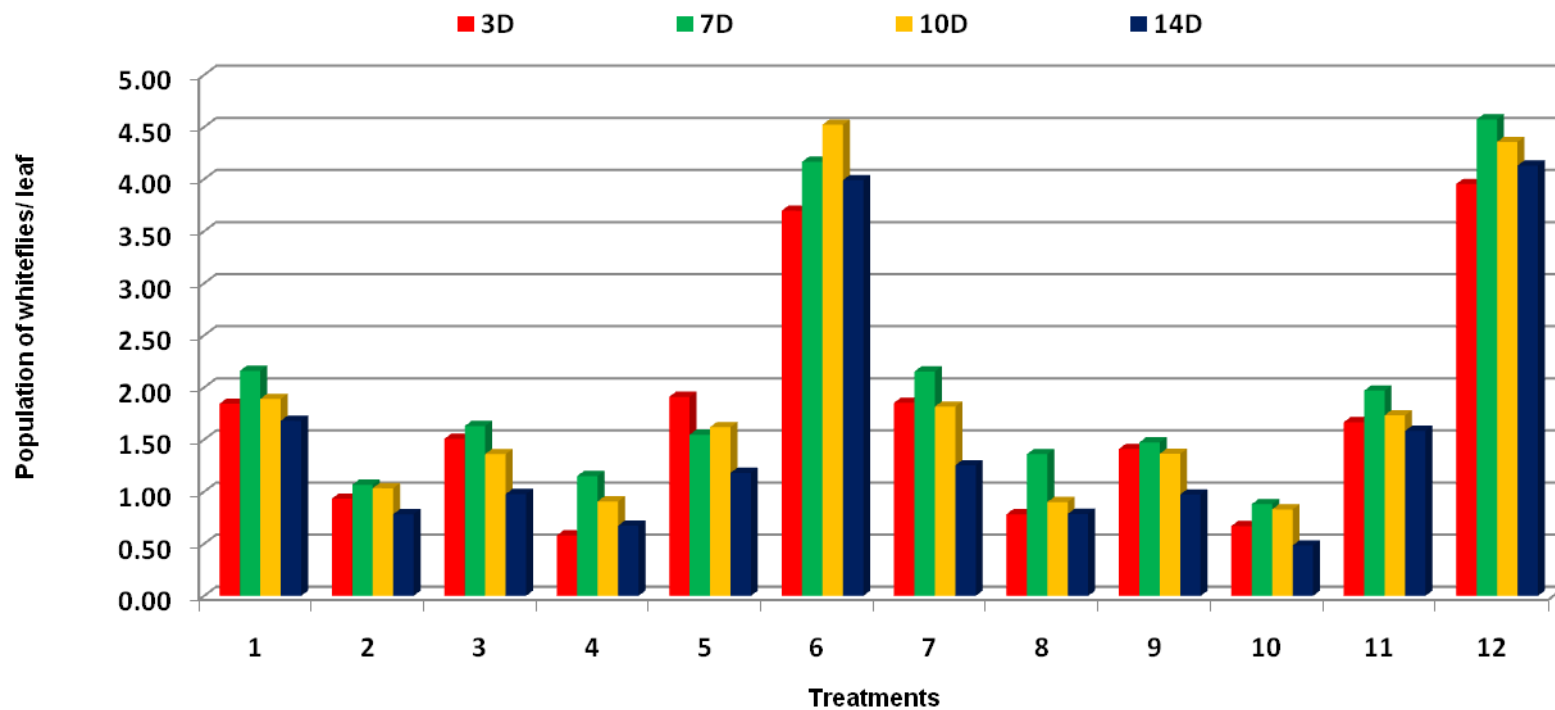


Fig 11. Cumulative effect of pesticides alone and in combination against cotton whiteflies

T₁ : Fipronil 5% SC

T₄: Diafenthiuron 50% WP

T₇ :Fipronil 5% SC + Copper oxychloride 50% WP

T₁₀: Diafenthiuron 50% WP + Copper oxychloride 50% WP

T₂ : Spiromesifen 22.9% SC

T₅:Acephate 50% + Imidacloprid 1.8% SP

T₈: Spiromesifen 22.9%SC + Copper oxychloride 50% WP

T₁₁: (Acephate 50% + Imidacloprid 1.8% SP) + Copper oxychloride 50% WP

T₃: Flonicamid 50% WG

T₆:Copper oxychloride 50% WP

T₉ :Flonicamid 50% WG + Copper oxychloride 50% WP

T₁₂: Untreated control

This treatment was followed by diafenthiuron 50% WP (0.67), spiromesifen 22.9% SC (0.78), spiromesifen 22.9% SC + copper oxychloride 50% WP (0.79), flonicamid 50% WG + copper oxychloride 50% WP (0.97) and flonicamid 50% WG (0.98). However, all these treatments were found at par with each other. Whereas, acephate 50% + imidacloprid 1.8% SP (1.18), fipronil 5% SC + copper oxychloride 50% WP (1.25), (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.58) and fipronil 5% SC (1.68) proves moderately effective in this respect. The plots treated with copper oxychloride 50% WP (3.99) and untreated control (4.13) reached maximum number of whiteflies.

4.11.5 Mean

The results on mean population of whiteflies after each spray (Table 12 and Fig.11) revealed that, all the treatments except copper oxychloride 50% WP were found statistically significant, recorded minimum population of whiteflies as against untreated control. Among the different treatments application of diafenthiuron 50% WP + copper oxychloride 50% WP (0.72), diafenthiuron 50% WP (0.83), spiromesifen 22.9% SC (0.95), spiromesifen 22.9% SC + copper oxychloride 50% WP (0.96), flonicamid 50% WG + copper oxychloride 50% WP (1.31) and flonicamid 50% WG (1.37) were the most promising treatments in recording lower population of whiteflies. Whereas, acephate 50% + imidacloprid 1.8% SP (1.56), (acephate 50% + Imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.74), fipronil 5% SC + copper oxychloride 50% WP (1.77) and fipronil 5% SC (1.89) appeared as next better treatments found at par with each other. Plots treated with copper oxychloride 50% WP and untreated control recorded maximum population of whiteflies with 4.09 and 4.25/leaf, respectively.

The present results on the effectiveness of diafenthiuron 50 WP against whiteflies are in accordance with research findings of Kalyan et al. (2017) who evaluated new molecules against cotton whiteflies. The results revealed that, at seven days after spray the maximum per cent reduction in whitefly population with mean of 81.71 and 83.27 was recorded in diafenthiuron 50 WP during both the year of experimentation, respectively and

was statistically at par with flonicamid 50 WG and fipronil 5 SC. Similarly, the earlier worker Surwase et al. (2017) in their field experiment evaluated newer insecticides against sucking pests of cotton. The pooled data of two years indicated that among different insecticides tested fipronil 5 SC were the most effective insecticides for reduction of whitefly population on cotton. These were followed by flonicamid 50 WG and spiromesifen 22.9% SC.

Similarly, Kumar et al. (2014) evaluated insecticides against sucking pests of *Bt* cotton. The result indicated that, diafenthiuron 50 WP found effective in reducing whitefly population over other treatments. Similar findings were also reported by Patel et al. (2010) who in their trial, conducted during two crop season studied the comparative bioefficacy of six insecticides of against cotton whiteflies. The result revealed that, insecticide of thio-urea class, diafenthiuron 50 WP @ 400 g a.i./ha was found effective and recorded maximum reduction in population of whiteflies. The earlier worker Boda and Ilyas (2017) concluded that, Spiromesifen 240 SC was found more superior in reducing whiteflies population on 3rd, 7th and 14th days after 1st and 2nd spray.

Similar findings were also made by Bontha and Mallapur (2017a) they concluded that number of mean whiteflies population per three leaves and % reduction over control recorded in following treatments, diafenthiuron 50 WP @ 0.6 g + carbendazim 50WP @ 1.0 g (0.77 /3 leaves and 87.78) followed by diafenthiuron 50 WP alone @ 0.6 g (0.88 /3 leaves and 86.14), diafenthiuron 50 WP @ 0.6 g + copper oxychloride 50WP @ 2g (0.92 /3 leaves and 85.43). Moreover, the earlier worker Ghelani et al. (2014) reported that flonicamid 50 WG caused significantly maximum mortality of whiteflies after 7 days of application.

4.12 Efficacy of pesticides alone and in combination against cotton thrips after first spray

The data on thrips population recorded a day before the first spray in different treatment plots was found statistically non significant indicating the uniform distribution of the pest in the experimental plots. The

population in the different treatment plots ranged from 11.30 to 15.05 thrips per leaf.

4.12.1 Three days after first spray

The data (Table 13 and Fig.12) in respect of population of thrips at three days after first spray showed that, all the treatments except copper oxychloride 50% WP were significantly effective over untreated control in recording minimum population of thrips. The plots treated with fipronil 5% SC + copper oxychloride 50% WP recorded the minimum population of thrips (4.40/leaf). This treatment was closely followed by fipronil 5% SC (5.31), diafenthiuron 50% WP (5.47), diafenthiuron 50% WP + copper oxychloride 50% WP (5.53), flonicamid 50% WG (5.73), flonicamid 50% WG + copper oxychloride 50% WP (5.87), spiromesifen 22.9% SC + copper oxychloride 50% WP (6.33) and acephate 50% + imidacloprid 1.8% SP (6.43). All these treatments found at par with each other. Whereas, (acephate 50% + imidacloprid 1.8 % SP) + copper oxychloride 50% WP and spiromesifen 22.9% SC recorded 7.13 and 7.20 thrips/ leaf, respectively. The plots treated with copper oxychloride 50% WP and untreated control recorded the maximum population of thrips with 16.57 and 17.03 per leaf, respectively.

4.12.2 Seven days after first spray

Among the different treatments under trial the plots treated with diafenthiuron 50% WP + copper oxychloride 50% WP was found effective with minimum population of thrips (11.17/leaf) at seven days after first spray Table 13 (Fig.12). This treatment was found at par with fipronil 5% SC, fipronil 5% SC + copper oxychloride 50% WP, flonicamid 50% WG + copper oxychloride 50% WP, flonicamid 50% WG, diafenthiuron 50% WP, acephate 50% + imidacloprid 1.8% SP, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, spiromesifen 22.9% SC and spiromesifen 22.9% SC + copper oxychloride 50% WP in which thrips population ranged between 11.87 to 14.30 per leaf. The highest population of thrips was recorded in untreated control (19.67) which was found at par with copper oxychloride 50% WP (18.55).

4.12.3 Ten days after first spray

The data displayed in Table 13 and illustrated under Fig.12 pertaining to population of thrips at ten days after first spray showed that, minimum population of thrips (9.27/leaf) was observed in the plots treated with fipronil 5% SC + copper oxychloride 50% WP. This treatment in turn found at par with fipronil 5% SC and diafenthiuron 50% WP with a population of 11.82 and 13.17 thrips/leaf, respectively. The treatments viz., diafenthiuron 50% WP+ copper oxychloride 50% WP (15.03), spiromesifen 22.9% SC + copper oxychloride 50% WP (15.37), spiromesifen 22.9% SC (15.71), flonicamid 50% WG + copper oxychloride 50% WP (16.11), acephate 50% + Imidacloprid 1.8% SP (16.39), flonicamid 50% WG (17.09) and (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (18.02) showed efficacy in descending order. Maximum population of thrips were recorded in plots treated with copper oxychloride 50% WP (25.10) and untreated control (26.54).

4.12.4 Fourteen days after first spray

The data on thrips population recorded at fourteen days after first spray showed that, the treatment fipronil 5% SC recorded minimum population of thrips (13.33/leaf) Table 13 (Fig.12). However, this treatment was found at par with fipronil

Table 13: Efficacy of pesticides alone and in combination against cotton thrips after first spray

Tr. No	Treatments	Number of thrips /leaf at					
		Pre count	3DAS	7DAS	10DAS	14DAS	Mean
1	Fipronil 5% SC	12.53 (3.68)	5.31 (2.50)	11.87 (3.58)	11.82 (3.57)	13.33 (3.75)	10.58 (3.35)
2	Spiromesifen 22.9% SC	13.14 (3.75)	7.20 (2.86)	13.90 (3.85)	15.71 (4.08)	19.83 (4.56)	14.16 (3.84)
3	Flonicamid 50% WG	15.05 (4.01)	5.73 (2.56)	12.45 (3.67)	17.09 (4.24)	14.99 (3.99)	12.57 (3.61)
4	Diafenthiuron 50% WP	11.30 (3.51)	5.47 (2.53)	12.58 (3.67)	13.17 (3.75)	18.09 (4.36)	12.32 (3.58)
5	Acephate 50% + Imidacloprid 1.8% SP	14.05 (3.88)	6.43 (2.72)	12.61 (3.69)	16.39 (4.16)	20.83 (4.67)	14.07 (3.81)
6	Copper oxychloride 50% WP	11.71 (3.56)	16.57 (4.18)	18.55 (4.42)	25.10 (5.09)	26.87 (5.30)	21.77 (5.64)
7	Fipronil 5% SC + Copper oxychloride 50% WP	13.71 (3.82)	4.40 (2.31)	11.93 (3.59)	9.27 (3.19)	13.80 (3.83)	9.85 (3.23)
8	Spiromesifen 22.9% SC + Copper oxychloride 50% WP	11.80 (3.58)	6.33 (2.70)	14.30 (3.90)	15.37 (4.04)	21.35 (4.77)	14.34 (3.85)
9	Flonicamid 50% WG + Copper oxychloride 50% WP	12.04 (3.61)	5.87 (2.61)	12.55 (3.67)	16.11 (4.12)	19.29 (4.49)	13.45 (3.72)
10	Diafenthiuron 50% WP+ Copper oxychloride 50% WP	11.46 (3.53)	5.53 (2.55)	11.17 (3.48)	15.03 (4.00)	15.29 (4.01)	11.75 (3.51)
11	(Acephate 50% +Imidacloprid 1.8% SP) + Copper oxychloride 50% WP	13.09 (3.74)	7.13 (2.84)	12.90 (3.71)	18.02 (4.33)	19.27 (4.50)	14.33 (3.84)
12	Untreated control	14.80 (3.91)	17.03 (4.21)	19.67 (4.53)	26.54 (5.26)	27.20 (5.38)	22.61 (5.82)
	F test	NS	Sig	Sig	Sig	Sig	Sig
	SE (m) ±	0.18	0.15	0.19	0.21	0.21	0.19
	CD at 5 %	0.53	0.44	0.55	0.60	0.60	0.55
	CV %	8.50	9.20	8.53	8.83	8.01	8.64

Note: Figures in parentheses are corresponding square root transformation values.

DAS- Days After Spraying

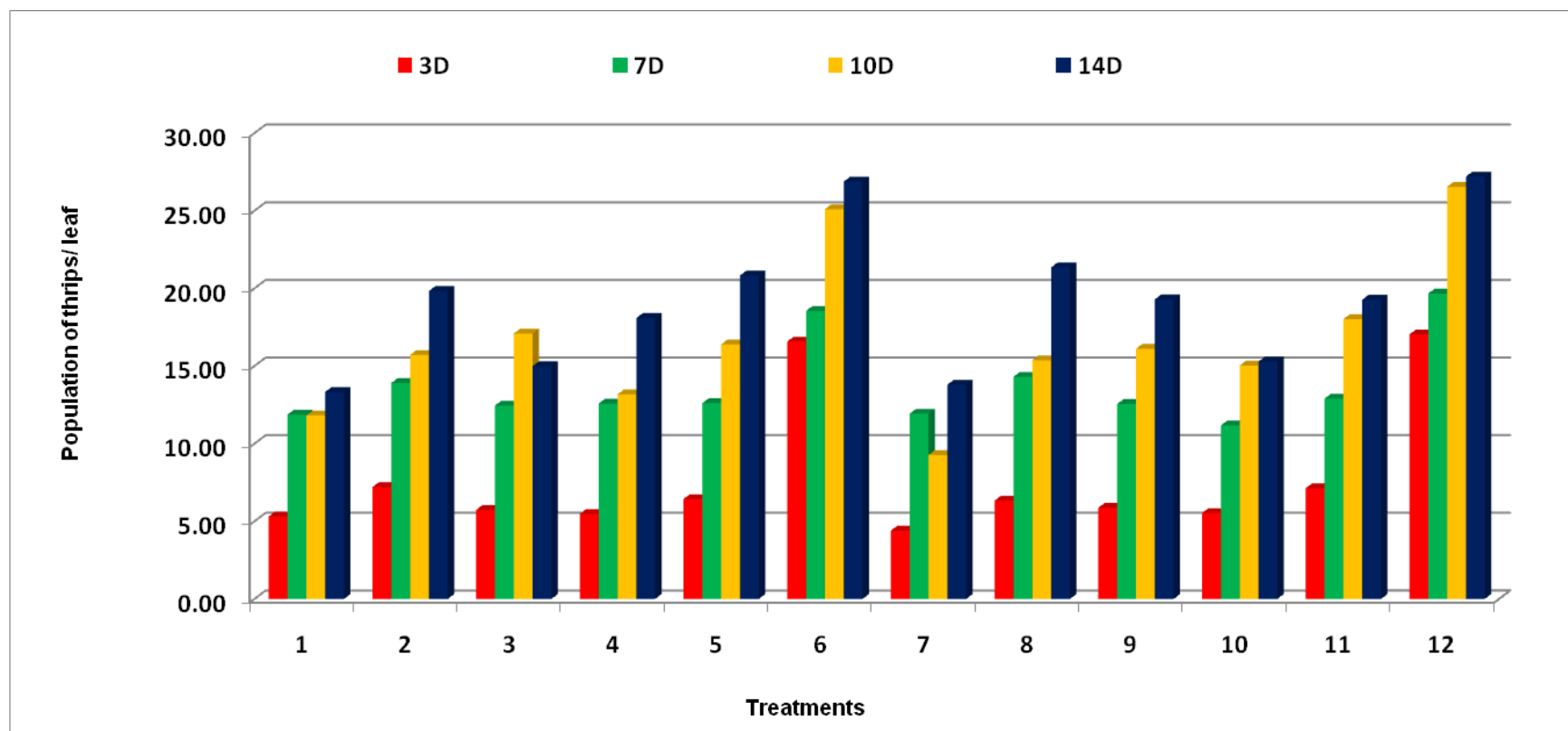


Fig 12. Efficacy of pesticides alone and in combination against cotton thrips after first spray

T₁ : Fipronil 5% SC

T₄: Diafenthiuron 50% WP

T₇ :Fipronil 5% SC + Copper oxychloride 50% WP

T₁₀: Diafenthiuron 50% WP + Copper oxychloride 50% WP

T₂ : Spiromesifen 22.9% SC

T₅:Acephate 50% + Imidacloprid 1.8% SP

T₈: Spiromesifen 22.9%SC + Copper oxychloride 50% WP

T₁₁: (Acephate 50% + Imidacloprid 1.8% SP) + Copper oxychloride 50% WP

T₃: Flonicamid 50% WG

T₆:Copper oxychloride 50% WP

T₉ :Flonicamid 50% WG + Copper oxychloride 50% WP

T₁₂: Untreated control

5% SC + copper oxychloride 50% WP, flonicamid 50% WG and diafenthiuron 50% WP + copper oxychloride 50% WP with the population of 13.80, 14.99 and 15.29/ leaf, respectively. Next effective treatments in order viz., diafenthiuron 50% WP (18.09), flonicamid 50% WG + copper oxychloride 50% WP (19.29), (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (19.27), spiromesifen 22.9% SC (19.83), acephate 50% + imidacloprid 1.8% SP (20.83) and spiromesifen 22.9% SC + copper oxychloride 50% WP found moderately effective with population of 21.35 thrips/leaf. The treatment copper oxychloride 50% WP and untreated control recorded maximum population of thrips 26.87 and 27.20/leaf.

4.12.5 Mean

All the treatments except copper oxychloride 50% WP found significantly superior over untreated control in recording minimum population of thrips (Table 13 and Fig.12). Among them, fipronil 5% SC + copper oxychloride 50% WP, fipronil 5% SC, diafenthiuron 50% WP + copper oxychloride 50% WP, diafenthiuron 50% WP, flonicamid 50% WG and flonicamid 50% WG + copper oxychloride 50% WP were the best treatments with less number i.e. 9.85, 10.58, 11.75, 12.32, 12.57 and 13.45 thrips/leaf, respectively. Next to above, the effective treatments were acephate 50% + imidacloprid 1.8% SP, spiromesifen 22.9% SC, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP and spiromesifen 22.9% SC + copper oxychloride 50% WP which were found at par with each other with population range between 14.07 to 14.34 thrips/leaf. The plots treated with copper oxychloride 50% WP recorded the maximum population of thrips (21.77) which is found at par with untreated control (22.61).

4.13 Efficacy of pesticides alone and in combination against cotton thrips after second spray

4.13.1 Three days after second spray

The data presented in Table 14 (Fig.13) regarding efficacy of different pesticides combination against thrips at three days after second spray was found statistically significant. Minimum thrips population was

observed due to application of diafenthiuron 50% WP (6.99/leaf). This treatment was found at par with fipronil 5% SC, fipronil 5% SC + copper oxychloride 50% WP, diafenthiuron 50% WP + copper oxychloride 50% WP, flonicamid 50% WG + copper oxychloride 50% WP, flonicamid 50% WG, acephate 50% + imidacloprid 1.8% SP, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP and spiromesifen 22.9% SC + copper oxychloride 50% WP in which population ranged between 7.66 to 9.97 thrips/leaf. The latter treatments were also found at par with spiromesifen 22.9% SC (11.03). Maximum thrips population recorded in copper oxychloride 50% WP (14.89) at par with untreated control (16.75).

4.13.2 Seven days after second spray

Among the treatments the thrips population recorded at seven days after second spray was minimum in the plots treated with fipronil 5% SC i.e. 5.72 thrips/leaf (Table 14 and Fig.13). However, this treatment was found at par with Fipronil 5% SC + copper oxychloride 50% WP (6.65), diafenthiuron 50% WP + copper oxychloride 50% WP (7.64), flonicamid 50% WG (8.13), diafenthiuron 50% WP (8.44), acephate 50% + imidacloprid 1.8 % SP (8.76) and flonicamid 50% WG + copper oxychloride 50% WP (8.88) .Whereas, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (9.55), spiromesifen 22.9% SC (10.73) and spiromesifen 22.9% SC + copper oxychloride 50% WP (11.01) appeared as next better treatments and are at par with each other. Highest number of thrips population was recorded in copper oxychloride 50% WP (16.56) which is found at par with untreated control (15.54).

4.13.3 Ten days after second spray

The data on effect of different treatments against thrips ten days after second spray (Table 14 and Fig.13) showed that, application fipronil 5% SC + copper oxychloride 50% WP recorded lower thrips population (4.60/leaf). This treatment was closely followed by fipronil 5% SC, flonicamid 50% WG, diafenthiuron 50% WP, diafenthiuron 50% WP + copper oxychloride 50% WP, flonicamid 50% WG + copper oxychloride 50% WP, spiromesifen 22.9% SC, spiromesifen 22.9% SC + copper oxychloride 50% WP, acephate

Table 14: Efficacy of pesticides alone and in combination against cotton thrips after second spray

Tr. No	Treatments	Number of thrips /leaf at				
		3DAS	7DAS	10DAS	14DAS	Mean
1	Fipronil 5% SC	7.66 (2.94)	5.72 (2.58)	4.81 (2.40)	1.55 (1.60)	4.94 (2.38)
2	Spiromesifen 22.9% SC	11.03 (3.46)	10.73 (3.40)	6.65 (2.75)	2.41 (1.84)	7.71 (2.86)
3	Flonicamid 50% WG	9.37 (3.20)	8.13 (3.01)	5.69 (2.58)	1.70 (1.63)	6.22 (2.60)
4	Diafenthiuron 50% WP	6.99 (2.82)	8.44 (3.06)	5.76 (2.59)	1.97 (1.72)	5.79 (2.55)
5	Acephate 50% + Imidacloprid 1.8% SP	9.49 (3.23)	8.76 (3.11)	6.90 (2.80)	2.39 (1.84)	6.88 (2.74)
6	Copper oxychloride 50% WP	14.89 (3.98)	16.56 (4.18)	10.47 (3.37)	7.10 (2.82)	12.25 (3.59)
7	Fipronil 5% SC + Copper oxychloride 50% WP	8.33 (3.04)	6.65 (2.76)	4.60 (2.36)	1.50 (1.58)	5.27 (2.43)
8	Spiromesifen 22.9% SC + Copper oxychloride 50% WP	9.97 (3.29)	11.01 (3.45)	6.65 (2.75)	2.86 (1.96)	7.62 (2.86)
9	Flonicamid 50% WG + Copper oxychloride 50% WP	8.74 (3.11)	8.88 (3.13)	6.12 (2.65)	1.90 (1.70)	6.41 (2.65)
10	Diafenthiuron 50% WP+ Copper oxychloride 50% WP	8.64 (3.09)	7.64 (2.93)	5.83 (2.59)	2.10 (1.75)	6.05 (2.59)
11	(Acephate 50% +Imidacloprid 1.8% SP) + Copper oxychloride 50% WP	9.64 (3.25)	9.55 (3.23)	7.09 (2.81)	2.14 (1.77)	7.10 (2.77)
12	Untreated control	16.75 (4.20)	15.54 (4.05)	11.83 (3.56)	6.23 (2.65)	12.59 (3.62)
	F test	Sig	Sig	Sig	Sig	Sig
	SE (m) ±	0.18	0.19	0.19	0.10	0.17
	CD at 5 %	0.51	0.56	0.54	0.28	0.47
	CV %	9.20	10.23	11.55	8.80	9.95

Note: Figures in parentheses are corresponding square root transformation values.

DAS- Days After Spraying

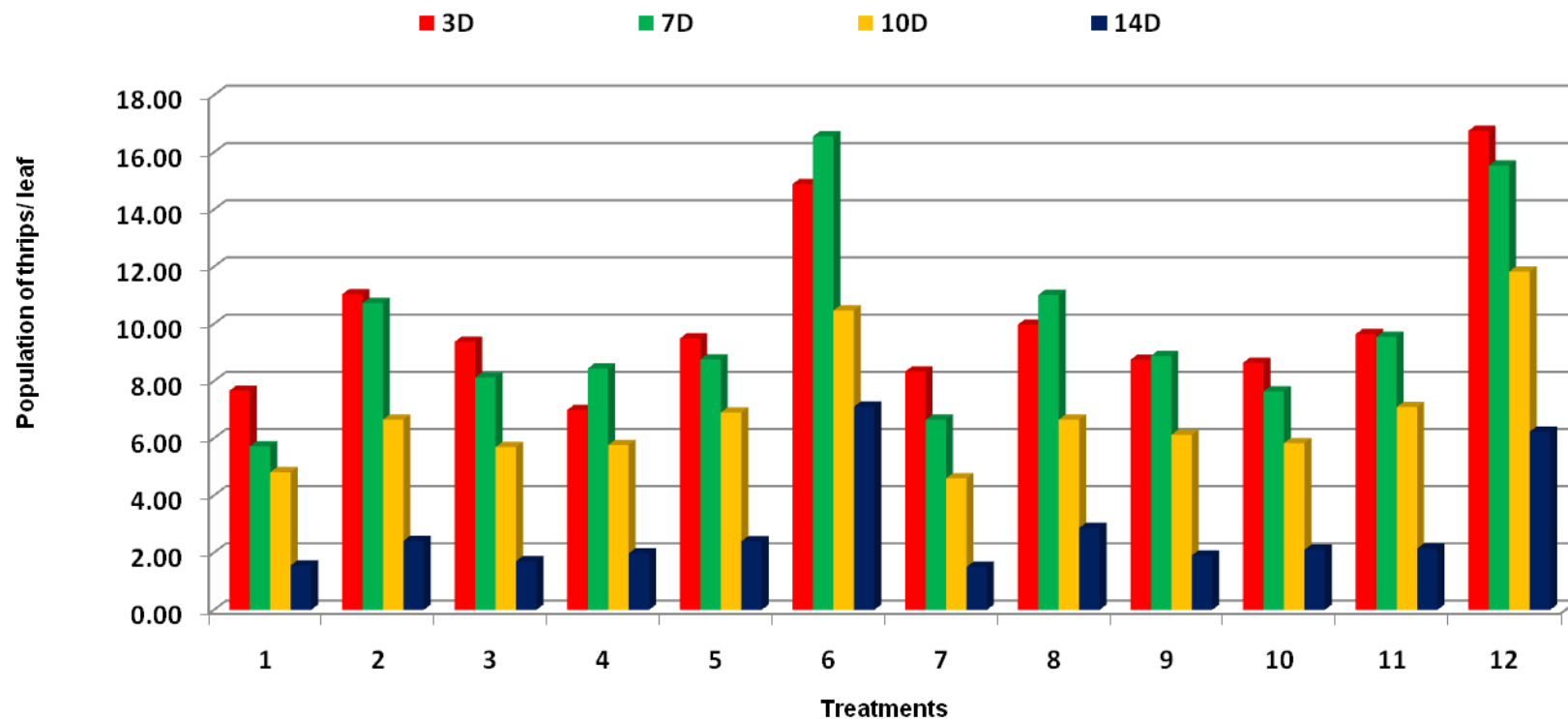


Fig 13. Efficacy of pesticides alone and in combination against cotton thrips after second spray

T₁ : Fipronil 5% SC

T₄: Diafenthiuron 50% WP

T₇ :Fipronil 5% SC + Copper oxychloride 50% WP

T₁₀: Diafenthiuron 50% WP + Copper oxychloride 50% WP

T₂ : Spiromesifen 22.9% SC

T₅:Acephate 50% + Imidacloprid 1.8% SP

T₈: Spiromesifen 22.9%SC + Copper oxychloride 50% WP

T₁₁: (Acephate 50% + Imidacloprid 1.8% SP) + Copper oxychloride 50% WP

T₃: Flonicamid 50% WG

T₆:Copper oxychloride 50% WP

T₉ :Flonicamid 50% WG + Copper oxychloride 50% WP

T₁₂: Untreated control

50% + imidacloprid 1.8% SP and (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP were found statistically equal in reducing the number of thrips in which 4.81, 5.69, 5.76, 5.83, 6.12, 6.65, 6.65, 6.90 and 7.09 thrips/leaf, respectively were recorded. All these treatments found at par with each other. Whereas, maximum number of thrips were observed in copper oxychloride 50% WP (10.47) which is found at par with untreated control (11.83).

4.13.4 Fourteen days after second spray

The population of thrips recorded during fourteen days after second spray (Table 14 and Fig.13) revealed that, plots treated with fipronil 5% SC + copper oxychloride 50% WP recorded minimum population of thrips (1.50/leaf). This treatment was found at par with fipronil 5% SC, flonicamid 50% WG, flonicamid 50% WG + copper oxychloride 50% WP, diafenthiuron 50% WP, diafenthiuron 50% WP+ copper oxychloride 50% WP, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, acephate 50% + imidacloprid 1.8% SP and spiromesifen 22.9% SC in which population of thrips ranged between 1.55 to 2.41 thrips/leaf. The latter six treatments were also found at par with spiromesifen 22.9%SC + copper oxychloride 50% WP (2.86). However, highest number of thrips were recorded in plots treated with copper oxychloride 50% WP and untreated control with population of 7.10 and 6.23 thrips/leaf, respectively.

4.13.5 Mean

The results on the efficacy of various treatments against thrips population after second spray (Table 14 and Fig.13) revealed that, all the treatment expect copper oxychloride 50% WP was found significantly effective in recording minimum thrips population. The treatments viz., fipronil 5% SC (4.94), fipronil 5% SC + copper oxychloride 50% WP (5.27), diafenthiuron 50% WP (5.79), diafenthiuron 50% WP+ copper oxychloride 50% WP (6.05), flonicamid 50% WG (6.22), flonicamid 50% WG + copper oxychloride 50% WP (6.41), acephate 50% + imidacloprid 1.8% SP (6.88) and (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (7.20) proved equally effective in recording minimum thrips population at different intervals of

observations. Whereas, the treatment with spiromesifen 22.9% SC + copper oxychloride 50% WP (7.62) and spiromesifen 22.9% SC (7.71) were found moderately effective. Maximum number of thrips were recorded in plots treated with copper oxychloride 50% WP and untreated control with 12.25 and 12.59 thrips per leaf, respectively found at par with each other.

4.14 Efficacy of pesticides alone and in combination against cotton thrips after third spray

4.14.1 Three days after third spray

The Table 15 (Fig.14) pertaining to population of thrips recorded at three days after third spray revealed that minimum thrips population was seen due to application of fipronil 5% SC + copper oxychloride 50% WP (0.32 thrips/leaf). However, this treatment was found at par with fipronil 5% SC, diafenthiuron 50% WP+ copper oxychloride 50% WP, diafenthiuron 50% WP, acephate 50% + imidacloprid 1.8% SP, flonicamid 50% WG, flonicamid 50% WG + copper oxychloride 50% WP and (acephate 50% + imidacloprid 1.8 % SP) + copper oxychloride 50% WP, in which population ranged between 0.37 to 0.77 thrips/leaf. These were followed by treatments of spiromesifen 22.9% SC (1.07) and spiromesifen 22.9% SC + copper oxychloride 50% WP (1.25) . Highest number of thrips population was recorded in copper oxychloride 50% WP (3.77) and untreated control (4.17) which were at par with each other.

4.14.2 Seven days after third spray

The data presented in Table 15 (Fig.14) showed that the plots treated with diafenthiuron 50% WP recorded minimum population of thrips (0.43/leaf). However, this treatment was found statistically equal with diafenthiuron 50% WP + copper oxychloride 50% WP, fipronil 5% SC + copper oxychloride 50% WP, fipronil 5% SC, flonicamid 50% WG, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, acephate 50% + imidacloprid 1.8% SP, flonicamid 50% WG + copper oxychloride 50% WP and spiromesifen 22.9% SC + copper oxychloride 50% WP with population of 0.44, 0.60, 0.70, 0.77, 0.84, 0.93, 0.99 and 1.23 thrips/leaf, respectively. The latter treatments were in turn found at par with spiromesifen 22.9% SC (1.37).

Table 15: Efficacy of pesticides alone and in combination against cotton thrips after third spray

Tr. No	Treatments	Number of thrips /leaf at				
		3DAS	7DAS	10DAS	14DAS	Mean
1	Fipronil 5% SC	0.37 (1.17)	0.70 (1.29)	0.50 (1.22)	0.57 (1.24)	0.53 (1.23)
2	Spiromesifen 22.9% SC	1.07 (1.43)	1.37 (1.52)	1.00 (1.41)	1.13 (1.46)	1.14 (1.45)
3	Flonicamid 50% WG	0.70 (1.30)	0.77 (1.32)	0.80 (1.34)	0.87 (1.36)	0.78 (1.33)
4	Diafenthiuron 50% WP	0.53 (1.24)	0.43 (1.20)	0.73 (1.31)	0.69 (1.30)	0.60 (1.26)
5	Acephate 50% + Imidacloprid 1.8% SP	0.63 (1.28)	0.93 (1.39)	0.94 (1.39)	1.10 (1.45)	0.90 (1.38)
6	Copper oxychloride 50% WP	3.77 (2.17)	3.90 (2.20)	3.80 (2.17)	4.07 (2.25)	3.88 (2.20)
7	Fipronil 5% SC + Copper oxychloride 50% WP	0.32 (1.15)	0.60 (1.26)	0.42 (1.19)	0.47 (1.21)	0.45 (1.20)
8	Spiromesifen 22.9% SC + Copper oxychloride 50% WP	1.25 (1.48)	1.23 (1.48)	1.03 (1.42)	1.30 (1.49)	1.21 (1.47)
9	Flonicamid 50% WG + Copper oxychloride 50% WP	0.73 (1.31)	0.99 (1.40)	0.87 (1.36)	0.90 (1.37)	0.87 (1.36)
10	Diafenthiuron 50% WP+ Copper oxychloride 50% WP	0.47 (1.21)	0.44 (1.20)	0.63 (1.27)	0.90 (1.37)	0.61 (1.26)
11	(Acephate 50% +Imidacloprid 1.8% SP) + Copper oxychloride 50% WP	0.77 (1.32)	0.84 (1.35)	1.17 (1.45)	1.03 (1.42)	0.95 (1.39)
12	Untreated control	4.17 (2.26)	4.23 (2.28)	4.17 (2.27)	3.93 (2.22)	4.13 (2.26)
	F test	Sig	Sig	Sig	Sig	Sig
	SE (m) ±	0.08	0.10	0.10	0.09	0.09
	CD at 5 %	0.25	0.30	0.28	0.27	0.28
	CV %	10.14	11.73	11.22	10.35	10.86

Note: Figures in parentheses are corresponding square root transformation values.

DAS- Days After Spraying

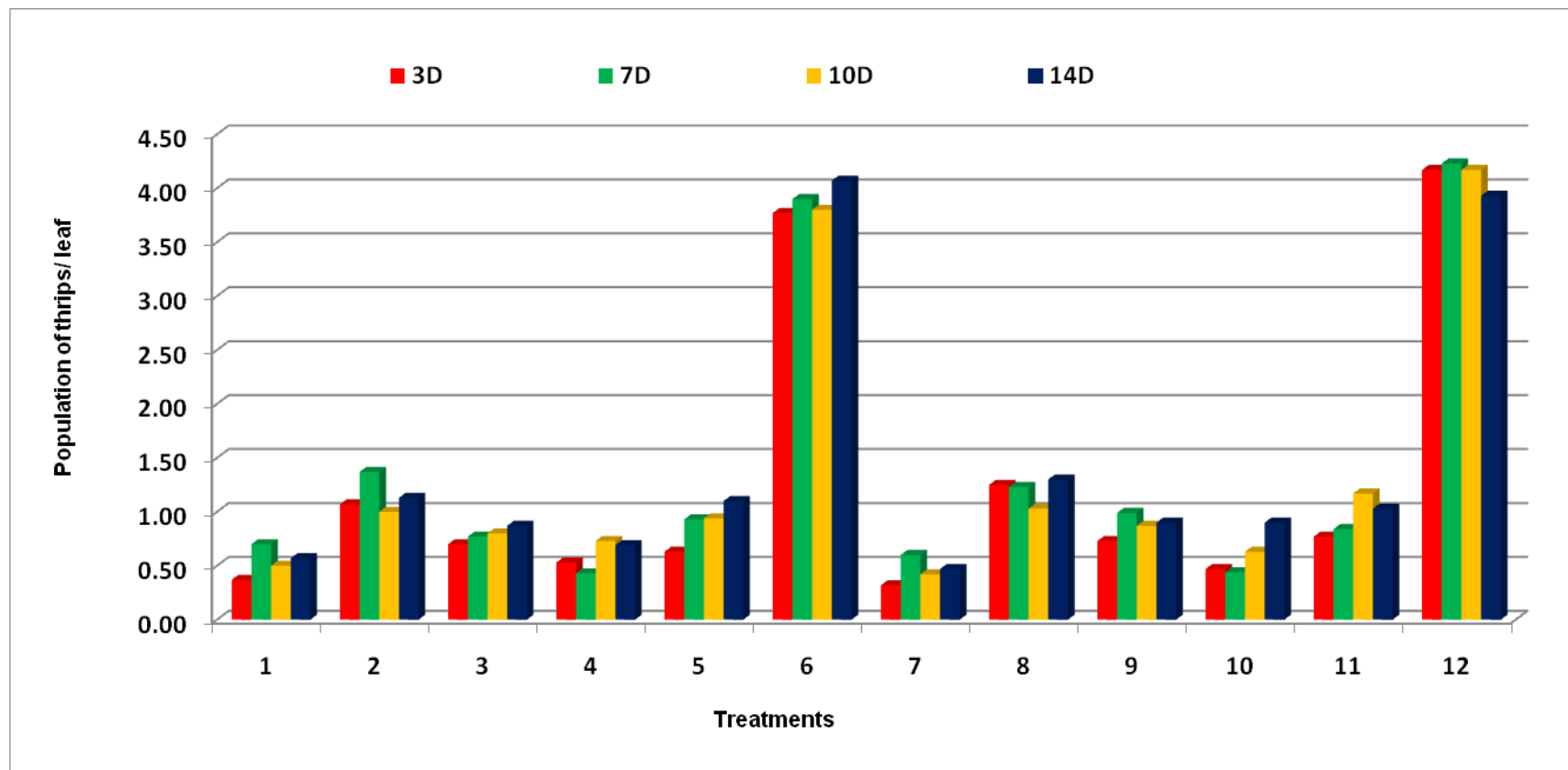


Fig 14. Efficacy of pesticides alone and in combination against cotton thrips after third spray

T₁ : Fipronil 5% SC

T₄: Diafenthiuron 50% WP

T₇ :Fipronil 5% SC + Copper oxychloride 50% WP

T₁₀: Diafenthiuron 50% WP+ Copper oxychloride 50% WP

T₂ : Spiromesifen 22.9% SC

T₅:Acephate 50% + Imidacloprid 1.8% SP

T₈: Spiromesifen 22.9% SC + Copper oxychloride 50% WP

T₁₁: (Acephate 50% + Imidacloprid 1.8% SP) + Copper oxychloride 50% WP

T₃: Flonicamid 50% WG

T₆:Copper oxychloride 50% WP

T₉ :Flonicamid 50% WG + Copper oxychloride 50% WP

T₁₂: Untreated control

The plots treated with copper oxychloride 50% WP and untreated control recorded the maximum population of thrips i.e. 3.90 and 4.23/leaf, respectively and are found at par with each other.

4.14.3 Ten days after third spray

The data on thrips population recorded at ten days after third spray (Table 15 and Fig.14) revealed that, the treatment fipronil 5% SC + copper oxychloride 50% WP recorded minimum population of thrips (0.42/leaf). However, this treatment was found at par with fipronil 5% SC, diafenthiuron 50% WP + copper oxychloride 50% WP, diafenthiuron 50% WP, flonicamid 50% WG, flonicamid 50% WG + copper oxychloride 50% WP, acephate 50% + imidacloprid 1.8% SP, spiromesifen 22.9% SC, spiromesifen 22.9% SC + copper oxychloride 50% WP and (acephate 50% + Imidacloprid 1.8% SP) + copper oxychloride 50% WP in which population ranged between 0.50 to 1.17 thrips/leaf. Maximum thrips population was observed in plots treated with copper oxychloride 50% WP and untreated control i.e. 3.80 and 4.17 thrips/leaf, respectively.

4.14.4 Fourteen days after third spray

The data (Table 15 and Fig.14) in respect of population of thrips at fourteen days after third spray showed that, all the treatments except copper oxychloride 50% WP were significantly effective over untreated control in recording minimum population of thrips. Among them, plots treated with fipronil 5% SC + copper oxychloride 50% WP recorded minimum population of thrips (0.47/leaf). However, this treatment was found statistically equal with fipronil 5% SC (0.57), diafenthiuron 50% WP (0.69), flonicamid 50% WG (0.87), diafenthiuron 50% WP + copper oxychloride 50% WP (0.90), flonicamid 50% WG + copper oxychloride 50% WP (0.90), (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (1.03), acephate 50% + imidacloprid 1.8% SP (1.10) and spiromesifen 22.9% SC (1.13). The latter treatments were also in turn found at par with spiromesifen 22.9% SC + copper oxychloride 50% WP (1.30). Highest number of thrips were recorded in copper oxychloride 50% WP (4.07) and untreated control (3.93).

4.14.5 Mean

The mean data (Table 15 and Fig.14) regarding the population of thrips after third spray revealed that, all the treatments except copper oxychloride 50% WP proved significantly effective over untreated control in recording minimum number of thrips. Amongst the various treatments, fipronil 5% SC + copper oxychloride 50% WP recorded the minimum population of thrips (0.45/leaf). However, this treatment was found statistically equal with fipronil 5% SC (0.53), diafenthiuron 50% WP (0.60), diafenthiuron 50% WP+ copper oxychloride 50% WP (0.61), flonicamid 50% WG (0.78), flonicamid 50% WG + copper oxychloride 50% WP (0.87), acephate 50% + imidacloprid 1.8% SP (0.90), (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (0.95), spiromesifen 22.9% SC (1.14) and spiromesifen 22.9% SC + copper oxychloride 50% WP (1.21). Whereas, maximum population was observed in plots treated with copper oxychloride 50% WP (3.88 thrips/leaf) and found at par with untreated control (4.13 thrips/leaf).

4.15 Cumulative effect of pesticides alone and in combination against cotton thrips

4.15.1 Three days after spray

The data presented in Table 16 (Fig.15) regarding cumulative effect of different pesticides combination against thrips at three days after spray was found statistically significant. Minimum thrips population was observed due to application of fipronil 5% SC + copper oxychloride 50% WP (4.33/leaf). However, this treatment was found at par with diafenthiuron 50% WP (4.35), fipronil 5% SC (4.45), diafenthiuron 50% WP + copper oxychloride 50% WP (4.88), flonicamid 50% WG + copper oxychloride 50% WP (5.11), flonicamid 50% WG (5.27), acephate 50% + imidacloprid 1.8% SP (5.52), (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (5.85) and spiromesifen 22.9% SC + copper oxychloride 50% WP (5.85). The latter treatments were also in turn found at par with spiromesifen 22.9% SC (6.43 thrips/leaf). Maximum population of thrips were recorded in copper oxychloride 50% WP (11.74) at par with untreated control (12.65).

Table 16: Cumulative effect of pesticides alone and in combination against cotton thrips

Tr. No	Treatments	Number of thrips /leaf at				
		3DAS	7DAS	10DAS	14DAS	Mean
1	Fipronil 5% SC	4.45 (2.20)	6.10 (2.48)	5.71 (2.40)	5.15 (2.20)	5.35 (2.32)
2	Spiromesifen 22.9% SC	6.43 (2.58)	8.67 (2.92)	7.79 (2.73)	7.79 (2.62)	7.67 (2.72)
3	Flonicamid 50% WG	5.27 (2.35)	7.15 (2.67)	7.86 (2.75)	5.85 (2.33)	6.52 (2.52)
4	Diafenthiuron 50% WP	4.35 (2.20)	7.12 (2.64)	6.55 (2.55)	6.92 (2.46)	6.24 (2.46)
5	Acephate 50% + Imidacloprid 1.8% SP	5.52 (2.41)	7.43 (2.73)	8.08 (2.78)	8.11 (2.65)	7.28 (2.64)
6	Copper oxychloride 50% WP	11.74 (3.44)	13.00 (3.60)	13.12 (3.54)	12.68 (3.46)	12.64 (3.51)
7	Fipronil 5% SC + Copper oxychloride 50% WP	4.33 (2.17)	6.39 (2.54)	4.76 (2.25)	5.26 (2.21)	5.19 (2.29)
8	Spiromesifen 22.9% SC + Copper oxychloride 50% WP	5.85 (2.49)	8.85 (2.94)	7.68 (2.72)	8.50 (2.74)	7.72 (2.73)
9	Flonicamid 50% WG + Copper oxychloride 50% WP	5.11 (2.34)	7.47 (2.73)	7.70 (2.72)	7.36 (2.52)	6.91 (2.58)
10	Diafenthiuron 50% WP+ Copper oxychloride 50% WP	4.88 (2.28)	6.42 (2.54)	7.16 (2.62)	6.10 (2.38)	6.14 (2.45)
11	(Acephate 50% +Imidacloprid 1.8% SP) + Copper oxychloride 50% WP	5.85 (2.47)	7.76 (2.76)	8.76 (2.86)	7.48 (2.56)	7.46 (2.67)
12	Untreated control	12.65 (3.56)	13.15 (3.62)	14.18 (3.70)	12.45 (3.42)	13.11 (3.57)
	F test	Sig	Sig	Sig	Sig	Sig
	SE (m) ±	0.14	0.16	0.17	0.13	0.15
	CD at 5 %	0.40	0.47	0.47	0.38	0.43
	CV %	9.51	10.16	10.53	9.05	9.81

Note: Figures in parentheses are corresponding square root transformation values.

DAS- Days After Spraying

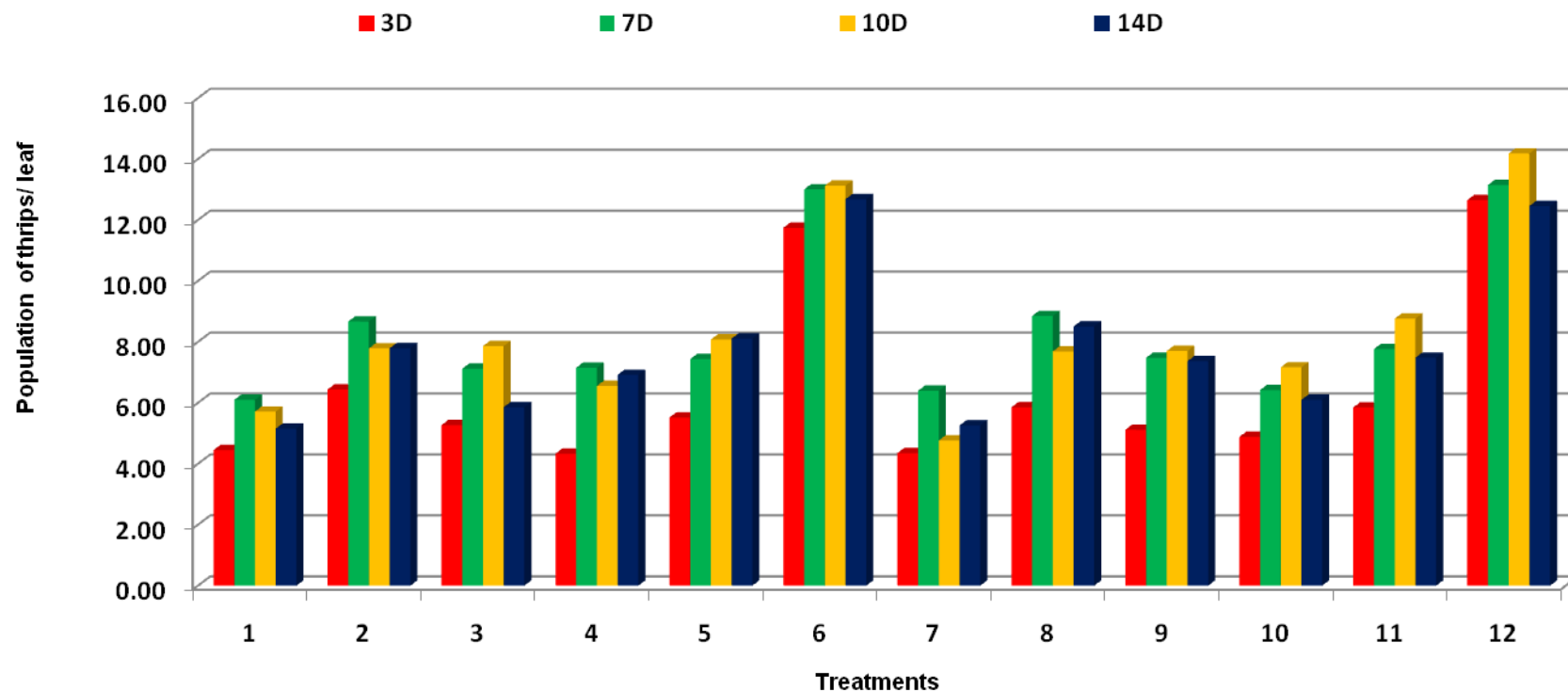


Fig 15. Cumulative effect of pesticides alone and in combination against cotton thrips

T₁ : Fipronil 5% SC

T₄: Diafenthiuron 50% WP

T₇ :Fipronil 5% SC + Copper oxychloride 50% WP

T₁₀: Diafenthiuron 50% WP+ Copper oxychloride 50% WP

T₂ : Spiromesifen 22.9% SC

T₅:Acephate 50% + Imidacloprid 1.8 % SP

T₈: Spiromesifen 22.9%SC + Copper oxychloride 50% WP

T₁₁: (Acephate 50% + Imidacloprid 1.8% SP) + Copper oxychloride 50% WP

T₃: Flonicamid 50% WG

T₆:Copper oxychloride 50% WP

T₉ :Flonicamid 50% WG + Copper oxychloride 50% WP

T₁₂: Untreated control

4.15.2 Seven days after spray

The data depicted in Table 16 (Fig.15) regarding thrips population at seven days after each spray showed that, treatment with fipronil 5% SC recorded minimum population of thrips (i.e. 6.10 thrips/leaf). However, this treatment was found at par with fipronil 5% SC + copper oxychloride 50% WP, diafenthiuron 50% WP + copper oxychloride 50% WP, diafenthiuron 50% WP, flonicamid 50% WG, acephate 50% + imidacloprid 1.8% SP, flonicamid 50% WG + copper oxychloride 50% WP, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, spiromesifen 22.9% SC and spiromesifen 22.9% SC + copper oxychloride 50% WP in which 6.39, 6.42, 7.12, 7.15, 7.43, 7.47, 7.76, 8.67 and 8.85 thrips/leaf, were recorded. Highest number of thrips population was recorded in copper oxychloride 50% WP (13.00) and found at par with untreated control (13.15).

4.15.3 Ten days after spray

The data presented in Table 16 (Fig.15) revealed that, all the treatments except copper oxychloride 50% WP found statistically superior over untreated control. Among the different treatments, plots treated with fipronil 5% SC + copper oxychloride 50% WP recorded minimum number of thrips i.e. 4.76/leaf. This treatment was closely followed by fipronil 5% SC (5.71), diafenthiuron 50% WP (6.55), diafenthiuron 50% WP + copper oxychloride 50% WP (7.16), spiromesifen 22.9% SC + copper oxychloride 50% WP (7.68) and flonicamid 50% WG + copper oxychloride 50% WP (7.70). All these treatments found statistically equal with each other. Whereas, spiromesifen 22.9% SC (7.79), flonicamid 50% WG (7.86), acephate 50% + imidacloprid 1.8% SP (8.08) and (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (8.76) appeared as next better treatments. Plots treated with copper oxychloride 50% WP and untreated control recorded maximum population of thrips with 13.12 and 14.18/leaf, respectively.

4.15.4 Fourteen days after spray

The data recorded on thrips population at fourteen days after each spray presented in Table 16 and illustrated under Fig.15 was found statistically significant. Minimum thrips population was seen due to application

of fipronil 5% SC (5.15/leaf). However, this treatment was found at par with fipronil 5% SC + copper oxychloride 50% WP, flonicamid 50% WG, diafenthiuron 50% WP + copper oxychloride 50% WP, diafenthiuron 50% WP, flonicamid 50% WG + copper oxychloride 50% WP and (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP with 5.26, 5.85, 6.10, 6.92, 7.36 and 7.48 thrips/leaf, respectively. These were followed by treatments of spiromesifen 22.9% SC, acephate 50% + imidacloprid 1.8% SP and spiromesifen 22.9% SC + copper oxychloride 50% WP in which 7.79, 8.11 and 8.50 thrips/leaf were recorded respectively, found statistically equal with each other. Whereas, maximum population of thrips was observed in copper oxychloride 50% WP (12.68) and untreated control (12.45).

4.15.5 Mean

Results on the efficacy of various treatments against thrips population after each spray (Table 16 and Fig.15) showed that, fipronil 5% SC + copper oxychloride 50% WP recorded the minimum population of thrips (5.19/leaf). This treatment was found at par with fipronil 5% SC, diafenthiuron 50% WP + copper oxychloride 50% WP, diafenthiuron 50% WP, flonicamid 50% WG, flonicamid 50% WG + copper oxychloride 50% WP, acephate 50% + imidacloprid 1.8% SP, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP and spiromesifen 22.9% SC in which population ranged between 5.35 to 7.67 thrips/leaf, respectively. All these treatments were found at par with spiromesifen 22.9% SC + copper oxychloride 50% WP (7.72/leaf). Highest number of thrips were recorded in treatment copper oxychloride 50% WP and untreated control with population of 12.64 and 13.11 thrips/leaf, respectively.

The findings of the present study are in line with the findings of Surwase et al. (2017) evaluated newer insecticides against sucking pests of cotton. The pooled data of two years indicated that fipronil 5 SC and flonicamid 50 WG were the most effective insecticides for reduction of thrips population on cotton which were at par with each other. Similar findings were also reported by Bontha and Mallapur (2017a) who reported lower mean population of thrips in diafenthiuron 50% WP and diafenthiuron 50% WP +

copper oxychloride 50 WP i.e. 2.15 and 2.36 thrips /3 leaves, respectively as against untreated control 18.38/3 leaves.

Similarly, Boda and Ilyas (2017) in their field experiment reported efficacy of newer insecticides against sucking pests of *Bt* cotton. They reported that, fipronil 5 SC recorded the minimum population of thrips (1.27 /3 leaves) among all the treatments as against untreated control (21.20 /3 leaves) during both the spray. Whereas, Gaurkhede et al. (2015) who evaluated the bioefficacy of newer insecticides against sucking pest of *Bt* cotton. Experimental finding showed that, application of fipronil 5 SC @ 0.015 per cent effectively minimized the incidence of thrips population 2.59 per leaf at the end of third spray and found at par with flonicamid 50 WG(3.18/leaf). Similarly, Bharpoda et al. (2014) who concluded that, diafenthiuron 50 WP @ 0.05% found more effective in control of thrips population(1.43 thrips /leaf).

Whereas, Patil et al. (2009) who noticed that the pooled observation of both years significantly recorded lower thrip populations in fipronil 5% SC @ 800 g/ha treatment (8.47 /3 leaves). Similarly, Stanley et al. (2010) who revealed that, diafenthiuron alone has recorded 52.77 per cent reduction, while diafenthiuron + urea recorded the maximum reduction of 58.14 per cent followed by diafenthiuron + carbendazim (55.80%) against cardamom thrips. Both urea and carbendazim showed synergistic effect with diafenthiuron.

4.16 Cumulative effect of pesticides alone and in combination on population of natural enemies

The data in the Table 17 on the coccinellids population at different intervals of observations after treatment sprays indicated non significant differences among the treatments. The population of coccinellids was observed in the range of 0.50 to 0.74 per plant. However, numerically more number of coccinellids were recorded in untreated control plots. The data presented in Table 18 regarding chrysopids population, recorded at different intervals of observation after treatment sprays was non-significant. However, numerically more number of chrysopids was recorded in the untreated control plot (0.69 per plant). Whereas, the population of chrysopids ranged between 0.50 to 0.60 grubs per plant in the plots treated with different insecticides.

Table 17: Cumulative effect of pesticides alone and in combination on population of coccinellids in cotton

Tr. No	Treatments	Average population of coccinellids (No / plant) at				
		3DAS	7DAS	10DAS	14DAS	Mean
1	Fipronil 5% SC	0.61 (1.26)	0.60 (1.26)	0.60 (1.26)	0.53 (1.23)	0.59 (1.25)
2	Spiromesifen 22.9% SC	0.62 (1.27)	0.63 (1.27)	0.51 (1.23)	0.60 (1.26)	0.59 (1.26)
3	Flonicamid 50% WG	0.53 (1.23)	0.65 (1.28)	0.50 (1.22)	0.52 (1.23)	0.55 (1.24)
4	Diafenthuron 50% WP	0.54 (1.24)	0.56 (1.25)	0.60 (1.26)	0.63 (1.27)	0.58 (1.25)
5	Acephate 50% + Imidacloprid 1.8% SP	0.56 (1.24)	0.52 (1.23)	0.65 (1.28)	0.57 (1.25)	0.58 (1.25)
6	Copper oxychloride 50% WP	0.57 (1.25)	0.62 (1.27)	0.55 (1.24)	0.54 (1.24)	0.57 (1.25)
7	Fipronil 5% SC + Copper oxychloride 50% WP	0.53 (1.23)	0.59 (1.25)	0.57 (1.25)	0.62 (1.27)	0.58 (1.25)
8	Spiromesifen 22.9% SC + Copper oxychloride 50% WP	0.59 (1.26)	0.59 (1.25)	0.59 (1.26)	0.51 (1.23)	0.57 (1.25)
9	Flonicamid 50% WG + Copper oxychloride 50% WP	0.66 (1.28)	0.63 (1.27)	0.59 (1.26)	0.58 (1.25)	0.61 (1.27)
10	Diafenthuron 50% WP+ Copper oxychloride 50% WP	0.53 (1.23)	0.64 (1.27)	0.62 (1.27)	0.57 (1.25)	0.59 (1.26)
11	(Acephate 50% +Imidacloprid 1.8% SP) + Copper oxychloride 50% WP	0.54 (1.24)	0.59 (1.26)	0.57 (1.25)	0.60 (1.26)	0.58 (1.25)
12	Untreated control	0.71 (1.30)	0.74 (1.31)	0.72 (1.31)	0.73 (1.31)	0.73 (1.31)
	F test	NS	NS	NS	NS	NS
	SE (m) ±	0.07	0.07	0.06	0.06	0.06
	CD at 5 %	10.10	10.79	9.50	9.03	9.85

Note: Figures in parentheses are corresponding $\sqrt{x} + 0.5$ transformation value

Table 18: Cumulative effect of pesticides alone and in combination on population of chrysopids in cotton

Tr. No	Treatments	Average population of chrysopids (No / plant) at				
		3DAS	7DAS	10DAS	14DAS	Mean
1	Fipronil 5% SC	0.57 (1.25)	0.54 (1.24)	0.57 (1.25)	0.56 (1.24)	0.56 (1.24)
2	Spiromesifen 22.9% SC	0.51 (1.23)	0.51 (1.22)	0.50 (1.22)	0.58 (1.25)	0.52 (1.23)
3	Flonicamid 50% WG	0.52 (1.23)	0.52 (1.23)	0.59 (1.26)	0.52 (1.23)	0.54 (1.24)
4	Diafenthiuron 50% WP	0.50 (1.22)	0.51 (1.22)	0.59 (1.25)	0.56 (1.24)	0.54 (1.24)
5	Acephate 50% + Imidacloprid 1.8% SP	0.54 (1.24)	0.59 (1.26)	0.56 (1.24)	0.60 (1.26)	0.57 (1.25)
6	Copper oxychloride 50% WP	0.56 (1.24)	0.52 (1.23)	0.57 (1.25)	0.54 (1.24)	0.55 (1.24)
7	Fipronil 5% SC + Copper oxychloride 50% WP	0.54 (1.24)	0.55 (1.24)	0.58 (1.25)	0.54 (1.24)	0.56 (1.24)
8	Spiromesifen 22.9% SC + Copper oxychloride 50% WP	0.57 (1.25)	0.54 (1.24)	0.57 (1.25)	0.51 (1.23)	0.55 (1.24)
9	Flonicamid 50% WG + Copper oxychloride 50% WP	0.53 (1.24)	0.58 (1.25)	0.56 (1.25)	0.54 (1.24)	0.56 (1.25)
10	Diafenthiuron 50% WP+ Copper oxychloride 50% WP	0.50 (1.21)	0.55 (1.24)	0.50 (1.22)	0.53 (1.24)	0.52 (1.23)
11	(Acephate 50% +Imidacloprid 1.8% SP) + Copper oxychloride 50% WP	0.51 (1.23)	0.50 (1.22)	0.51 (1.23)	0.56 (1.24)	0.52 (1.23)
12	Untreated control	0.66 (1.28)	0.63 (1.27)	0.69 (1.30)	0.66 (1.28)	0.66 (1.29)
	F test	NS	NS	NS	NS	NS
	SE (m) $\pm$	0.06	0.07	0.06	0.06	0.06
	CD at 5 %	8.67	9.25	9.03	8.64	8.90

Note: Figures in parentheses are corresponding $\sqrt{x + 0.5}$ transformation value

The results tabulated in Table 19 revealed non significant differences among the treatments in respect of spider population recorded at different intervals of observations after treatment sprays. The population of spider recorded in different insecticidal treated plots ranged between 0.50 to 0.76 spiders per plant. Whereas, in untreated control plots numerically higher number of spider were observed (0.80 spiders/plant).

Table 19: Cumulative effect of pesticides alone and in combination on population of spider in cotton

Tr. No	Treatments	Average population of spider (No / plant) at				
		3DAS	7DAS	10DAS	14DAS	Mean
1	Fipronil 5% SC	0.54 (1.24)	0.57 (1.25)	0.51 (1.22)	0.55 (1.24)	0.54 (1.24)
2	Spiromesifen 22.9% SC	0.61 (1.26)	0.55 (1.24)	0.60 (1.26)	0.54 (1.24)	0.58 (1.25)
3	Flonicamid 50% WG	0.56 (1.24)	0.66 (1.28)	0.65 (1.28)	0.55 (1.24)	0.60 (1.26)
4	Diafenthiuron 50% WP	0.63 (1.27)	0.53 (1.23)	0.54 (1.24)	0.53 (1.24)	0.56 (1.25)
5	Acephate 50% + Imidacloprid 1.8% SP	0.50 (1.22)	0.51 (1.23)	0.57 (1.25)	0.53 (1.24)	0.53 (1.23)
6	Copper oxychloride 50% WP	0.56 (1.24)	0.76 (1.27)	0.55 (1.24)	0.61 (1.26)	0.62 (1.25)
7	Fipronil 5% SC + Copper oxychloride 50% WP	0.60 (1.26)	0.59 (1.26)	0.62 (1.26)	0.57 (1.25)	0.59 (1.26)
8	Spiromesifen 22.9% SC + Copper oxychloride 50% WP	0.57 (1.25)	0.66 (1.28)	0.52 (1.23)	0.57 (1.25)	0.58 (1.25)
9	Flonicamid 50% WG + Copper oxychloride 50% WP	0.59 (1.25)	0.60 (1.26)	0.56 (1.25)	0.54 (1.24)	0.57 (1.25)
10	Diafenthiuron 50% WP+ Copper oxychloride 50% WP	0.54 (1.24)	0.71 (1.25)	0.50 (1.26)	0.56 (1.25)	0.58 (1.25)
11	(Acephate 50% +Imidacloprid 1.8% SP) + Copper oxychloride 50% WP	0.60 (1.26)	0.60 (1.26)	0.55 (1.24)	0.51 (1.23)	0.56 (1.25)
12	Untreated control	0.80 (1.28)	0.75 (1.32)	0.75 (1.32)	0.70 (1.30)	0.75 (1.31)
	F test	NS	NS	NS	NS	NS
	SE (m) ±	0.07	0.08	0.06	0.06	0.07
	CD at 5 %	9.98	11.14	9.60	8.42	9.79

Note: Figures in parentheses are corresponding $\sqrt{x + 0.5}$ transformation value



Coccinellid beetle



Chrysopid(grub)



Spider

Plate 3. Different natural enemies observed during experimentation

The present result revealed that, all the treatments under the present investigation proved less detrimental to the predatory fauna like spiders, chrysopids and coccinellids in cotton ecosystem. Similar findings were reported by Naik et al. (2017) who noticed that, in second spray diafenthiuron 50 WP recorded highest population of coccinellid. Whereas, the population of spider was significantly high level in plots treated with fipronil 5 SC (0.89 spider/plant). They further concluded that, insecticides viz., diafenthiuron 50% WP, fipronil 5% SC, spiromesifen 22.9% SC and flonicamid 50% WG were found safer to natural enemies.

However, the workers like Jeer et al. (2017) evaluated various doses of acephate 50% + imidacloprid 1.8% SP and concluded that, all the doses of this insecticide were found safer to natural enemies in rice ecosystem i.e. *Cyrtorhinus lividipennis* and spiders. Similar findings were also reported by Bontha and Mallapur (2017a) who noticed that, diafenthiuron 50% WP in combination with carbendazim 50% WP and copper oxychloride 50% WP were found to be safer towards natural enemies in cotton ecosystem (coccinellids, chrysopids and spiders). Earlier worker Kodandaram et al. (2017) reported that applications of flonicamid 50% WG was safer to the natural enemies (spiders and rove beetles) prevailing in the okra ecosystem.

However, the earlier worker Nemade et al. (2015) in their field trial on evaluation of new molecule against sucking pests *Bt* cotton. They had not observed any deleterious effect flonicamid 50% WG and diafenthiuron 50% WP on population of natural enemies. However, Gaurkhede et al. (2015) who revealed that, flonicamid 50% WG @ 0.01 and 0.02 per cent and fipronil 5% SC @ 0.015 per cent were not showed any deleterious effect on population of natural enemies in cotton ecosystem. Similarly, Bharpoda et al. (2014) evaluated new insecticides against sucking pests of cotton and recorded highest population of spider, coccinellids and chrysopids in the plots treated with plots treated with difenthiuron 50 WP @ 0.05% and proved comparatively less toxic.

Table 20: Phytotoxic effect of pesticides combination on cotton

Tr. No	Treatments	Phytotoxicity ratings					
		Leaf tip injury	Wilting	Vein clearing	Necrosis	Epinasty	Hyponasty
1	Fipronil 5% SC	0	0	0	0	0	0
2	Spiromesifen 22.9% SC	0	0	0	0	0	0
3	Flonicamid 50% WG	0	0	0	0	0	0
4	Diafenthiuron 50% WP	0	0	0	0	0	0
5	Acephate 50% + Imidacloprid 1.8% SP	0	0	0	0	0	0
6	Copper oxychloride 50% WP	0	0	0	0	0	0
7	Fipronil 5% SC + Copper oxychloride 50% WP	0	0	0	0	0	0
8	Spiromesifen 22.9%SC + Copper oxychloride 50% WP	0	0	0	0	0	0
9	Flonicamid 50% WG + Copper oxychloride 50% WP	0	0	0	0	0	0
10	Diafenthiuron 50% WP+ Copper oxychloride 50% WP	0	0	0	0	0	0
11	(Acephate 50% +Imidacloprid 1.8 % SP) + Copper oxychloride 50% WP	0	0	0	0	0	0
12	Untreated control	0	0	0	0	0	0

4.17 Phytotoxic effect of pesticides combination on cotton

The five insecticides fipronil 5% SC, spiromesifen 22.9% SC, flonicamid 50% WG, diafenthiuron 50% WP and acephate 50% + imidacloprid 1.8% SP and one fungicide copper oxychloride 50% WP tested alone as well as in combinations viz., fipronil 5% SC + copper oxychloride 50% WP, spiromesifen 22.9% SC + copper oxychloride 50% WP, flonicamid 50% WG + copper oxychloride 50% WP, diafenthiuron 50% WP + copper oxychloride 50% WP and (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP against sucking pests of cotton. The results revealed that, the pesticide combinations did not showed any phytotoxic symptoms like injury to leaf tip and leaf surface, wilting, vein clearing, necrosis and epinasty and hyponasty in any of the treatments (Table 20).

The results of present study pertaining to phytotoxic effects of different pesticides combination on cotton crop are in agreement with the investigations of Raju et al. (2018) had not observed any phytotoxic effects such as injury to leaf tip, yellowing, wilting, necrosis, vein clearing, epinasty and hyponasty in leaves of rice crop due to combination of insecticides with fungicides. Similarly, Bontha and Mallapur (2017a) concluded that, diafenthiuron in combination copper oxychloride 50 WP at recommended doses had not caused any phytotoxic symptoms such as injury to leaf tip and leaf surface, wilting, vein clearing, necrosis, epinasty and hyponasty on 60 and 90 old cotton crop.

Whereas, Shaila (2010) who revealed that, the combinations of four insecticides viz., abamectin, emamectin benzoate, novaluron and lufenuron with three fungicides viz., mancozeb, chlorthalonil and carbendazim showed no phytotoxic symptoms on one and half month old groundnut plants at recommended concentrations. Similarly, Stanley et al. (2010) revealed that, diafenthiuron alone and its combinations with carbendazim did not cause any phototoxic symptoms such as injury to leaf tip and leaf surface, wilting, vein clearing, necrosis, epinasty and hyponasty in cardamom.

Table 21: Effect of different pesticides alone and in combination on seed cotton yield (q/ha)

Sr. No.	Treatments	Dose ml /L	Seed cotton yield (q/ha)			
			RI	R II	R III	Mean
1	Fipronil 5% SC	3.0ml	10.49	11.29	10.95	10.91
2	Spiromesifen 22.9% SC	1.2ml	12.96	13.36	12.04	12.79
3	Flonicamid 50% WG	0.3g	13.58	13.54	12.96	13.36
4	Diafenthiuron 50% WP	1.2g	15.43	14.13	15.12	14.89
5	Acephate 50% + Imidacloprid 1.8% SP	2.0g	11.57	11.04	10.18	10.93
6	Copper oxychloride 50% WP	2.5g	8.02	7.09	8.96	8.02
7	Fipronil 5% SC + Copper oxychloride 50% WP	3.0ml+2.5g	11.11	10.55	11.41	11.02
8	Spiromesifen 22.9%SC + Copper oxychloride 50% WP	1.2ml+2.5g	13.73	13.54	12.96	13.41
9	Flonicamid 50% WG + Copper oxychloride 50% WP	0.3g+2.5g	13.88	14.19	14.87	14.31
10	Diafenthiuron 50% WP+ Copper oxychloride 50% WP	1.2g+2.5g	16.35	15.00	16.04	15.80
11	(Acephate 50% +Imidacloprid 1.8% SP) + Copper oxychloride 50% WP	2.0g+2.5g	11.17	11.72	12.34	11.74
12	Untreated control	-	7.71	8.67	6.79	7.72
	F test	-	-	-	-	Sig
	Sig SE (M) ±	-	-	-	-	0.38
	CD at 5 %	-	-	-	-	1.12
	CV %	-	-	-	-	5.48

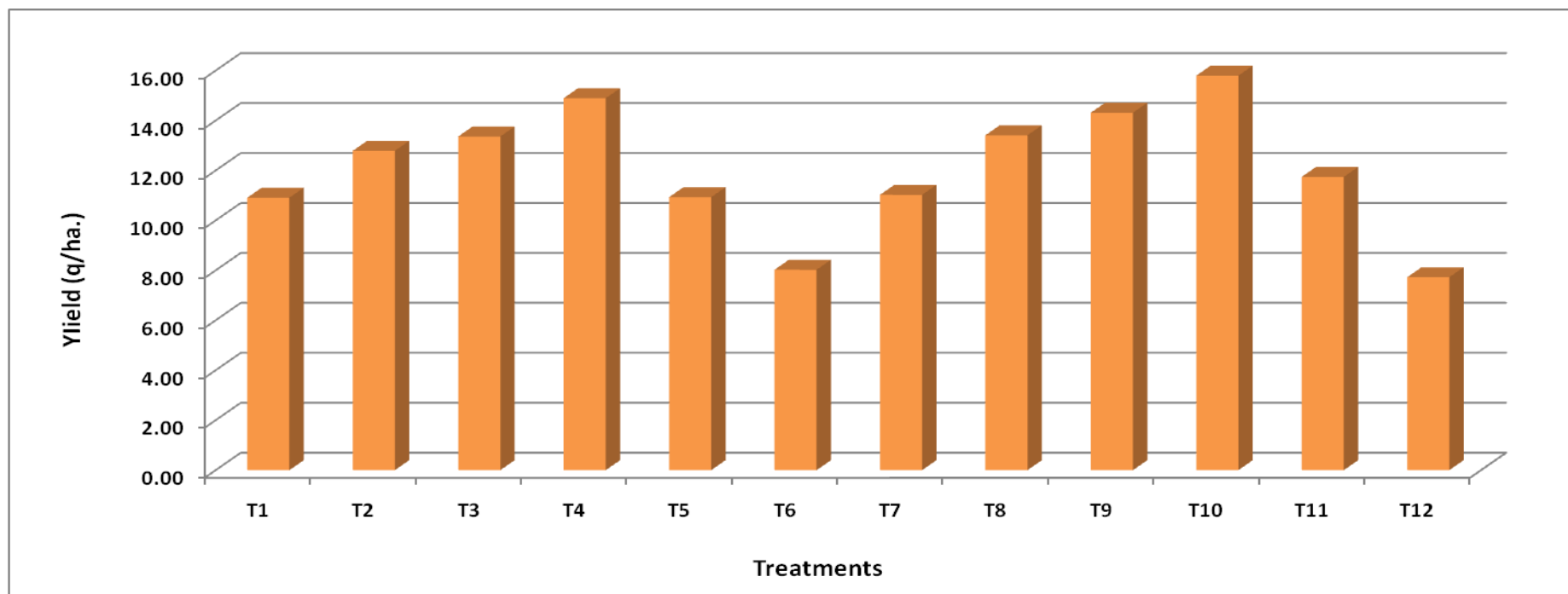


Fig 16. Effect of pesticides alone and in combination on seed cotton yield

T₁ : Fipronil 5% SC	T₄: Diafenthiuron 50% WP	T₇ :Fipronil 5% SC + Copper oxychloride 50% WP	T₁₀: Diafenthiuron 50% WP + Copper oxychloride 50% WP
T₂ : Spiromesifen 22.9% SC	T₅:Acephate 50% + Imidacloprid 1.8% SP	T₈: Spiromesifen 22.9%SC + Copper oxychloride 50% WP	T₁₁: (Acephate 50% + Imidacloprid 1.8% SP) + Copper oxychloride 50% WP
T₃: Flonicamid 50% WG	T₆:Copper oxychloride 50% WP	T₉ :Flonicamid 50% WG + Copper oxychloride 50% WP	T₁₂: Untreated control

However, the earlier worker Suneel Kumara et al. (2016) who observed slight phytotoxic symptoms (chlorosis) in combination treatments of thiodicarb 75 WP + hexaconazole 5 EC and chlorfenapyr 10 SC + hexaconazole 5 EC with phytotoxicity score of 1 (0 to 10%) on groundnut crop.

4.18 Effect of different pesticides alone and in combination on seed cotton yield (q/ha)

The data presented in Table 21 (Fig. 16) indicated that, all the treatments produced significantly higher seed cotton yield except copper oxychloride 50% WP over untreated control plot. Amongst them, the plots treated with diafenthiuron 50% WP + copper oxychloride 50% WP recorded highest seed cotton yield of 15.80 q/ha. This treatment was found at par with diafenthiuron 50% WP (14.89 q/ha). The latter treatment was also in turn found at par with flonicamid 50% WG + copper oxychloride 50% WP (14.31 q/ha). The next effective treatments viz., spiromesifen 22.9%SC + copper oxychloride 50% WP (13.41 q/ha), flonicamid 50% WG (13.36 q/ha), spiromesifen 22.9% SC (12.79 q/ha), (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP (11.74 q/ha), fipronil 5% SC + copper oxychloride 50% WP (11.02 q/ha), acephate 50% + imidacloprid 1.8% SP (10.93 q/ha) and fipronil 5% SC (10.91 q/ha) recorded yield in descending order and found superior over copper oxychloride 50% WP and untreated control (7.72 q/ha).

The present findings on seed cotton yield finds support in the work carried out by Nemade et al. (2017) who obtained maximum seed cotton yield (1681.02 Kg/ha) from flonicamid 50% WG @ 75 g a.i./ha followed by flonicamid 50% WG @ 100 g a.i./ha (1627.31 Kg/ha) and difenthiuron 50 WP (1222.84 Kg/ha). Similarly, Kalyan et al. (2017) they also recorded maximum seed cotton yield in difenthiuron 50 WP (3101 kg/ha) with highest net profit of Rs. 51,381/ ha. Similar results were also reported by Bontha and Mallapur (2017a) who recorded highest seed cotton per hectare in treatments of diafenthiuron 50 WP @ 0.6 g + carbendazim 50WP @ 1.0 g (19.07 q/ha) and diafenthiuron 50 WP @ 0.6 g + copper oxychloride 50WP @ 2g (18.18 q/ha)

followed by diafenthiuron 50 WP alone found to be significantly superior over rest of the treatments.

However, the earlier worker Gaurkhede et al. (2015) reported that, application of fipronil 0.015 per cent recorded highest seed cotton yield, which was closely followed by dinotefuran 0.008 per cent and flonicamid 0.02 per cent. Similarly, Zanwar et al. (2012) and Prasadarao et al. (2011) also reported maximum seed cotton yield from plots treated with fipronil 5% SC.

4.19 Incremental cost benefit ratio for different treatments

The data presented in Table 22 revealed that, treatment with flonicamid 50% WG emerged as the most economically viable treatment giving the highest ICBR of 1:4.2. It was followed by the treatment diafenthiuron 50% WP (1:3.1) and acephate 50% + Imidacloprid 1.8% SP (1:3.0). The next better treatments flonicamid 50% WG + copper oxychloride 50% WP, diafenthiuron 50% WP + copper oxychloride 50% WP, spiromesifen 22.9% SC, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, fipronil 5% SC and spiromesifen 22.9% SC + copper oxychloride 50% WP 1:2.5, 1:2.2, 1:1.7, 1:1.5, 1:1.2 and 1:1.1, respectively. The treatment with fipronil 5% SC + copper oxychloride 50% WP found to be comparatively less economical exhibiting ICBR of 1:0.4. Whereas, copper oxychloride 50% WP was found uneconomical with negative ICBR (-1:0.72) in this respect.

The present results on the cost effectiveness of different treatments against sucking pests are agreement with the results of Bontha and Mallapur (2017a) they recorded 0.91 of benefit cost ratio due to application of diafenthiuron 50 WP in combination copper oxychloride 50 WP. Whereas, Ghelani et al. (2014) reported that, acetamiprid 0.004 per cent was found most economical insecticidal treatment with C:B ratio of 1:42.59 followed by flonicamid 0.02 per effective in control of major sucking pests of *Bt* cotton with high net return and C:B ratio. Similarly, Kalyan et al. (2017) obtained maximum net profit of Rs. 51,381/ha in difenthiuron 50 WP @ 300g a.i./ha, followed by flonicamid 50 WP@ 100g a.i. (Rs.46,772) and fipronil 5 EC @ 100g a.i. ha (Rs.43,900) in the experiment on evaluation of new molecule against sucking pest of *Bt* cotton.

Table 22: Incremental cost benefit ratio for different treatments

Sr. No.	Treatments	Quantity of pesticide (ml or g/ha)	No. of sprays	Cost of pesticides Rs/ha	Labour and sprayer charges (Rs/ha)	Cost of Plant protection (Rs/ha) (A)	Yield of Seed cotton (q/ha)	Increase in yield over control (q/ha)	value of increased yield over control (Rs/ha) @ Rs 5450/ (B)	Net gain over control (c) (B-A)	ICBR	Rank
1	Fipronil 5% SC	1500	3	6624	1530	8154	10.91	3.19	17386	9254	1:1.2	VIII
2	Spiromesifen 22.9% SC	600	3	8712	1530	10242	12.79	5.07	27632	17390	1:1.7	VI
3	Flonicamid 50% WG	150	3	4410	1530	5940	13.36	5.64	30738	24798	1:4.2	I
4	Diafenthiuron 50% WP	600	3	7920	1530	9450	14.89	7.17	39077	29627	1:3.1	II
5	Acephate 50% + Imidacloprid 1.8 % SP	1000	3	2850	1530	4380	10.93	3.21	17495	13115	1:3.0	III
6	Copper oxychloride 50% WP	1875	3	4440	1530	5970	8.02	0.30	1635	-4335	- 1:0.73	XI
7	Fipronil 5% SC + Copper oxychloride 50% WP	1500+1875	3	11064	1530	12594	11.02	3.30	17985	5391	1:0.4	X
8	Spiromesifen 22.9%SC + Copper oxychloride 50% WP	600+1875	3	13152	1530	14682	13.41	5.69	31011	16329	1:1.1	IX
9	Flonicamid 50% WG + Copper oxychloride 50% WP	150+1875	3	8850	1530	10380	14.31	6.59	35916	25536	1:2.5	IV
10	Diafenthiuron 50% WP+ Copper oxychloride 50% WP	600+1875	3	12360	1530	13890	15.80	8.08	44036	30146	1:2.2	V
11	(Acephate 50% +Imidacloprid 1.8% SP) + Copper oxychloride 50% WP	1000+1875	3	7290	1530	8820	11.74	4.02	21909	13089	1:1.5	VII
12	Untreated control	-	-	-	-	-	7.72	-	-	-	-	-

1) Labour charges for one spray/ha. @ Rs. 230/ labour / day, 2) spray pump charges/ha. @ Rs. 50/ day/ pump 3) price of seed cotton @ Rs. 5450 /qtl.

Cost of insecticides: Fipronil 5% SC @ Rs. 2208/1500ml, Spiromesifen 22.9% SC @ Rs. 2904/600ml, Flonicamid 50% WG @ Rs. 1470/150g, Diafenthiuron 50% WP @ Rs. 2640/600g, Acephate 50% + Imidacloprid 1.8% SP @ Rs. 950/1000g and Copper oxychloride 50% WP @ 1480/2kg.

CHAPTER V

SUMMARY AND CONCLUSIONS

A field trial was conducted at research farm, Department of Agricultural Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, during *kharif* 2018-19. The experiment was laid out in Randomized Block Design with three replication and twelve treatments with a view to evaluate the compatibility of different pesticides against sucking pests of cotton.

The treatments included viz., fipronil 5% SC, spiromesifen 22.9% SC, flonicamid 50% WG, diafenthiuron 50% WP and acephate 50% + imidacloprid 1.8% SP alone and in combination with copper oxychloride 50% WP along with untreated control. In all three treatment sprays were applied at 15 days interval, of which first spray was initiated as soon as sucking pests incidence was noticed. The data were collected on the population of sucking pests at an interval of 3, 7, 10 and 14 days after spraying to assess the efficacy of different treatments against sucking pests. Similarly, data were also collected on the natural enemies i.e. total number of coccinellids, chrysopids and spiders. Besides, the phytotoxicity symptoms were recorded at 1, 3, 7, 10 and 14 days after each spray to assess compatibility of different pesticides on cotton crop. Finally, seed cotton yield was recorded in each of the net plots, so as to compare the effect of different treatments against sucking pests of cotton. The results of investigations are summarized in this chapter.

5.1 Efficacy of pesticides alone and in combination against cotton aphids

The minimum population of aphids at different intervals of observation were recorded from the plots treated with flonicamid 50% WG + copper oxychloride 50% WP after first spray. This treatment was found at par with flonicamid 50% WG, diafenthiuron 50% WP, diafenthiuron 50% WP + copper oxychloride 50% WP, spiromesifen 22.9% SC + copper oxychloride 50% WP and (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP. Whereas, the treatments acephate 50% + imidacloprid 1.8% SP,

spiromesifen 22.9% SC, fipronil 5% SC + copper oxychloride 50% WP were found statistically at par with fipronil 5% SC. The maximum population of aphids was recorded in copper oxychloride 50% WP treated plots which was found at par with untreated control.

Same trend of efficacy was also observed after second spray. Among the different treatments application of flonicamid 50% WG + copper oxychloride 50% WP recorded the minimum population of aphids and found at par with flonicamid 50% WG, diafenthiuron 50% WP + copper oxychloride 50% WP, diafenthiuron 50% WP, acephate 50% + imidacloprid 1.8% SP, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP and fipronil 5% SC. Nevertheless, all these treatments proved equally effective. Whereas, spiromesifen 22.9% SC, fipronil 5% SC + copper oxychloride 50% WP and spiromesifen 22.9% SC + copper oxychloride 50% WP exhibited moderate impact in this respect as against copper oxychloride 50% WP and untreated control.

The cumulative effect of two sprays of different treatments inferred that, treatments flonicamid 50% WG + copper oxychloride 50% WP, flonicamid 50% WG, diafenthiuron 50% WP, diafenthiuron 50% WP + copper oxychloride 50% WP, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, acephate 50% + imidacloprid 1.8% SP and spiromesifen 22.9% SC + copper oxychloride 50% WP proved most effective in checking the population of aphids. The application of spiromesifen 22.9% SC, fipronil 5% SC + copper oxychloride 50% WP and fipronil 5% SC exhibited better performance in this respect. Whereas, copper oxychloride 50% WP and untreated control recorded maximum aphid population.

5.2 Efficacy of pesticides alone and in combination against cotton leafhoppers

Among the different treatment tested significantly minimum number of leafhoppers was recorded in diafenthiuron 50% WP + copper oxychloride 50% WP after first spray. This treatment was found at par with diafenthiuron 50% WP, flonicamid 50% WP, flonicamid 50% WG + copper oxychloride 50% WP, spiromesifen 22.9% SC + copper oxychloride 50% WP,

spiromesifen 22.9% SC, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, acephate 50% + imidacloprid 1.8% SP, fipronil 5% SC and fipronil 5% SC + copper oxychloride 50% WP. All these treatments were found statistically equal in recording minimum population of leafhoppers as against copper oxychloride 50% WP and untreated control.

Same trend of efficacy was also observed after second spray. The treatment diafenthiuron 50% WP + copper oxychloride 50% WP proved effective with minimum number of leafhoppers. This treatment was found at par with diafenthiuron 50% WP, flonicamid 50% WG + copper oxychloride 50% WP, acephate 50% + imidacloprid 1.8% SP, flonicamid 50% WG, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP and spiromesifen 22.9% SC + copper oxychloride 50% WP. Whereas, fipronil 5% SC + copper oxychloride 50% WP, spiromesifen 22.9% SC and fipronil 5% SC appeared as next better treatments in this respect. Highest number of leafhopper population was recorded in copper oxychloride 50% WP and untreated control.

Minimum population of leafhoppers after third spray was observed in diafenthiuron 50% WP + copper oxychloride 50% WP. However, this treatment proved statistically equal with diafenthiuron 50% WP, acephate 50% + imidacloprid 1.8% SP, flonicamid 50% WG + copper oxychloride 50% WP, flonicamid 50% WG and (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50%. Whereas, Fipronil 5% SC + copper oxychloride 50% WP, spiromesifen 22.9% SC, fipronil 5% SC and spiromesifen 22.9% SC + copper oxychloride 50% WP appeared as next better treatments in this respect. Significantly highest number of leafhoppers was recorded in copper oxychloride 50% WP which was found at par with untreated control.

The cumulative effect of three sprays of different treatments inferred that, treatment diafenthiuron 50% WP + copper oxychloride 50% WP recorded minimum population of leafhoppers. However, this treatment was found statistically equal with diafenthiuron 50% WP, flonicamid 50% WG + copper oxychloride 50% WP, flonicamid 50% WG, acephate 50% + imidacloprid 1.8% SP, (acephate 50% + imidacloprid 1.8% SP) + copper

oxychloride 50% WP, spiromesifen 22.9% SC + copper oxychloride 50% WP and spiromesifen 22.9% SC. The treatments fipronil 5% SC + copper oxychloride 50% WP and fipronil 5% SC proved moderately effective in reducing the minimum population of leafhoppers. Maximum number of leafhoppers was observed in plots treated with copper oxychloride 50% WP and untreated control.

5.3 Efficacy of pesticides alone and in combination against cotton whiteflies

The treatment diafenthiuron 50% WP + copper oxychloride 50% WP recorded minimum population of whiteflies at different intervals of observation after first spray. This treatment closely followed by spiromesifen 22.9% SC, spiromesifen 22.9% SC + copper oxychloride 50% WP, diafenthiuron 50% WP, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, acephate 50% + imidacloprid 1.8% SP, flonicamid 50% WG + copper oxychloride 50% WP, flonicamid 50% WG and fipronil 5% SC + copper oxychloride 50% WP. All these treatments found equally effective. Whereas, fipronil 5% SC exhibited moderate impact in this respect as against copper oxychloride 50% WP and untreated control.

Same trend of efficacy was also observed after second spray. The plots treated with diafenthiuron 50% WP + copper oxychloride 50% WP recorded minimum whitefly population and found at par with spiromesifen 22.9% SC + copper oxychloride 50% WP, diafenthiuron 50% WP, spiromesifen 22.9% SC, flonicamid 50% WG and flonicamid 50% WG + copper oxychloride 50% WP. Whereas, acephate 50% + imidacloprid 1.8% SP, fipronil 5% SC + copper oxychloride 50% WP, fipronil 5% SC and (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP appeared as next better treatments and found at par with each other. Plots treated with copper oxychloride 50% WP and untreated control recorded maximum population of whiteflies.

After third spray, the treatments viz., diafenthiuron 50% WP + copper oxychloride 50% WP, as well as diafenthiuron 50% WP, spiromesifen 22.9% SC, spiromesifen 22.9% SC + copper oxychloride 50% WP and

flonicamid 50% WG + copper oxychloride 50% WP recorded minimum population of whiteflies. Whereas, the treatment with flonicamid 50% WG, acephate 50% + imidacloprid 1.8% SP, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, fipronil 5% SC + copper oxychloride 50% WP and fipronil 5% SC exhibited moderate impact in this respect as against copper oxychloride 50% WP and untreated control.

The cumulative effect of three sprays of different treatments indicated that the treatments with diafenthiuron 50% WP + copper oxychloride 50% WP, diafenthiuron 50% WP, spiromesifen 22.9% SC, spiromesifen 22.9% SC + copper oxychloride 50% WP, flonicamid 50% WG + copper oxychloride 50% WP and flonicamid 50% WG were the most effective treatments in recording lower population of whiteflies. Whereas, acephate 50% + imidacloprid 1.8% SP, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, fipronil 5% SC + copper oxychloride 50% WP and fipronil 5% SC appeared as next better treatments. The treatment copper oxychloride 50% WP and untreated control recorded maximum population of whiteflies.

5.4 Efficacy of pesticides alone and in combination against cotton thrips

The treatments fipronil 5% SC + copper oxychloride 50% WP, fipronil 5% SC, diafenthiuron 50% WP + copper oxychloride 50% WP, diafenthiuron 50% WP, flonicamid 50% WG and flonicamid 50% WG + copper oxychloride 50% WP appeared as the best treatments in recording minimum population of thrips after first spray. Whereas, acephate 50% + imidacloprid 1.8% SP, spiromesifen 22.9% SC, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP and spiromesifen 22.9% SC + copper oxychloride 50% WP appeared as a next effective as against copper oxychloride 50% WP and untreated control.

Minimum number of thrips were recorded from treatments viz., fipronil 5% SC, fipronil 5% SC + copper oxychloride 50% WP, diafenthiuron 50% WP, diafenthiuron 50% WP + copper oxychloride 50% WP, flonicamid 50% WG, flonicamid 50% WG + copper oxychloride 50% WP, acephate 50% + imidacloprid 1.8% SP and (acephate 50% + imidacloprid 1.8% SP) +

copper oxychloride 50% WP proved equally effective in reducing minimum thrips population after second spray. Whereas, the treatment with spiromesifen 22.9% SC and spiromesifen 22.9% SC + copper oxychloride 50% WP were found moderately effective. Maximum number of thrips were recorded in copper oxychloride 50% WP and untreated control.

Same trend of efficacy was also observed after third spray. The treatment fipronil 5% SC + copper oxychloride 50% WP recorded the minimum population of thrips. This treatment was found at par with fipronil 5% SC, diafenthiuron 50% WP, diafenthiuron 50% WP + copper oxychloride 50% WP, flonicamid 50% WG, flonicamid 50% WG + copper oxychloride 50% WP, acephate 50% + imidacloprid 1.8% SP, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, spiromesifen 22.9% SC and spiromesifen 22.9% SC + copper oxychloride 50% WP. The treatment copper oxychloride 50% WP and untreated control recorded maximum population of thrips.

The cumulative effect of three sprays of different treatments indicated that, the treatments with fipronil 5% SC + copper oxychloride 50% WP recorded minimum population of thrips. This treatment was found at par with fipronil 5% SC, diafenthiuron 50% WP + copper oxychloride 50% WP, diafenthiuron 50% WP, flonicamid 50% WG, flonicamid 50% WG + copper oxychloride 50% WP, acephate 50% + imidacloprid 1.8% SP, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP and spiromesifen 22.9% SC. However, latter treatments were also in turn at par with spiromesifen 22.9% SC + copper oxychloride 50% WP. Highest number of thrips were recorded in treatment copper oxychloride 50% WP and untreated control.

5.5 Effect of pesticides alone and in combination on population of natural enemies

The data on the cumulative effect of spraying indicated that there were no significant differences among the treatments in respect to population of natural enemies (i.e. coccinellids, chrysopids and spiders). However, numerically more number of natural enemies were observed in untreated control plot.

5.6 Phytotoxic effects of pesticides combination on cotton

All the test insecticides fipronil 5% SC, spiromesifen 22.9% SC, flonicamid 50% WG, diafenthiuron 50% WP and acephate 50% + imidacloprid 1.8% SP and their combinations with fungicide copper oxychloride 50% WP proved to be non phytotoxic on cotton crop.

5.7 Effect of pesticides alone and in combination on seed cotton yield

The result showed that, application of diafenthiuron 50% WP + copper oxychloride 50% WP was the most promising treatments in increasing seed cotton yield. This treatment was found at par with diafenthiuron 50% WP. The latter treatment was also in turn found at par with flonicamid 50% WG + copper oxychloride 50% WP. The next effective treatments viz., spiromesifen 22.9% SC + copper oxychloride 50% WP, flonicamid 50% WG, spiromesifen 22.9% SC, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, fipronil 5% SC + copper oxychloride 50% WP, acephate 50% + imidacloprid 1.8% SP and fipronil 5% SC recorded seed cotton yield in descending order and found superior over copper oxychloride 50% WP and untreated control.

5.8 ICBR

The economics of different treatment sprays indicated that application of flonicamid 50% WG proved to be the most economically viable treatment with maximum ICBR (1:4.2). While, diafenthiuron 50% WP and acephate 50% + Imidacloprid 1.8% SP emerged as the next best treatments in this respect. The other treatments viz., flonicamid 50% WG + copper oxychloride 50% WP, diafenthiuron 50% WP + copper oxychloride 50% WP, spiromesifen 22.9% SC, (acephate 50% + imidacloprid 1.8% SP) + copper oxychloride 50% WP, fipronil 5% SC, spiromesifen 22.9% SC + copper oxychloride 50% WP and fipronil 5% SC + copper oxychloride 50% WP appeared to be moderately economical.

5.9 Conclusions

Finally it is concluded that the treatment diafenthiuron 50% WP and flonicamid 50% WG proved effective in combating the menace of sucking

pest complex viz., aphids, leafhoppers, whiteflies and thrips and resulted in to highest seed cotton yield and proved economically viable with higher ICBR followed by acephate 50% + imidacloprid 1.8% SP. Whereas, all the treatments proved less detrimental in respect of predatory fauna like coccinellids, chrysopids and spiders. Moreover, compatibility of test insecticides with fungicide proved to be non phytotoxic on cotton and proved compatible.

Thus, these chemicals would be helpful in mitigating the sucking pest complex in *Bt* cotton, which is alarming in the present situation and could be included in Integrated Pest Management programme as a promising component without any negative effect on crops and natural enemies.

CHAPTER VI

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Appendix
Weekly weather data for the year 2018 recorded at Agro-meteorological observatory, Dr PDKV., Akola

Year	Week	TMAX	TMIN	RH1	RH2	WS	RF	SS	EVP
2018	1	29.5	9.4	74	23	0.8	0	7.5	3.8
2018	2	29.6	12.3	58	23	1.2	0	7.7	5.3
2018	3	31.3	12.1	68	20	1.3	0	7.9	6.4
2018	4	29.8	10	57	20	1.7	0	8.3	7.3
2018	5	32.4	10.9	58	15	1	0	8.7	6.7
2018	6	32.3	16	48	20	1.9	0	5.8	7.4
2018	7	29.9	14.9	70	35	3.9	0.7	6.1	6.6
2018	8	35.5	17.9	48	18	1.7	0	8	7.4
2018	9	37.3	18.5	40	15	1.7	0	8.1	7.6
2018	10	36.7	22.1	37	20	4	3	5.9	8.9
2018	11	34.7	20.3	56	18	2.5	0.4	4.8	7.3
2018	12	37.7	20.4	36	14	3.3	0	8.7	10.2
2018	13	41.1	20	27	7	3.2	0	9.2	11.1
2018	14	40.9	22.7	27	11	2.4	0	7.7	10.1
2018	15	40.4	24.5	45	16	2.9	0.3	8.6	10.4
2018	16	42.3	27.8	30	12	5.6	0	9.9	13.8
2018	17	42.9	26.4	28	7	3.8	0	10.1	11.7
2018	18	43.5	28.8	37	13	7.7	0	9.8	14.4
2018	19	43.7	29.3	30	11	6.3	0.5	9.4	14.9
2018	20	43.5	31.1	34	14	6.9	0	8	14.9
2018	21	44.3	31.1	41	18	8.8	0	7.6	15
2018	22	43.1	29.5	50	23	8.8	8.5	8	14.5
2018	23	37.5	25.5	73	44	10.7	72.5	4	11.2
2018	24	37.7	26.5	66	31	12.9	17.5	6.2	10.8
2018	25	36	24.6	80	49	6.5	83.1	7.2	9.5
2018	26	32.3	23.7	86	56	14.9	111	3.9	6.4
2018	27	32.7	24.3	83	61	5.9	54.8	3.8	6.3
2018	28	28.4	23.6	93	80	8.2	140.3	1	4.2
2018	29	29.9	24.1	88	71	7.3	35.1	0.6	3.2
2018	30	28	23.5	90	74	4.4	30.7	0.7	3.2
2018	31	32.2	24.2	81	56	8.1	3.2	5.8	6
2018	32	30.8	24.3	84	65	9.4	4.8	1.4	5.2
2018	33	29.4	24	89	74	8.5	97.8	1.2	4.1
2018	34	27.6	22.6	91	77	9.2	106.4	1.8	4
2018	35	28.5	23.4	88	70	6.6	1	0.1	2.9
2018	36	29.8	21.9	84	56	8.1	1	3.8	4.5
2018	37	32.6	24	81	48	2.6	0	8.6	5.6
2018	38	33.3	23.1	85	52	3.3	62.4	4.4	4.9
2018	39	33.6	22.7	85	49	0.6	0	8.5	4.5
2018	40	35.1	21.3	78	38	0.6	0	8.6	4.9
2018	41	35.4	18.6	77	29	0.8	0	8.6	5.1
2018	42	34.8	19.3	72	30	0.5	0	8.5	5.1
2018	43	35.3	17.1	68	22	0.4	0	8.9	5.2
2018	44	33.4	18.1	68	32	1.3	0	8.9	5.9
2018	45	33.6	16.5	76	28	0.5	0	7	4.2
2018	46	33.3	14	66	20	0.4	0	8.9	5
2018	47	32.8	17.2	78	34	0.6	4.5	7.8	4.8
2018	48	31	12.3	74	27	0.5	0	8	4.4
2018	49	29.8	15.9	76	41	1	0	5.2	4
2018	50	29	12.3	83	31	1.1	0	6.6	4.1
2018	51	26.5	10.2	74	34	1.1	0	7.5	4.2
2018	52	27.5	9.6	59	23	1.5	0	8.4	5