# EVALUATION OF INSECT GROWTH REGULATORS AGAINST COTTON SUCKING PESTS

**THESIS**

**Submitted to**
**Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola**
**in partial fulfilment of the requirements**
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**IN**
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**By**

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**Enrolment Number- QQ/3083 2020**

## DECLARATION OF STUDENT

I hereby declare that the experimental work and its interpretation in the thesis entitled **“EVALUATION OF INSECT GROWTH REGULATORS AGAINST COTTON SUCKING PESTS.”** or part there of 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 course of materials used and all assistance received during the course of investigation have been duly acknowledged.

Place: Akola **(KAMBLE BHAGYASHRI DATTARAO)**

Date: / /2020 Enrolment No. QQ/3083

# CERTIFICATE

This is to certify that, the thesis entitled **"EVALUATION OF INSECT GROWTH REGULATORS AGAINST COTTON SUCKING PESTS."** submitted in partial fulfilment of the requirement for the degree of "**Master of Science in Agriculture (Agricultural Entomology)"** of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is a record of bonafide research work carried out by **KAMBLE BHAGYASHRI DATTARAO** under my guidance and supervision.

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

Place: Akola
Date: / / 2020

**(Dr. S. K. Bhalkare)**
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THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE INCLUDING EXTERNAL EXAMINER (AFTER VIVA–VOCE)

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Place: Akola **(KAMBLE BHAGYASHRI DATTARAO)**

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## Table of contents

## (A) LIST OF TABLES

## (B) LIST OF FIGURES

## (B) LIST OF PLATES

## (D) ABBREVIATIONS

| | | |
|---|---|---|
| % | - | per cent |
| / | - | per |
| @ | - | At the rate |
| CD | - | Critical difference |
| cm | - | Centimetre |
| m | - | Meter |
| CV | - | Coefficient of variation |
| DAE | - | Days after emergence |
| DBS | - | Days before spraying |
| DAS | - | Days after spraying |
| et al. | - | et alia (And others) |
| etc | - | Etcetera |
| Fig. | - | Figure |
| ha | - | Hectare |
| i.e. | - | id est. (that is) |
| kg | - | kilogram |
| LBB | - | Lady bird beetle |
| mm | - | millimetre |
| No. | - | Number |
| NS | - | Non significant |
| q | - | Quintal |
| RBD | - | Randomized block design |
| SE (m)± | - | Standard error of mean |
| Sig. | - | Significant |
| *Viz.*, | - | Videlicet (Namely) |
| NSE | - | Neem Seed Extract |
| IGR’s | - | Insect Growth Regulators |

## E) THESIS ABSTRACT

| | |
|---|---|
| **a)** Title of the thesis | : **"EVALUATION OF INSECT GROWTH REGULATORS AGAINST COTTON SUCKING PESTS"** |
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## ABSTRACT

The present investigation entitled "Evaluation of Insect Growth Regulators against cotton sucking pests'' was conducted on the farm of Department of Agricultural Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *kharif* season of 2019-20. The experiment was laid in Randomized Block Design with eight treatments replicated thrice. The treatments included were, buprofezin 25% SC, pyriproxyfen 10% EC, diflubenzuron 25% WP, NSE 5%, buprofezin 25% SC + NSE 5%, pyriproxyfen 10% EC + NSE 5% and diflubenzuron 25% WP + NSE 5%

along with untreated control. Four treatment sprays were applied at 15 days interval to study the comparative efficacy of IGR's against sucking pests of cotton. The observations were recorded at an interval of 3, 7 and 14 days after spraying. Similarly, the observations on natural enemies i.e. predators like, coccinellids, chrysopids and spiders were also recorded. Seed cotton yield data was 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 buprofezin 25% SC proved effective in minimizing the aphid population. However, this treatment was found at par with pyriproxyfen 10% EC. The latter treatment in turn found statistically equal to buprofezin 25% SC + NSE 5% and pyriproxyfen 10% EC + NSE 5%. The treatment of NSE 5% was found moderately effective in this respect. Whereas, diflubenzuron 25% WP + NSE 5% and diflubenzuron 25% WP proved less effective against aphids.

Similarly, the treatment buprofezin 25% SC also recorded minimum number of leafhoppers. However, this treatment was found statistically equal with pyriproxyfen 10% EC and buprofezin 25% SC + NSE 5%. Whereas, the treatment of pyriproxyfen 10% EC + NSE 5%, NSE 5% and diflubenzuron 25% WP + NSE 5% proved moderately effective in reducing the leafhopper population. The treatment of diflubenzuron 25% WP recorded comparatively more number of leafhoppers and was found at par with untreated control.

The application of pyriproxyfen 10% EC, pyriproxyfen 10% EC + NSE 5% and buprofezin 25% SC proved statistically equal in reducing whiteflies population. The treatment buprofezin 25% SC + NSE 5% and NSE 5% were found moderately effective. These were followed by diflubenzuron 25% WP + NSE 5%. Comparatively higher number of whiteflies were recorded in diflubenzuron 25% WP found at par with untreated control.

Whereas, amongst the different treatments, buprofezin 25% SC recorded minimum number of thrips. This treatment was found at par with pyriproxyfen 10% EC, buprofezin 25% SC + NSE 5%, pyriproxyfen 10% EC + NSE 5% and NSE 5%. The treatment diflubenzuron 25% WP + NSE 5% and diflubenzuron 25 % WP appeared moderately effective in this respect.

The interventions of treatments under present investigation 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, and spiders).

All the treatments under the trial 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 buprofezin 25% SC. However, this treatment was found at par with pyriproxyfen 10% EC and buprofezin 25% SC + NSE 5%. The treatments *viz;* pyriproxyfen 10% EC + NSE 5%, NSE 5%, diflubenzuron 25% WP + NSE 5% and diflubenzuron 25% WP found statistically equal with each other in respect of seed cotton yield. Whereas, lowest yield was harvested in untreated control.

On the basis of economics the treatment buprofezin 25% SC proved as most economically viable treatment giving the highest ICBR. It was followed by the treatment NSE 5% and buprofezin 25% SC + NSE 5%.

The present findings indicated that these insect growth regulators can be suitably incorporated in an integrated pest management programme to protect the cotton crop from sucking pest complex without any negative effect on natural enemies.

## CHAPTER I

# INTRODUCTION

### 1.1 Background Information

Cotton is a major fiber crop of global significance, cultivated in more than seventy countries in the world. Cotton crop plays important role in economic, political and social affairs of the world. India remains the leading country in the world in terms of area under cotton cultivation and raw cotton production. In India it is cultivated on 122.35 lakh ha with a production of 377 lakh bales and the average productivity of cotton in India is 524 kg lint per ha (Anonymous, 2019). The India ranks first in area and second in production on global basis. Despite of the large area, the productivity in India is very low. In Maharashtra, cotton is being grown on an area of 41.91 lakh ha with a productivity of 325 kg lint per ha, with total production of 78.29 lakh bales (Anonymous, 2019).

The pests of major significance in *Bt* cotton are sucking insect pests *viz*., aphids (*Aphis gossypii,* Glover), leafhoppers (*Amrasca biguttula biguttula,* Ishida), whiteflies (*Bemisia tabaci*, Gennadius) and thrips (*Thrips tabaci,* Linnaman). Sucking pests, also referred to as "sap feeders", limit the realization of potential productivity of cotton, they are deleterious to the cotton plant growth and development by being assimilate sappers, stand reducers and light stealers. The heavy infestation of nymphs and adults of sucking pests results in leaf yellowing, wrinkled leaves, leaf distortion and oily spots on leaves. Secondly, they found to secrete honeydew which leads to growth and development of sooty mould fungus (*Capnodium* sp*.*) on leaves. The fungus inhibits the photosynthetic activity of the plants resulting into chlorosis that affect the seed cotton yield. Moreover, whitefly also acts as a vector to transmit leaf curl disease in cotton. The yield losses to the tune of 48.89 per cent have been reported in *Bt* cotton hybrids due to sucking pests damage. The avoidable losses of 33.02 per cent due to sucking pests were recorded in unprotected condition over protected condition in *Bt* cotton (Nikam et al*.,* 2017)

## 1.2 Importance and need of the study

Among the various causes of low productivity in *Bt* cotton, the incidence of insect pests is of major concern. For last few decades bollworms attack on cotton was a serious problem but with the introduction of *Bt* cotton this problem has been solved to some extent and a significant change in cropping scheme in the cotton growing areas has been observed (Ahsan & Altaf, 2009). But the problem of sucking pests attack is remained unsolved still now. These pests causes quantitative and qualitative losses to cotton. The lint quality, ginning percentage, oil content and its quality are also adversely affected. The insect pest management programme in cotton still relies on the chemical insecticides. The pest problem is aggravated more rapidly due to control failures in many cotton growing tracts in India. The indiscriminate use of insecticides has led to problems like, insecticides resistance, pest resurgence and environmental pollution besides upsetting the natural ecosystem.

Contrary to the problems associated with the use of synthetic chemicals, the advantages of Insect Growth Regulators (IGR's) make them highly desirable in integrated pest management programs. They do not persist long in the environment due to their rapid biodegradation. In addition, they exhibit low toxicity for non-target organisms (Zibaee et al*.,* 2011). The Buprofezin is an insect growth regulator that inhibits chitin synthesis in several homopteran pests, including whiteflies (De Cock et al*.,* 1990). Whereas, Pyriproxyfen is a juvenile hormone mimic affecting the hormonal balance in insects and resulting in strong suppression of embryogenesis and adult formation (Ishaaya and Horowitz, 1992). The unique mode of action of these compounds, together with their selectivity against targeted insect pests and relative safety to beneficial insects and other organisms, presents and exciting opportunity for their effective integration into pest management strategies (Darvas and Polgar, 1998). The availability of such chemical diversity enables the development of a management strategy that minimizes the threat of insecticides resistance (Denholm et al*.,* 1998).

Keeping in view the potential of the IGR’s in pest management, the present investigation was carried out on “Evaluation of insect growth regulators against cotton sucking pests” with the following objectives

**1.3 Objectives:**

1. To evaluate the efficacy of insect growth regulators alone and in combination with NSE 5% against sucking pests of *Bt* cotton.

2. To assess the effect of various treatments on natural enemies.

3. To work out the economics of different treatments.

**1.4 Scope and limitations**

*Bt* gene has given protection to cotton plant against bollworms and that to for a stipulated time. On the contrary sucking pests infestation is increasing on *Bt* cotton and needs eco-friendly management of these pests to get desirable yield of seed cotton. Many IGR’s are labelled "reduced risk" by the Environmental Protection Agency, meaning that they target juvenile harmful insects population while causing less detrimental effects to beneficial insects. Many beekeepers have reported that IGR's negatively affecting brood and young bees. Unlike classic insecticides, IGR’s do not affect an insect's nervous system and are thus more friendly to "worker insects" within closed environments. IGR’s are also more compatible with pest management systems that use biological control. In addition, while insects can become resistant to insecticides, they are less likely to become resistant to IGR’s.

**1.5 Limitations**

1. IGR’s targets specific stages of the insect life cycle and do not prevent some or all damage by targeting immature stages of the insects.

2. The belated mortality is an important psychological disadvantage; the farmer does not see dead insects immediately and consequently doubts the efficiency of the IGR’s.

3. The rapid biodegradation is one of the limitations of using IGR’s.

4. Development of new IGR’s and their approval by the competent authorities are costly, especially in relation to marketing limitation.
5. The effectiveness of IGR’s depends on timing of application.

### 1.6 Hypothesis

Application of insect growth regulators in sequence through foliar sprays are effective, economic and may prove less interfering with natural fauna. Similarly, resistance development and resurgence of pests can be prolonged by the judicious use of insect growth regulators. Keeping in view, the study was conducted to identify the most effective and economical IGR treatment for management of sucking pests on cotton.

## CHAPTER II

# REVIEW OF LITERATURE

The present investigation was conducted with an view to evaluate insect growth regulators against cotton sucking pests and to assess their effect on natural enemies. The literature collected pertaining to the objectives of the experiment is reviewed and presented below.

Ali et al. (2005) evaluated the efficacy of insecticides *viz.,* acetamiprid (625 kg/ha), diafenthiuron (625 ml/ha), imidacloprid (625 ml/ha), endosulfan (1.5 l/ha), buprofezin (1.5 kg/ha) and fenpropathrin (1.5 l/ha) against the whitefly (*Bemisia tabaci*) infesting cotton and concluded that buprofezin proved to be effective against whiteflies nymphs.

Gogi et al. (2006) evaluated the field efficacy of two insect growth regulators (IGR's) at two recommended application rates i.e. buprofezin at 370 and 555 g AI $ha^{(-1)}$ and lufenuron at 37 and 49 g AI $ha^{(-1),}$ against the *Bemisia tabaci* (Gennadius), and *Helicoverpa armigera* (Hubner) at the Directorate of Cotton Research, Faisalabad, Pakistan. The experimental finding revealed that, lower doses of both IGR's appeared safe to predator populations which did not differed significantly in IGR's treated versus untreated control plots. Application of both the IGR's significantly reduced the population of *Bemesia tabaci* at each application rate at 24, 48 and 72 h after treatment and higher doses were more effective than lower doses.

Dhananjaya et al. (2009) evaluated the efficacy of botanicals and mycopathogens in the management of mites and thrips under polyhouse condition. They observed that at 10 days after treatment spray, NSKE found effective (4.68 thrips /leaflet) followed by *verticillium lecanii* (5.80 thrips/leaflet) as against untreated control (12.00 thrips /leaflet).

Hedge et al. (2009) conducted the field experiment to evaluate the effect of newer chemicals on planthoppers and their mirid predator in rice. The result revealed that buprofezin 25 SC @ 1 ml/l recorded lowest planthopper population at 10 days after spray. Moreover, the plots treated with buprofezin also recorded significantly higher predatory mirid bug population as compared to other insecticides. The application of buprofezin 25 SC @ 1 ml/l resulted in higher yields with maximum net returns of Rs. 24970/- and 2.61 benefit cost ratio as against untreated control.

Qureshi et al. (2009) evaluated the efficacy of pyriproxyfen against whiteflies, *Bemisia tabaci* (Gennadius) in bitter melons *Momordica charantia* L. They reported that, pyriproxyfen was effective in controlling whitefly population in bitter melons as compare to the buprofezin. Further, they concluded that both pyriproxyfen and buprofezin may have the potential to increase yield and their longer-term use may increase predation by natural enemies.

Vinodhini et al. (2011) conducted field study to find out the effect of different botanical pesticides on the sucking pests of cotton, *Gossypium hirsutum*. They reported that, neem seed kernel extract (5%) was found to be effective against the sucking pests (leafhoppers and aphids) of cotton. Whereas, it was followed by *Pongamia glabra* seed kernel extract (5%) and neem oil (3%). Maximum population reduction was noticed on the 3rd day after treatment.

Bansal et al. (2012) tested the effect of diflubenzuron, a chitin-synthesis inhibitor on *Aphis glycines* survival, fecundity and body weight.  Experimental result showed that, when fed with soybean leaves previously dipped in 50 ppm diflubenzuron solution, *Aphis glycines* nymphs suffered significantly higher mortality compared to control. *Aphis glycines* nymphs feeding on diflubenzuron treated leaves showed a slightly enhanced expression (1.67fold) compared to nymphs on untreated leaves.

Borkar et al. (2012) conducted the field experiment on management of sucking pest complex with plant products in cotton ecosystem. The result revealed that, application of neem oil 1% emerged as the most effective treatment in recording the minimum population of aphids and whiteflies while, NSE 5% was observed to be most effective in recording the lowest population of leafhoppers and thrips.

Liu et al. (2012) conducted experiment to evaluate the effect of pyriproxyfen and buprofezin on the development of the immature stages of the stable fly and the effect of pyriproxyfen on oviposition and egg hatching. Experimental results showed that, both pyriproxyfen and buprofezin had significant inhibitory effects on immature development. A significant reduction in the mean number of eggs laid was observed at the highest pyriproxyfen dose (8 μg/fly). They concluded pyriproxyfen has the potential to be used as part of an integrated management programme

Meena et al. (2013) efficacy of microbial agents (*Verticillium lecanii*, *Beauveria bassiana* and *Metarhizium anisopliae* @ 5 g per litre of water), plant products (Tobacco, onion and neem seed kernel extract @ 5%), cow urine @ 50 litre/ha and dimethoate 30EC @ 300 g a.i/ha were evaluated against mustard aphid, *Lipaphis erysimi* (Kalt.) and their safety to natural enemies and pollinators. The result showed that, the per cent reduction of aphid population after 10 days of spray was maximum under dimethoate 30 EC @ 300 g a.i/ha (91.00%) followed by NSKE @ 5% (83.20%), *B. bassiana* @ 5 g per litre of water (78.00%), cow urine @ 50 litre per ha (76.33%), onion extract @ 5% (76.00%), tobacco extract @ 5% (75.40%), *V. lecanii* @ 5 g per litre of water (75.0%) and *M. anisopliae* @ 5 g per litre of water (74.0%). Most favourable cost-benefit ratio was obtained under the treatment i.e. dimethoate 30 EC @ 300 g a.i/ha (1:38) followed by neem seed kernel extract @ 5% (1:18), onion extract @ 5% (1:17), cow urine @ 50 litre/ha (1:11), *Beauveria bassiana* @ 5 g per litre of water (1:10), *Verticillium lecanii* @ 5 g per litre of water (1:10), *Metarhizium anisopliae* @ 5 g per litre of water (1:8), tobacco extract @ 5% (1:6) and water spray (1:2).

Nboyine et al. (2013) evaluated field efficacy of neem based biopesticides like neem seed kernel extract (NSKE) and neem seed oil (NSO) as an alternative for the management of insect pests of cotton in northern Ghana. The results showed that, the treatments *viz.,* NSKE 5%, NSO 2%, NSO 5% and NSKE 10% recorded 2.54, 2.61, 2.96, and 3.29 whiteflies per plant, respectively as against untreated control (6.75 /plant). The neem was non-toxic to the natural enemies. Seed cotton yield were obtained between 52.20% and 90.82% higher in the neem treated plots than the untreated control plots.

Das and Isalam (2014) evaluated the efficacy of fipronil @ 1 ml/L water, imidacloprid 70 WG @ 0.2 g/L water, buprofezin 40 SC @ 2 ml/L water and thiamethoxam + emamectin benzoate 40 WG @ 0.1 g/L water against *Amrasca devastan* and *Bemisia tabaci* on brinjal. Data were collected on 1, 3 and 7 days after treatment application. The result showed that among four, the treatment buprofezin 40 SC @ 2 ml/L water has provided the best efficacy against jassids and whiteflies which recorded 83.04% and 55.27% reduction in mean population over untreated control, respectively.

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. 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).

Karkar et al*.* (2014) evaluated the botanicals for their bio-efficacy against insect pests infesting brinjal during *summer* 2012. The result revealed that, the population of aphids, leafhoppers and whiteflies on brinjal plant after first spray was found to a minimum level i.e. 1.89, 2.27 and 2.28/leaf in NSKE 5% followed by neem oil 2.04, 2.36 and 2.37 /leaf, as against untreated control (2.69, 3.20 and 3.18 /leaf), respectively. Excellent performance of NSKE 5%, neem oil @ 0.3% were also observed in second spray. Similarly, the pooled data showed that, among the seven botanical products tested relatively less number of aphids, leafhoppers and whiteflies were recorded in NSKE 5% i.e. 1.88, 2.26 and 2.25 /leaf as against untreated control (2.60, 3.19 and 3.16 /leaf). Maximum fruit yield

(5471 kg/ha) was harvested in the treatment of NSKE followed by neem oil (4228 (kg/ha). Maximum net realization (20450/ha) with highest (1:24.06) Incremental Cost Benefit Ratio (ICBR) were registered in NSKE. With respect to net realization, the treatment of neem oil ranked next to NSKE, but failed to show higher ICBR.

Ravichandra et al. (2014) conducted the experiment on management of insect-pests of paddy by organic approaches at Agricultural Research Station, Gangavathi during *Kharif* 2011. The result revealed that, the treatment buprofezin 25% SC @ 1.0 ml/l recorded higher population of mirid bugs and spiders/hill after 7 days of spray. Moreover, buprofezin 25% SC @ 1.0 ml/l significantly differ from other organic treatments recorded higher yield of 72.88 q/ha followed by commercial neem @ 3.0 ml/l (70.22 q/ha).

Yadav and Raghuraman (2014) evaluated the bioefficacy of certain newer insecticides *viz.,* fipronil 80 WG, imidacloprid 17.8 SL, buprofezin 25 SC and acephate 75 SP along with a new combination product consisting of buprofezin (15%) and acephate (35%) WP against the shoot and fruit borer (*Leucinodes orbonalis* Guen.), sucking pest complex jassids (*Amrasca devastans* Dist.) and whitefly (*Bemisia tabaci* Genn.) on brinjal. The result revealed that, the treatment buprofezin 25 SC recorded 46.8% and 40.7% mean population reduction in case of whitefly and jassids after first spray. Application of buprofezin 25 SC recorded 15215 kg/ha yield followed by fipronil 80 WG (14560 kg/ha). The yield of brinjal fruits in untreated control was only 9754 kg/ha

Choudhary et al. (2015) evaluated the bioefficacy of pyriproxyfen 10 EC with different doses (75, 100 and 125 g a.i./ha.) against sucking insect pest of cotton. The result revealed that, all the treatments were significantly superior over control. After third spray during 2010-11 pyriproxyfen 10 EC @ 125 g a.i./ha recorded significantly lower population of aphids, leafhoppers, whiteflies and thrips i.e. 15.23, 12.53, 9.14 and 13.06 per 3 leaves, respectively. Significantly highest seed cotton yield (1331 and 1327 kg/ha) was picked by pyriproxifen 10 EC @ 125 g a.i./ha during both the years of experimentation, proving it better than commercial check acetamiprid 20 SP @ 20g a.i./ha (1225 and 1168 kg/ha) and difenthiuron 50 WP @ 300g a.i./ha (1181 and 1145 kg/ha).

Hole et al. (2015) evaluated the effect of wild plant fruit extract (hinganbet, *Balanites roxburghii*, ritthaa/soap nut, *Sapindus trifoliatus*, shikekaaee, *Acacia concinna*, Neem, *Azadirachta indica*, Karanj, *Pongamia pinnata* and vekhand, *Acorus calamus* L.) to screen their efficiency for the control of sucking pests of *Bt* cotton during *Kharif* 2009 to 2012 at Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri. The result showed that, all the organic pesticide treatments were superior over untreated control. NSE 5% @ 2 L/ha recorded 28.96, 12.61, 17.71 and 15.18 aphids, leafhopper, thrips and whiteflies per three leaves, respectively, with the seed cotton yield of 12.31 quintal per hectare. Moreover, the counts on natural enemies in the organic pesticide treatments were more or less similar to those recorded in untreated control. This clearly indicated that there was no adverse effect on natural enemies due to spraying of organic pesticide at evaluated doses.

Iqbal et al. (2015) the extracts of eight indigenous plants *viz*., tumha (*Citrullus colosynthis* L.), datura (*Datura innoxia* M.), neem (*Azadirachta indica* A.), castor (*Ricinus communis* L.), hing (*Ferula asafetida* L.), eucalyptus (*Eucalyptus* spp.) bitter gourd (*Memordica chrantia* L.) and garlic (*Allium sativum* L.) were tested for their potential insecticidal efficacy against sucking insect pests, leafhopper (*Amrasca bigutulla bigutulla* I.), whitefly (*Bemisia tabaci* G.) and thrips (*Thrips tabaci* L.) in okra. It was revealed that, neem followed by garlic significantly reduce the mean population of jassid (6.31, 6.86), whiteflies (7.41, 8.21) and thrips (11.99, 12.43), respectively. Neem also showed minimum fruit damage percentage (3.38%) followed by garlic (6.67%). The maximum yield (3178.7 kg/ha) was observed in neem treated plots. It was concluded that these plants could be the possible alternate option in insect pest management program.

Mahalakshmi et al. (2015) evaluated field efficacy of different new insecticide molecules against whiteflies and yellow mosaic virus disease in urdbean at RARS, Lam, Guntur, Andhra Pradesh for two consecutive seasons i.e. during *Rabi* 2010-11 and 2011-12. The result revealed that, among the tested insecticides spiromesifen 240 SC 0.4 ml/l followed by buprofezin 10 EC @ 1.0 ml/ l were found as the most effective treatments with more than 75 per cent mean reduction in nymphal population of whiteflies. Application of buprofezin 10 EC @ 1.0 ml/l recorded 75.41 % mean reduction in nymphal population of whiteflies with 11.05 q/ha yield in urdbean.

Nisha et al. (2015) evaluated relative toxicity of imidacloprid, acetamiprid, thiamethoxam, diflubenzuron and two horticulture mineral oil (HMO'S) *viz.,* servo and esso against the second instar nymphs of the greenhouse whitefly, *Trialeurodes vaporariorm* westwood infesting tomato under laboratory conditions. The result showed that, all the test insecticides and HMO'S caused significant and dosage dependant mortality. The $LC_{50}$ values calculated for imidacloprid, acetamiprid, thiamethoxam, diflubenzuron, esso and servo were 0.016, 0.019, 0.041, 0.067, 0.28 and 0.35 per cent, respectively. Whereas, $LC_{90}$ for these insecticides were 0.20, 0.23, 0.34, 0.53, 2.65 and 2.74 per cent, respectively. On the basis of these studies imidacloprid was found to be the most toxic insecticide followed by acetamiprid, thiamethoxam and diflubenzuron.

Sahito et al. (2015) evaluated the efficacy of some insecticides against whitefly, *Bemesia tabaci* on cotton at khairpur-sindh. The overall mean population of whiteflies was observed 9.91 per leaf in pre-treatment data collection. When sprayed with pyriproxyfen 10 EC insecticide, the post-treatment data showed 69.37%, 68.36%, 66.81%, 69.41% and 62.61% reduction in the population of whitefly after one day, second day, third day, seventh day and on twelfth day of spray, respectively. The overall reduction was 67.31±1.27% in overall sprays as compared to control (un-sprayed) plot.

Sathyan et al. (2015) evaluated different botanicals, microbials and non-insecticidal materials against leafhoppers, *Amrasca devastans* (Distant) in cotton at Agricultural College and Research Institute, Killikulam, Tuticorin District, Tamil Nadu. The result of the field study revealed that, among all the botanicals and non-insecticides used, teak leaf extract @ 5.0 % and neem seed kernel extract @ 5.0 % were found effective against the leafhoppers with mean population of 3.80 /3 leaves and 4.51 /3 leaves, respectively.

Dudhbale et al. (2016) evaluated field efficacy of chemical insecticides against whiteflies on soyabean. They reported that, whiteflies were significantly reduced in plots treated with lambda cyhalothrin 5 EC @ 300 ml/ha followed by triazophos 40 EC @ 800 ml/ha which were at par with each other and the next superior treatment was diflubenzuron 25 WP @ 400 g/ha. The highest yield was obtained from plots treated with lambda cyhalothrin 5 EC @ 300 ml/ha (2500kg/ha) followed by triazophos 40 EC @ 800 ml/ha (2451 kg/ha) and diflubenzuron 25 WP @ 400 g/ha (2400kg/ha).

Dutta et al. (2016) evaluated efficacy of four new generation insecticides along with a botanical against mustard aphid (*Lipaphis erysimi* Kalt.) and their toxicity to coccinellid beetles and foraging honeybees during 2014-15 at Agricultural Research Institute, Gazipur, Bangladesh. The result revealed that, the treatment buprofezin 40 SC showed the lowest population with 2.96 aphids/top 10 cm central twig as against 22.88 aphids/ top 10 cm (central twig) in untreated control at 3 days after spraying. Among the treatments, significantly highest population of coccinellid beetle was observed in plots treated with Azadirachtin (7.12 beetles /5 plants) which was followed by buprofezin 40 SC (5.62 beetles/ 5 plants). However, the highest yield was obtained from buprofezin 40 SC (1.57 t $ha^{-1}$) treated plot although this was statistically identical to that diafenthiuron 500SC (1.52 t $ha^{-1}$) and Azadirachtin 1EC (1.48 t $ha^{-1}$) treated plots.

Kumar and sing (2016) evaluated the efficacy of new molecule pyriproxyfen 10 EC against sucking insect pests *viz.,* whitefly, leafhoppers and thrips on cotton during *kharif* 2010 and 2011 in comparison with conventional insecticides *viz.*, thiomethoxam 25 WG. The studies revealed that, the maximum reduction (56.07%) in whitefly population was offered by pyriproxyfen 10 EC @ 1000 ml/ha in comparison of standard check thiomethoxam 25 WG @ 200 g/ha (44.46%). In case of leafhopper, the maximum reduction percentage (44.94%) was recorded in thiomethoxam and followed by pyriproxyfen 10 EC. Whereas, maximum reduction in the population of thrips (56.98%) was recorded in the plot treated with pyriproxyfen 10 EC followed by thiomethoxam (48.52%). While the maximum population of the natural enemies *viz.*, chrysopids, coccinellids and spiders were recorded in the plots treated with pyriproxyfen 10 EC as compared to tested insecticide. Moreover, the plots treated with pyriproxyfen 10 EC @ 500 ml/ha yielded highest seed cotton yield (24.58 q/ha) followed by seed cotton yield (23.55 q/ha) in the plot receiving pyriproxyfen 10 EC @ 1000 ml/ha though the differences between the two were non-significant.

Noonari et al. (2016) bio-pesticides *viz.,* Neem seed extract, Neem oil, Asafoetida (Hing) and Tobacco leaf extract were evaluated against sucking pest complex on cotton. The result showed that among all the bio-pesticides, the highest percent reduction of thrips (67.65%), leafhoppers (71.97%) and whiteflies (59.38%) was recorded in Neem seed extract followed by Neem oil (60.00%), (70.06%) and (59.78%) after 96 h. of application of pesticides, respectively. The botanical pesticides started reducing their toxicity after 96 h. However, the effective reduction of pests was recorded up to one week.

Pazhanisamy et al. (2016) evaluated the antifeedant activity and mortality effects of NSKE @ 5%, garlic + chili (kerosene extracts) @ 5% and neem leaf extract @ 5% against *Earias vittella* under the laboratory conditions. The results of *in vitro* studies showed that, the maximum antifeedant activity was recorded in neem leaf extract and neem seed kernel extract 24 hours after treatment. Whereas, highest per cent mortality was observed in neem seed kernel extract 5% followed by garlic + chili (kerosene extracts), neem leaf extract and oleander seed extract at 72 hours after the treatment. The data demonstrated that these botanicals extracts have potential for the management of *Earias vittella* on bhendi.

Shera et al. (2016) evaluated field efficacy of buprofezin 25 SC @ 625, 750 and 875 l/ha against brown planthopper (BPH) and white backed planthopper (WBPH) infesting paddy crop. The result revealed that, buprofezin 25 SC @ 750 and 825 ml/ha was found to be at par with imidacloprid 17.8 SL. The treatment with buprofezin 25 SC @ 750 and 825 ml/ha resulted in 79.02 and 82.00% reduction in WBPH at 7 days after spray, respectively. The yield increases over control was 15.27 and 16.50% in buprofezin 25 SC @ 750 and 825 ml/ha, respectively as against 15.33% in imidacloprid 17.8 SL.

Ananthi et al. (2017) conducted the field experiment to find out the effect of seed biopriming with biocontrol agents on chilli pests at TNAU, Coimbatore during *Kharif* 2013 and *Rabi* 2013. The results showed that NSKE 5% was the most effective in controlling the thrips on chilli during both the seasons of experimentation. Whereas, seeds bioprimed with *P. fluorescens* 60% for 12h and the plants sprayed with neem seed kernel extract 5% protected the population of natural enemies like spiders and Coccinellids than imidacloprid spray.

Ambarish et al. (2017) studied the bio-efficacy of new insecticide molecules against insect pests in cotton. In total three sprays were taken up at 40, 80 and 120 days after sowing using manually operated knapsack sprayer. The mean of three sprays indicated that, application of pyriproxyfen 5% EC @ 37.5 g ai/ha recorded a lower number of whiteflies, aphids, leafhoppers and thrips i.e. 0.57, 1.57, 1.69 and 3.59 per leaf, respectively.

Boda et al. (2017) evaluated the efficacy of new insecticides *viz.,* Spiromesifen 240 SC, Acetamiprid 20% SC, Trizophos 40% SP, Fipronil 45% SC, Spinosad 45% SC, Thiamethoxam 25% WG, Clothianidin 50% WDG, Fenpropathrin 30% EC and NSKE 5% sprayed at an interval of

20 days to ascertain the number of sucking pests on *Bt* cotton. Experimental findings showed that, all the treatments were found superior to untreated check. Among the treatments NSKE 5% @ 2500 ml/ha recorded 5.43 aphids/3leaves, 11.80 leafhoppers /3 leaves, 7.77 thrips /3 leaves and 15.43 whiteflies /3 leaves at 14 days of second spray.

Cremonez et al. (2017) conducted experiment on performance of reproductive system of *Dichelops melacanthus* (Hemiptera: Pentatomidae) subjected to buprofezin and pyriproxyfen for morphological analysis of ovarioles and testes. The insecticides used were buprofezin (a chitin biosynthesis inhibitor) at a sublethal concentration ($LC_{30}$ of 2.99 g/L) and pyriproxyfen (a juvenile hormone analog) at a sublethal concentration ($LC_{30}$ of 8.35 ml/L). The result revealed that, the treatment buprofezin and pyriproxyfen did not affect the adult sex ratio or female fecundity. Pyriproxyfen reduced the percentage of encloded nymphs 71.6% and buprofezin 90.6%, respectively. Morphological changes were observed in both treatments with buprofezin and pyriproxyfen. The alterations observed in female and male reproductive systems by the action of buprofezin and pyriproxyfen on the morphology of both ovarioles and testes.

Kalyan et al. (2017) evaluated the efficacy of new molecules as well as biopesticides against jassids and whiteflies of *Bt* cotton. The result revealed that, among the different treatments maximum per cent reduction in jassids and whiteflies population with a mean of 56.85; 54.54% and 55.77; 58.45 % was recorded in buprofezin 25 SC seven days after second spray during 2014 and 2015, respectively. Among biopesicides, NSKE 5% gave comparatively higher per cent reduction in population of jassids 46.86; 46.20% and whiteflies 46.85; 46.86% compare to entomopathogenic fungus. Moreover, the treatment with buprofezin 25 SC @ 250 g a.i./ha recorded maximum seed cotton yield of 2536 kg/ha with highest net profit of Rs. 35,708/ha as against untreated control (1735 kg/ha).

Khan et al. (2017) studies were carried out to compare the effect of chemical pesticides and Non pesticide Management practices on the activity of chilli pests, natural enemies during 2012-2013 and 2013-2014. The results revealed that the treatment with NSKE 5% at 2, 5, 7 & 11 WAT (weeks after transplanting) followed by 5% *Vitex* Decoction at 9 WAT recorded highest number of *Chrysoperla carnea*. Whereas, chemical pesticide practices recorded least number of natural enemies.

Khatun et al. (2017) conducted the experiment to know the effect of buprofezin 40 SC an insect growth regulator against 2$^{nd}$ instar larvae of *Spodoptera litura* (Fabricius) under laboratory conditions at three different concentrations *viz.,* 200, 400, and 600 ppm through three different application methods like direct or topical, indirect or leaf-dip and combined. The results revealed that, this growth regulator strongly arrested the growth and development of *S. litura* (Fabricius) from larval stage to adult. The treated data were recorded after adult emergence and compared with untreated control adult. The results clearly showed that, buprofezin 40 SC had significant effect on the inhibition of adult weight, wing length and width compared to control and consequence were clearly dose, time and method dependent. Whereas, the maximum (54.53%) adult weight reduction was recorded from 600 ppm of buprofezin 40 SC through combined application method which was followed by leaf-dip (46.41%) and topical application method (39.86%).

Naik et al. (2017) evaluated the impact of newer pesticides and botanicals on sucking pest management in cotton under high density planting system. The result showed that, the lowest leafhopper (3.31 /3leaves) and whitefly (2.11 /3leaves) population was recorded in the plots treated with buprofezin 25 SC. Whereas, application of NSKE 1% recorded 5 leafhoppers /3leaves and 1.14 whiteflies /3leaves. Further these insecticides were found to be ecofriendly and safe to natural enemies. The plots treated with buprofezin 25% SC recorded 0.69, 0.53, 0.30 per plant population of spiders, coccinellids and chrysopids, respectively.

Nemade et al. (2017) evaluated new molecules against sucking pests of *Bt c*otton. The data obtained revealed that buprofezin 25 SC recorded minimum population of thrips (3.13, 1.33, 0.27/3 leaves) as against untreated control (5.6, 3.53,1.00/3 leaves) during all three sprays, respectively. However, during study they observed no deleterious effect of insecticidal treatments on population of natural enemies. The seed cotton yield of 1103.55 kg/ha was obtained from buprofezin 25% SC @ 250 ml a.i./ha as against untreated control 715.28 kg/ha.

Sahito et al. (2017) conducted the experiment on comparative efficacy of novel pesticides against jassids, *Amarasca bigutulla bigutulla* (Ishida) on cotton crop by evaluating different pesticides such as acetamiprid, pyriproxyfen, difenthiuron, acephate and nitenpyram. The percent reduction of Jassids was evaluated through Henderson and Tilton formula. Oneway ANOVA was used to find significant differences. The results revealed that the pesticide pyriproxyfen was effective against *Amarasca bigutulla bigutulla* (Ishida) recorded 23.61% reduction when compared with control plot 1.83%.

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

Kumar and kumar (2018) evaluated the efficacy of newer insecticides against thrips and leafhoppers in groundnut. Experimental findings showed that the treatment buprofezin 25 EC was found most effective against leafhoppers and thrips with 50.8 and 31.7 per cent reduction, respectively over untreated check. The treatment with buprofezin also recorded highest net returns (Rs. 24140/ ha) with ICBR of 22.2

Mahalakshmi et al. (2018) evaluated the field efficacy of entomopathogenic fungi and certain new insecticide molecules against leafhoppers, *Amrasca devastans* (Distant) on *Bt* cotton at Regional Agricultural Research Station, Lam, Guntur, Andhra Pradesh for two consecutive years. The result revealed that the highest mean per cent reduction of leafhoppers was noted in buprofezin 25 SC (63.8 %) followed by NSKE 5% (49.7%). Application of buprofezin 25% SC and NSKE 5%

obtained 22.3 and 18.1 q/ha seed cotton yield, respectively as against untreated control 13.8 q/ha.

Swami et al. (2018) evaluated the bioefficacy of pyriproxyfen 10 EC (75 g a.i./ha) @ 750, 1000, 1250 ml/ha against thrips, *Thrips tabaci* and jassids, *Amrasca biguttula biguttula* (Ishida) infesting chilli crop at Horticulture Farm, Rajasthan College of Agriculture, Udaipur during *Kharif* 2016 and 2017. Among the treatments, pyriproxyfen 10 EC @ 1250 ml/ha was found most effective to reduce mean per cent population of thrips (69.56,71.51%) and jassids (72.91, 71.02%) at 14 days after first and second spray in chilli crop during *Kharif* 2016 and 2017, respectively.

Thumar et al. (2018) conducted the field experiment with a view to evaluate the bioefficacy of diafenthiuron 25% + pyriproxyfen 5% SE @ 500, 750, 1000, 1250 ml/ha, pyriproxyfen 10% EC (GSP sample) @ 1000 ml/ha and pyriproxyfen 10% EC @ 1000 ml/ha (marketed sample) against sucking insects pests of cotton during two consecutive *kharif* seasons of 2014-15 and 2015-16. The results showed that, pyriproxyfen 10% EC @ 1000 ml/ha (marketed sample) recorded lowest population of aphids, jassids, thrips and whiteflies i.e. 3.00, 3.18, 3.32 and 2.13 per leaf respectively. Moreover, the plots treated with pyriproxyfen 10% EC @ 1000 ml/ha (marketed sample) harvested highest seed cotton yield of 19.04, and 15.81 q/ha as against untreated control (12.38 & 11.03 q/ha) during both the years of experimentation, respectively.

Adhikari et al. (2019) evaluated the efficacy of new molecules against green leafhopper in rice at Central Research Farm, Orissa University of Agriculture and Technology, Bhubaneswar during *Kharif,* 2015. The result revealed that buprofezin 25 SC @ 0.20 kg a.i./ha registered highest per cent reduction in green leafhopper population (86.58%) at 50 DAT followed by imidacloprid 200 SL @ 25 g a.i./ha (83.22). Application of buprofezin 25 SC @ 1.6 ml/l also recorded highest population of spiders (0.87) after 14 days of spray.

Amjad et al. (2019) studied the impact of selected insecticides on functional response of seven spotted lady beetle, *Coccinella septempunctata* L., to melon aphid, *Aphis gossypii* Glover under laboratory conditions. In response to insecticides, all stages of *C. septempunctata* had Type II functional response. Whereas, Type III was observed for third, fourth, and adult stages in the check treatment. The result revealed that, the least handling time, high attack rate and greatest theoretical predation were found with buprofezin 25 WP in 1$^{st}$ instar (0.098 ± 1.461h, 1.179 ± 0.051h-1, 244.90), 2$^{nd}$ instar ( 0.04 ± 0.278h, 0.404 ± 0.008h-1, 600.00), 3$^{rd}$ instar (0.032 ± 0.313h, 1.182 ± 0.060h1, 750.00), 4$^{th}$instar (0.028 ± 0.14h, 2.704 ± 0.005h-1, 857.14) and adult (0.031 ± 0.159h, 1.137 ± 0.159h-1, 774.19), respectively.

Kumar and Bhattacharya (2019) tested seven insecticides *viz;* Imidacloprid 17.8% SL, Diafenthiuron 50%WP, Diflubenzuron 25%WP, Acephate 50% + Imidacloprid 1.8% SP, Lambda Cyhalothrin 5% EC, Quinalphos 25% EC and Chlorpyriphos 20% EC against groundnut aphid at Agricultural Research Farm, Visva-Bharati, Birbhum, West Bengal during summer 2016. The results of the experiment suggested that all the insecticidal treatments imposed were superior over the untreated check. Among the seven insecticides tested, treatment diflubenzuron 25% WP (300 g a.i. /ha) was found effective recorded 61.49 per cent reduction in aphid population at 10 DAS as compared to chlorpyriphos 20% EC (55.95%).

Sahar (2019) evaluated the efficacy of flonicamid 50% WG, pyriproxyfen 10% EC and buprofezin 25% SC against the field strain of cotton aphid, *Aphis gossypii* adults and their adverse impact on natural enemies tested under laboratory and field conditions. They reported that in field conditions highest mean reduction percentages of *Aphis gossypii* were achieved by pyriproxyfen 10% EC (74.03 and 69.77%) followed by buprofezin 25% SC (70.59 and 66.84%) in both seasons 2017 and 2018, respectively. In case of natural enemies the lowest mean reduction percentages of *C. undecimpuctata* was observed in pyriproxyfen 10% EC (31.95 and 26.64%) and buprofezin 25% SC (28.87 and 24.60%) in both seasons 2017 and 2018, respectively, demonstrated less toxicity to *C. undecimpuctata.*

# CHAPTER III

# MATERIAL AND METHODS

The present investigation entitled "Evaluation of Insect growth regulators against cotton sucking pests" was carried out at Research farm, Department of Agricultural Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *kharif* 2019-20. The material used and methods adopted during the course of investigation are described below.

## 3.1 Material

For conducting this experiment material like, *Bt* cotton seed (Ajeet-155) BG II, Insect growth regulators, agricultural implements, bullock pair, labours, rope, tags, marker, wooden pegs, measuring tape, polythene bags, manures and fertilizers, knapsack sprayer, weighing balance etc. were used.

## 3.2 Methods

### 3.2.1 Experimental details

| | | |
|---|---|---|
| 1. Design of experiment | : Randomized Block Design (RBD) | |
| 2. Number of treatments | : Eight (8) | |
| 3. Number of replications | : Three (3) | |
| 4. Season | : *Kharif* (2019-20) | |
| 5. Crop | : *Bt* Cotton | |
| 6. Variety | : Ajeet-155 BG II | |
| 7. Gross plot size | : 5.40 m × 5.40 m | |
| 8. Net plot size | : 3.60 m × 4.20 m | |
| 9. Spacing | : Row to Row | 90 cm |
| | : Plant to Plant | 60 cm |
| 10. Fertilizer dose | : 60:30:30 kg NPK/ha | |
| 11) Date of sowing | : 03 July 2019 | |
| 12) Date of emergence | : 08 July 2018 | |

13) Method of sowing : Dibbling

### 3.2.2 Treatment details

| Treatment No. | Treatments | Concentration (%) |
|---|---|---|
| T1 | Buprofezin 25% SC | 0.05% |
| T2 | Pyriproxyfen 10% EC | 0.02% |
| T3 | Diflubenzuron 25% WP | 0.015% |
| T4 | NSE | 5% |
| T5 | Buprofezin 25% SC + NSE | 0.05% + 5% |
| T6 | Pyriproxyfen 10% EC + NSE | 0.02% + 5% |
| T7 | Diflubenzuron 25% WP + NSE | 0.015 % + 5% |
| T8 | Untreated control | - |

### 3.2.3 Experimental site

The present investigation was conducted on the experimental farm of Department of Agriculture Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *Kharif* 2019-20. The layout of plan for the experiment is illustrated in (Fig.1).

### 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 eight treatments replicated thrice. The gross plot size was 5.40 x 5.40 $m^2$ and spacing was 90 x 60 cm.

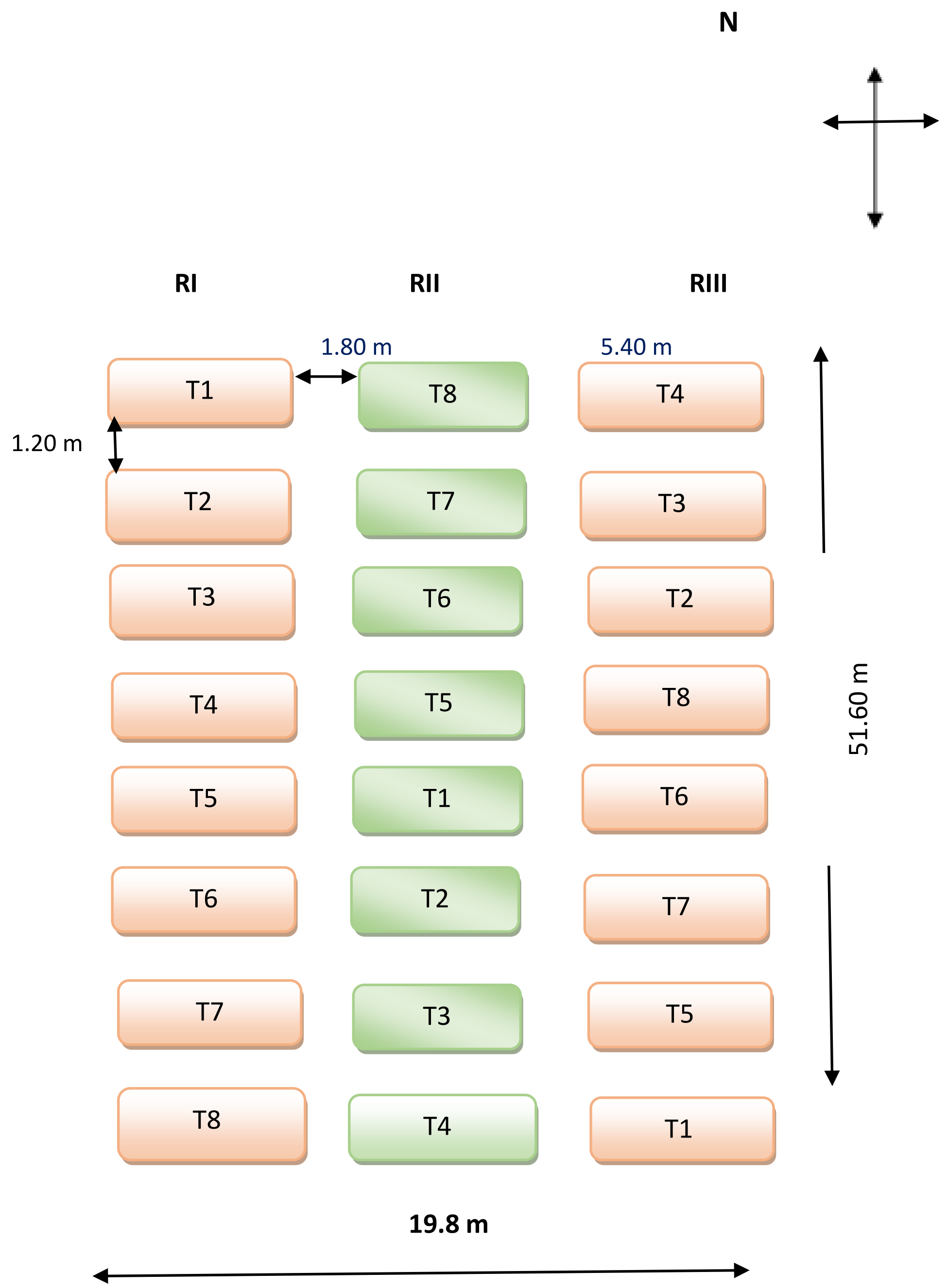


**Fig. 1 Plan of experimental layout**

**Plate 1. View of experimental plot**

#### 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 3rd July 2019 by dibbling 2 to 3 seeds 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 and thinning

Gap filling was done on 7th day after emergence and thinning operation was performed at 12th day after emergence of the crop. One healthy seedling was kept at each hill.

#### 3.2.4.5 Application of fertilizers

The recommended dose of fertilizers were applied at the rate of 60:30:30 kg of N, $P_2O_5$ and $K_2O$ 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 was undertaken with knapsack sprayer. The sprayer was thoroughly cleaned and again flushed with fresh water after each treatment spray. Care was taken to avoid the drift on surrounding plots at the time of spraying. The treatment spray was initiated at ETL of sucking pest complex. In all four sprays were undertaken at an interval of 15 days.

### 3.2.6 Neem Seed Extract (NSE)

One day before, 50 gram neem seed powder was soaked for an overnight in plastic bucket in 900 ml of water and similarly 2 gram detergent powder was also soaked in 50 ml of water for an overnight separately. Next day morning the extract was decanted through muslin cloth and homogeneous detergent solution was added to the extract. Thereafter the water was added to makeup the volume of one-liter extract.

## 3.3. Method of recording observations:

### 3.3.1 Observations on the sucking pest

Periodical observations were undertaken to record the incidence of sucking pest *viz*., aphids, leafhoppers, whiteflies and thrips from top, middle and bottom canopy of five randomly selected plants per plot to monitor the buildup of sucking pest population for effective treatment sprays. The treatment spraying was initiated at ETL of sucking pest complex. The subsequent treatment 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 and 14 days after each treatment sprays on three leaves of randomly selected five plants per plot to assess the efficacy of different treatments against sucking pests.

### 3.3.2 Observations on the natural enemies

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

### 3.4 Seed Cotton Yield

Seed cotton yield obtained at each pickings from the net plot was recorded. In all three pickings were undertaken and total yield was worked out. Yield of seed cotton in q/ha was calculated in order to compare the effect of different treatments.

### 3.5 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” was worked out based on total seed cotton yield in terms of rupees, cost of treatments, labour charges and cost of application calculated at the prevailing market rates during the period of experimentation in order to find out cost effective treatment against sucking pest of cotton.

### 3.6 Meteorological data

The weekly Meteorological data on maximum and minimum temperature, relative humidity, rainfall, rainy days and sunshine hours, during the crop season of 2019-20 recorded at Agricultural Meteorological Observatory, Dr. PDKV, Akola is presented in Appendix-I.

# CHAPTER IV

# RESULTS AND DISCUSSION

The present investigation was conducted with a view to evaluate the efficacy of different Insect Growth Regulators against major sucking pests of *Bt* cotton and to assess their effect on natural enemies. The experiment was carried out at research farm of Department of Agricultural Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *kharif* 2019-20.

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 IGR's against cotton aphids after first spray

The data on aphid population recorded a day before the first spray in different plots found statistically non-significant indicating the uniform distribution of the pest in the experimental plots. The population in the different treatment plots ranged between 12.25 to 21.78 aphids per leaf.

### 4.1.1 Three days after first spray

The data presented in Table 1 (Fig.2) pertaining to population of aphids at three days after first spray revealed that all the treatments found significantly effective over untreated control. The lowest population of aphids (3.13/leaf) was recorded in plot treated with buprofezin 25% SC which proved significantly superior over rest of the treatments. It was followed by treatment pyriproxyfen 10% EC (5.11/leaf) which was found at par with buprofezin 25% SC + NSE 5% (7.21/leaf). The latter treatment in turn found at par with NSE 5% (7.53/leaf) and pyriproxyfen 10% EC + NSE 5% (7.96/leaf). Whereas, the treatment diflubenzuron 25% WP (10.73/leaf) and diflubenzuron 25% WP + NSE 5% (11.50 aphids/leaf) proved moderately effective. The highest population of aphid was recorded in untreated control (15.91 aphids/leaf).

### 4.1.2 Seven days after first spray.

The data tabulated in Table 1 (Fig.2) revealed that all the treatments were significantly superior over untreated control in recording minimum number of aphids at seven days after first treatment spray. Among the different treatments buprofezin 25% SC recorded minimum population of aphids (3.87/leaf). It was closely followed by pyriproxyfen 10% EC with 4.61 aphids/leaf. Both these treatments found at par with each other. The latter treatment was in turn found at par with pyriproxyfen 10% EC + NSE (6.02/leaf), buprofezin 25% SC + NSE 5% (6.12/leaf). The treatment with NSE 5% proved moderately effective recorded 6.69 aphids/leaf. The treatment diflubenzuron 25% WP + NSE 5% and diflubenzuron 25% WP recorded 10.85 and 11.87 aphids/leaf, respectively and found comparatively less effective against aphids. The maximum population of aphids was recorded in untreated control (17.71/leaf).

**4.1.3 Fourteen days after first spray.**

The data pertaining to aphid population at fourteen days after first spray presented in Table 1 (Fig.2) was found statistically significant. Among the treatments buprofezin 25% SC recorded minimum aphid population i.e. 10.28 aphids/leaf. However, this treatment was found at par with pyriproxyfen 10% EC, pyriproxyfen 10% EC + NSE 5%, buprofezin 25% SC + NSE 5% and NSE 5% with population of 10.86, 12.60, 12.62 and 13.17 aphids per leaf, respectively. The treatment of diflubenzuron 25% WP + NSE 5% (15.78/leaf) and diflubenzuron 25% WP (17.67/leaf) were found at par with untreated control (18.97 aphids/leaf).

**4.1.4 Mean**

The data on mean population of aphids after first spray presented in Table 1 (Fig.2) revealed that all the treatments were significantly effective in recording minimum population of aphids as against untreated control. Amongst the various treatments, buprofezin 25% SC recorded the lowest population of aphids (5.76/leaf). This treatment was found at par with pyriproxyfen 10% EC (6.86/leaf). However, the latter treatment was in turn found statistically equal to buprofezin 25% SC + NSE 5% (8.65/leaf), pyriproxyfen 10% EC + NSE 5% (8.86/leaf) and NSE 5%

(9.13/leaf). Whereas, diflubenzuron 25% WP + NSE 5% (12.71/leaf) and diflubenzuron 25% WP (13.42/leaf) showed moderate effect against aphids. Maximum population of aphids was recorded in untreated control (17.53/leaf).

**Table 1: Efficacy of IGR's against cotton aphids after first spray**

| Sr. No | Treatments | Conc. | Number of aphids /leaf at | | | | Mean |
|---|---|---|---|---|---|---|---|
| | | | 1 DBS | 3 DAS | 7 DAS | 14 DAS | |
| 1 | Buprofezin 25% SC | 0.05% | 12.59 (3.54) | 3.13 (1.76) | 3.87 (1.96) | 10.28 (3.19) | 5.76 (2.30) |
| 2 | Pyriproxyfen 10% EC | 0.02% | 12.25 (3.50) | 5.11 (2.26) | 4.61 (2.12) | 10.86 (3.29) | 6.86 (2.56) |
| 3 | Diflubenzuron 25% WP | 0.015 % | 21.78 (4.66) | 10.73 (3.27) | 11.87 (3.44) | 17.67 (4.18) | 13.42 (3.63) |
| 4 | NSE | 5% | 13.63 (3.69) | 7.53 (2.74) | 6.69 (2.58) | 13.17 (3.61) | 9.13 (2.98) |
| 5 | Buprofezin 25% SC + NSE | 0.05 % + 5% | 13.78 (3.71) | 7.21 (2.68) | 6.12 (2.47) | 12.62 (3.55) | 8.65 (2.90) |
| 6 | Pyriproxyfen 10% EC + NSE | 0.02 % +5% | 13.20 (3.63) | 7.96 (2.82) | 6.02 (2.45) | 12.60 (3.53) | 8.86 (2.93) |
| 7 | Diflubenzuron 25% WP + NSE | 0.015 % + 5% | 16.85 (4.10) | 11.50 (3.37) | 10.85 (3.29) | 15.78 (3.97) | 12.71 (3.54) |
| 8 | Untreated control | - | 12.84 (3.58) | 15.91 (3.99) | 17.71 (4.21) | 18.97 (4.35) | 17.53 (4.18) |
| | F test | - | NS | Sig | Sig | Sig | Sig |
| | SE (m) ± | - | | 0.15 | 0.13 | 0.21 | 0.16 |
| | CD @ 5% | - | | 0.46 | 0.40 | 0.63 | 0.50 |
| | CV (%) | - | | 9.28 | 8.14 | 9.83 | 9.08 |

Note: Figures in parentheses are corresponding square root transformation value DBS- Day Before Spraying, DAS- Days After Spraying

### 4.2 Efficacy of IGR's against cotton aphids after second spray

#### 4.2.1 Three days after second spray

Data presented in Table 2 (Fig.3) pertaining to aphid population at three days after second spray revealed that the lowest

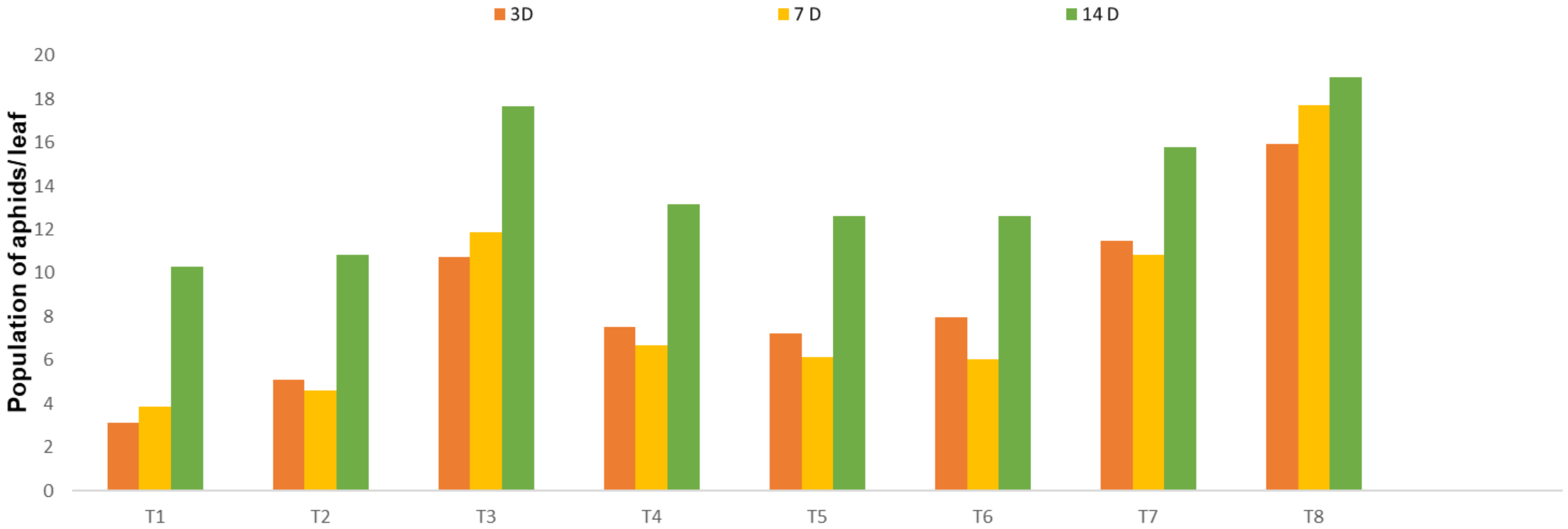


Fig. 2 Efficacy of IGR's against cotton aphids after first spray

**$T_1$: Buprofezin 25% SC** **$T_2$: Pyriproxyfen 10% EC** **$T_3$: Diflubenzuron 25% WP** **$T_4$: NSE 5%**

**$T_5$: Buprofezin 25% SC + NSE 5%** **$T_6$: Pyriproxyfen 10% EC + NSE 5%** **$T_7$: Diflubenzuron 25% WP + NSE 5%**

**$T_8$: Untreated control**

**Aphids**

**Leafhopper**

Whitefly

Thrips

**Plate 2. Sucking pests observed on cotton**

population of aphids (6.12/leaf) was recorded in plot treated with buprofezin 25% SC. The next effective treatments were pyriproxyfen 10% EC, buprofezin 25% SC + NSE 5%, pyriproxyfen 10% EC + NSE 5% and NSE 5% in which 9.67, 10.02, 11.97 and 12.43 aphids/leaf were recorded, respectively. All this treatments were found at par with each other. However, the treatment diflubenzuron 25% WP (14.67/leaf) and diflubenzuron 25% WP + NSE 5% (15.26/leaf) showed moderate efficacy against aphids. Whereas, untreated control recorded highest number of aphids (19.53/leaf).

**4.2.2 seven days after second spray**

The data on effect of different treatments against aphids at seven days after second spray (Table 2 and Fig.3) revealed that, application of buprofezin 25% SC recorded lowest population of aphids (7.86/leaf). However, this treatment was found at par with buprofezin 25% SC + NSE 5% (8.06/leaf), pyriproxyfen 10% EC (8.35/leaf) and pyriproxyfen 10% EC + NSE 5% (9.91/leaf). The treatment of NSE 5% (10.66/leaf) proved moderately effective against aphids. The next in order of efficacy were diflubenzuron 25% WP + NSE 5% (14.86/leaf) and diflubenzuron 25% WP (15.17/leaf). The maximum population of aphids was recorded in untreated control (20.86/leaf).

**4.2.3 Fourteen days after second spray**

The data on aphid population at fourteen days after second spray presented in Table 2 (Fig.3) was found statistically significant. Among the treatments buprofezin 25% SC recorded minimum aphid population i.e. 10.14/leaf. However, this treatment was found at par with buprofezin 25% SC + NSE 5%, pyriproxyfen 10% EC, pyriproxyfen 10% EC + NSE 5%, and NSE 5%, with population of 10.54, 11.21, 11.23, and 11.92 aphids per leaf, respectively. Whereas, the treatments with diflubenzuron 25% WP + NSE 5% (15.12/leaf) and diflubenzuron 25% WP (17.74/leaf) recorded relatively more number of aphids and found at par with untreated control (18.47aphids/leaf).

**4.2.4 Mean**

The data on mean population of aphids after second spray displayed in Table 2 (Fig.3) revealed that treatments *viz.,* buprofezin 25% SC (8.04/leaf), buprofezin 25% SC + NSE 5% (9.54/leaf), pyriproxyfen 10% EC (9.75/leaf) and pyriproxyfen 10% EC + NSE 5% (11.03/leaf) proved equally effective in recording minimum aphid population. The next effective treatment was NSE 5% (11.67/leaf) and diflubenzuron 25% WP + NSE 5% (15.08/leaf). Whereas, diflubenzuron 25% WP (15.86/leaf) was found statistically equal to untreated control (19.62/leaf).

**Table 2: Efficacy of IGR's against cotton aphids after second spray**

| **Sr. No** | **Treatments** | **Conc.** | **Number of aphids /leaf at** | | | **Mean** |
|---|---|---|---|---|---|---|
| | | | **3 DAS** | **7 DAS** | **14 DAS** | |
| 31 | Buprofezin 25% SC | 0.05% | 6.12 (2.47) | 7.86 (2.79) | 10.14 (3.17) | 8.04 (2.81) |
| 2 | Pyriproxyfen 10% EC | 0.02% | 9.67 (3.10) | 8.35 (2.89) | 11.23 (3.33) | 9.75 (3.11) |
| 3 | Diflubenzuron 25% WP | 0.015% | 14.67 (3.82) | 15.17 (3.89) | 17.74 (4.21) | 15.86 (3.98) |
| 4 | NSE | 5% | 12.43 (3.52) | 10.66 (3.26) | 11.92 (3.45) | 11.67 (3.41) |
| 5 | Buprofezin 25% SC + NSE | 0.05 % + 5% | 10.02 (3.15) | 8.06 (2.83) | 10.54 (3.25) | 9.54 (3.08) |
| 6 | Pyriproxyfen 10% EC + NSE | 0.02 % +5% | 11.97 (3.45) | 9.91 (3.14) | 11.21 (3.34) | 11.03 (3.31) |
| 7 | Diflubenzuron 25% WP + NSE | 0.015 % + 5% | 15.26 (3.90) | 14.86 (3.84) | 15.12 (3.87) | 15.08 (3.87) |
| 8 | Untreated control | - | 19.53 (4.42) | 20.86 (4.57) | 18.47 (4.30) | 19.62 (4.43) |
| | F test | - | Sig | Sig | Sig | Sig |
| | SE (m) ± | - | 0.16 | 0.15 | 0.18 | 0.16 |
| | CD @ 5% | - | 0.49 | 0.46 | 0.54 | 0.50 |
| | CV (%) | - | 8.15 | 10.87 | 8.67 | 9.23 |

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


**Fig. 3 Efficacy of IGR's against cotton aphids after second spray**

**$T_1$: Buprofezin 25% SC** **$T_2$: Pyriproxyfen 10% EC** **$T_3$: Diflubenzuron 25% WP** **$T_4$: NSE 5%**

**$T_5$: Buprofezin 25% SC + NSE 5%** **$T_6$: Pyriproxyfen 10% EC + NSE 5%** **$T_7$: Diflubenzuron 25% WP + NSE 5%**

**$T_8$: Untreated control**

### 4.3 Efficacy of IGR's against cotton aphids after third spray

#### 4.3.1 Three days after third spray

Among the different treatments the aphids population recorded at three days after third spray (Table 3 and Fig.4) was significantly lowest in the plots treated with buprofezin 25% SC (1.32 aphids/leaf). Next in order of efficacy were pyriproxyfen 10% EC (2.42/leaf) and buprofezin 25% SC + NSE 5% (2.70/leaf) found at par with each other. This was followed by treatment pyriproxyfen 10% EC + NSE 5% (4.23/leaf) which proved statistically equal with NSE 5% (4.95/leaf). Whereas, the treatments with diflubenzuron 25% WP + NSE 5% (6.23/leaf) and diflubenzuron 25% WP (6.23/leaf) were found at par with untreated control (6.86 aphids/leaf).

#### 4.3.2 Seven days after third spray.

The data tabulated in Table 3 (Fig.4) revealed that all the treatments except diflubenzuron 25% WP + NSE 5% (5.78/leaf) and diflubenzuron 25% WP (5.91/leaf) were found significantly superior over untreated control (6.13/leaf) in recording minimum number of aphids at seven days after third spray. Among the different treatments buprofezin 25 % SC and buprofezin 25% SC + NSE 5% recorded minimum population of aphids i.e. 1.08 and 1.84 aphids/leaf, respectively. Next in order of efficacy were pyriproxyfen 10% EC (2.13/leaf), pyriproxyfen 10% EC + NSE 5% (3.12/leaf) and NSE 5% (3.67/leaf).

#### 4.3.3 Fourteen days after third spray.

The data on aphids population at fourteen days after third spray presented in Table 3 (Fig.4) was found statistically significant. Among the treatments buprofezin 25% SC recorded lowest aphids population (0.66/leaf) proved significantly superior over rest of the treatments. The pyriproxyfen 10% EC (1.33/leaf) and buprofezin 25% SC + NSE 5% (1.91/leaf) were the next effective treatments found at par with each other. These were followed by treatment of pyriproxyfen 10% EC + NSE 5% and NSE 5% with 2.28 and 2.96 aphids/leaf, respectively found statistically equal with each other. The treatment of diflubenzuron 25% WP

+ NSE 5% (3.35/leaf) and diflubenzuron 25% WP (3.39/leaf) proved moderate effective. Whereas, the maximum population of aphids was recorded in untreated control (4.55/leaf).

**Table 3: Efficacy of IGR's against cotton aphids after third spray**

| Sr. No | Treatments | Conc. | Number of aphids /leaf at | | | Mean |
|---|---|---|---|---|---|---|
| | | | 3 DAS | 7 DAS | 14 DAS | |
| 1 | Buprofezin 25 % SC | 0.05% | 1.32 (1.10) | 1.08 (1.04) | 0.66 (0.81) | 1.02 (0.98) |
| 2 | Pyriproxyfen 10% EC | 0.02% | 2.42 (1.55) | 2.13 (1.42) | 1.33 (1.15) | 1.96 (1.37) |
| 3 | Diflubenzuron 25 % WP | 0.015% | 6.27 (2.50) | 5.91 (2.43) | 3.39 (1.81) | 5.19 (2.25) |
| 4 | NSE | 5% | 4.95 (2.22) | 3.67 (1.91) | 2.96 (1.72) | 3.86 (1.95) |
| 5 | Buprofezin 25% SC + NSE | 0.05 % + 5% | 2.70 (1.64) | 1.84 (1.36) | 1.91 (1.38) | 2.15 (1.46) |
| 6 | Pyriproxyfen 10% EC + NSE | 0.02 % +5% | 4.23 (2.05) | 3.12 (1.76) | 2.28 (1.51) | 3.21 (1.77) |
| 7 | Diflubenzuron 25% WP + NSE | 0.015 % + 5% | 6.23 (2.49) | 5.78 (2.40) | 3.35 (1.83) | 5.12 (2.24) |
| 8 | Untreated control | - | 6.86 (2.62) | 6.13 (2.47) | 4.55 (2.13) | 5.85 (2.41) |
| | F test | - | Sig | Sig | Sig | Sig |
| | SE (m) ± | - | 0.10 | 0.11 | 0.09 | 0.10 |
| | CD @ 5% | - | 0.32 | 0.35 | 0.29 | 0.32 |
| | CV (%) | - | 9.25 | 11.01 | 10.91 | 10.39 |

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

**4.3.4 Mean**

The data (Table 3 Fig.4) pertaining to mean population of aphids after third spray revealed that treatment with buprofezin 25% SC proved significantly effective with lowest number of aphids (1.02/leaf). This was followed by pyriproxyfen 10% EC (1.96/leaf) and buprofezin 25% SC + NSE 5% (2.15/leaf) which proved statistically equal with each other in recording

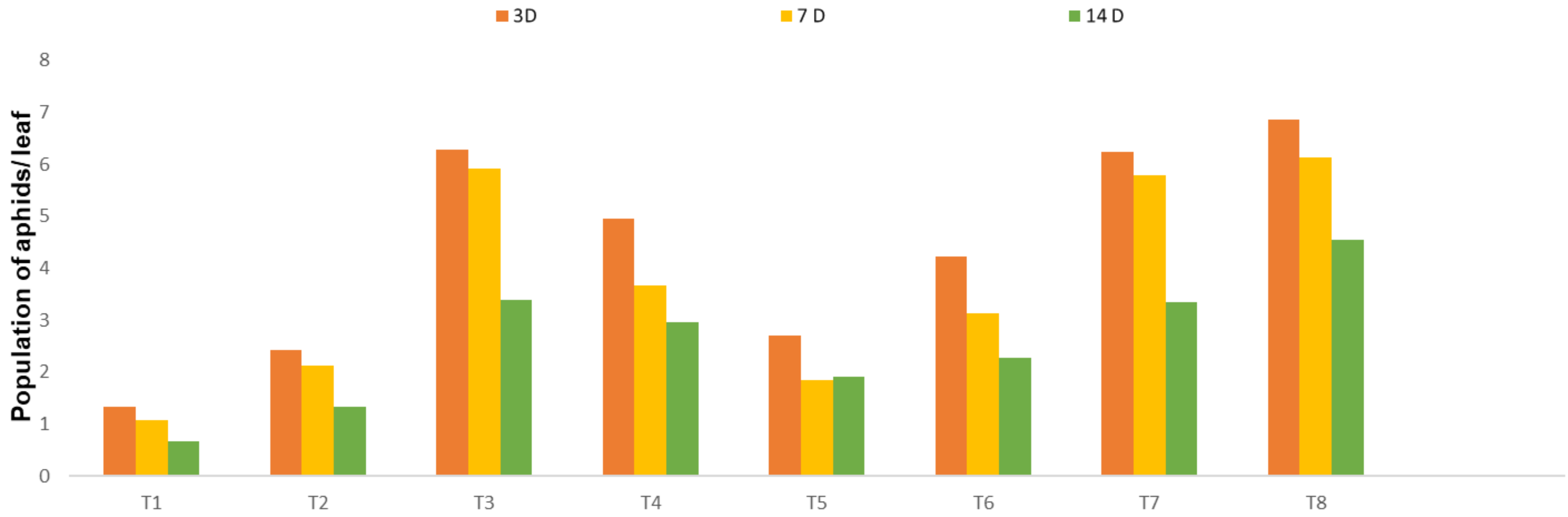


**Fig. 4 Efficacy of IGR's against cotton aphids after third spray**

**$T_1$: Buprofezin 25% SC** **$T_2$: Pyriproxyfen 10% EC** **$T_3$: Diflubenzuron 25% WP** **$T_4$: NSE 5%**

**$T_5$: Buprofezin 25% SC + NSE 5%** **$T_6$: Pyriproxyfen 10% EC + NSE 5%** **$T_7$: Diflubenzuron 25% WP + NSE 5%**

**$T_8$: Untreated control**

minimum number of aphids. Next in order of efficacy were the treatment of pyriproxyfen 10% EC + NSE 5% and NSE 5% with 3.21 and 3.86 aphids/leaf, respectively. Whereas, in plots treated with diflubenzuron 25% WP + NSE 5% (5.12/leaf) and diflubenzuron 25% WP (5.19/leaf) relatively more number of aphids were observed. Both these treatments were found at par with untreated control (5.85aphids/leaf).

### 4.4 Cumulative effect of IGR's against cotton aphids

#### 4.4.1 Three days after spray

The data displayed in Table 4 (Fig.5) pertaining to cumulative effect of IGR's against aphids at three days after spray revealed that buprofezin 25% SC proved most effective in recording the lowest population of aphids (3.52/leaf). This was followed by pyriproxyfen 10% EC (5.73/leaf) and buprofezin 25% SC + NSE 5% (6.64/leaf). Both this treatments were found at par with each other. However, the latter treatment was also in turn found statistically equal with pyriproxyfen 10% EC + NSE 5% (8.05/leaf) and NSE 5% (8.30/leaf). Whereas, the treatments with diflubenzuron 25% WP (10.55/leaf) and diflubenzuron 25% WP + NSE 5% (10.99/leaf) proved moderately effective. Highest number of aphids was recorded in untreated control plots (14.10/leaf).

#### 4.4.2 Seven days after spray

The data on cumulative effect of different treatments against aphids at seven days after spray (Table 4 and Fig.5) showed that application of buprofezin 25% SC, pyriproxyfen 10% EC and buprofezin 25% SC + NSE 5% proved statistically equal in recording minimum number of aphids i.e. 4.27, 5.03 and 5.34 per leaf, respectively. Next in order of efficacy were pyriproxyfen 10% EC + NSE 5% (6.35/leaf) and NSE 5% (7.00/leaf). Whereas, diflubenzuron 25% WP + NSE 5% (10.50/leaf) and diflubenzuron 25% WP (10.98/leaf) appeared moderate effective in this respect. Highest number of aphids was recorded in untreated control (14.56/leaf).

#### 4.4.3 Fourteen days after spray

Amongst the different treatments cumulative aphid population recorded at fourteen days after spray (Table 4 and Fig.5) was lowest in the plots treated with buprofezin 25% SC i.e.7.03 aphids/leaf. This treatment was found at par with pyriproxyfen 10% EC, buprofezin 25% SC + NSE 5% and pyriproxyfen 10% EC + NSE 5% in which 7.81, 8.36 and 8.70 aphids per leaf, were recorded respectively. This was followed by NSE 5 % with 9.35 aphids per leaf.

**Table 4: Cumulative effect of IGR's against cotton aphids**

| Sr. No | Treatments | Conc. | Number of aphids /leaf at | | | Mean |
|---|---|---|---|---|---|---|
| | | | 3 DAS | 7 DAS | 14 DAS | |
| 1 | Buprofezin 25 % SC | 0.05% | 3.52 (1.78) | 4.27 (1.93) | 7.03 (2.39) | 4.94 (2.03) |
| 2 | Pyriproxyfen 10% EC | 0.02% | 5.73 (2.30) | 5.03 (2.14) | 7.81 (2.59) | 6.19 (2.34) |
| 3 | Diflubenzuron 25 % WP | 0.015 % | 10.56 (3.20) | 10.98 (3.25) | 12.93 (3.40) | 11.49 (3.28) |
| 4 | NSE | 5% | 8.30 (2.83) | 7.00 (2.58) | 9.35 (2.93) | 8.22 (2.78) |
| 5 | Buprofezin 25% SC + NSE | 0.05 % + 5% | 6.64 (2.49) | 5.34 (2.22) | 8.36 (2.73) | 6.78 (2.48) |
| 6 | Pyriproxyfen 10% EC + NSE | 0.02 % +5% | 8.05 (2.77) | 6.35 (2.45) | 8.70 (2.79) | 7.70 (2.67) |
| 7 | Diflubenzuron 25% WP + NSE | 0.015 % + 5% | 10.99 (3.25) | 10.50 (3.18) | 11.42 (3.22) | 10.97 (3.22) |
| 8 | Untreated control | - | 14.10 (3.68) | 14.90 (3.75) | 14.00 (3.59) | 14.33 (3.67) |
| | F test | - | Sig | Sig | Sig | Sig |
| | SE (m) ± | - | 0.14 | 0.13 | 0.16 | 0.14 |
| | CD @ 5% | - | 0.42 | 0.40 | 0.49 | 0.43 |
| | CV (%) | - | 8.89 | 10.00 | 9.80 | 9.56 |

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

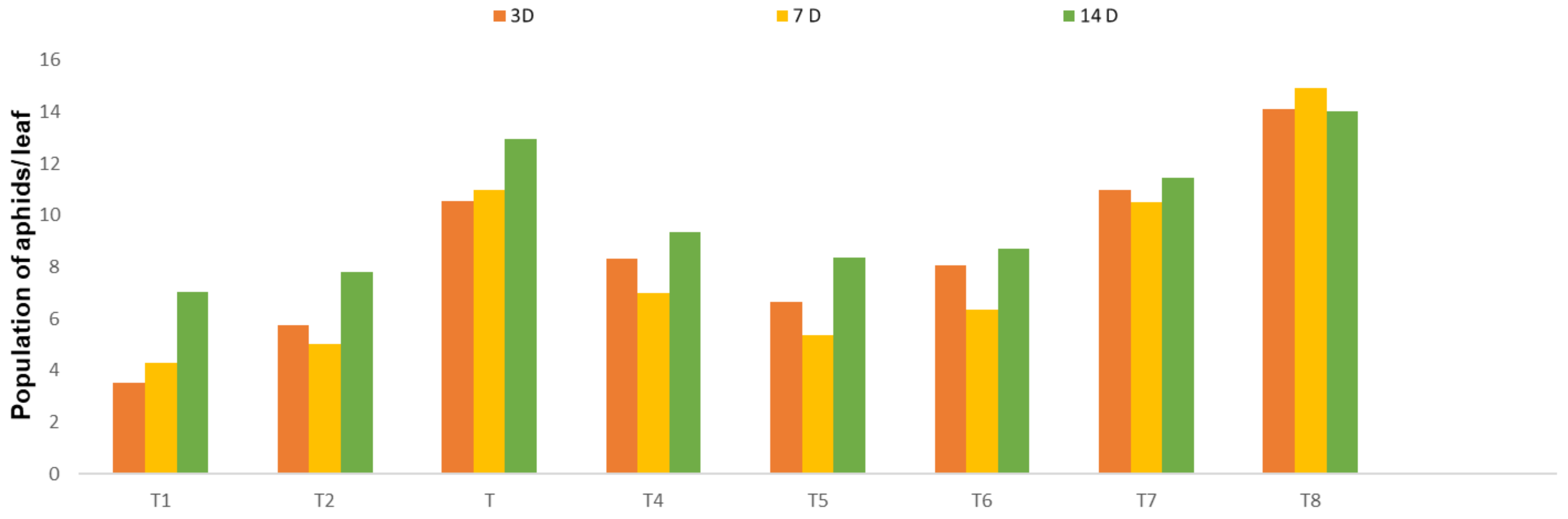

Fig. 5 Cumulative effect of IGR's against cotton aphids

**$T_1$: Buprofezin 25% SC** **$T_2$: Pyriproxyfen 10% EC** **$T_3$: Diflubenzuron 25% WP** **$T_4$: NSE 5%**

**$T_5$: Buprofezin 25% SC + NSE 5%** **$T_6$: Pyriproxyfen 10% EC + NSE 5%** **$T_7$: Diflubenzuron 25% WP + NSE 5%**

**$T_8$: Untreated control**

Whereas, diflubenzuron 25% WP + NSE 5% (11.42/leaf), diflubenzuron 25% WP (12.93/leaf) recorded relatively more number of aphids and found at par with untreated control (14.00 aphids/leaf).

**4.4.4 Mean**

It is evident from the cumulative mean data presented in Table 4 and illustrated under Fig.5 that after three sprays treatment with buprofezin 25% SC proved effective with minimum number of aphids (4.94/leaf). This treatment was followed by pyriproxyfen 10% EC (6.19/leaf). Both these treatments found at par with each other. However, the latter treatment in turn found statistically equal to buprofezin 25% SC + NSE 5% (6.78/leaf) and pyriproxyfen 10% EC + NSE 5% (7.70/leaf). The treatment of NSE 5% recorded 8.22 aphids per leaf. Whereas, the diflubenzuron 25% WP + NSE 5% (10.97/leaf) and diflubenzuron 25% WP (11.49/leaf) proved less effective against aphids. However, both this treatment were found at par with untreated control (14.33/leaf).

The present findings pertaining to effectiveness of IGR'S against aphids are in agreement with studies of Sahar (2019) evaluated the effectiveness of insecticides against cotton aphid, *Aphis Gossypii*. They reported that, the highest mean per cent reduction of *Aphis gossypii* were achieved by pyriproxyfen 10% EC (74.03 and 69.77%) followed by buprofezin 25% SC (70.59 and 66.84%) during 2017 and 2018, respectively. Whereas, Dutta *et al.* (2016) reported that, at 3 days after spraying, buprofezin 40 SC showed the lowest population with 2.96 mustard aphids /top 10 cm central twig as against 22.88 aphids/ top 10 cm (central twig) in untreated control. Moreover, Thumar *et al.* (2018) conducted the field experiment and reported that, among the different insecticides evaluated against cotton sucking pests pyriproxyfen 10% EC @ 1000 ml/ha (marketed sample) treated plots recorded lowest aphid population (3.00/leaf). Similarly, Choudhary *et al.* (2015) evaluated the bioefficacy of pyriproxyfen 10 EC with different doses (75, 100 and 125 g a.i./ha.) against sucking pests of cotton. They found that, all the treatments were significantly superior over control. They further reported that after third spray during 2010-11 pyriproxyfen @ 125 g a.i./ha recorded significantly lower population of aphids (15.23/ 3 leaves). Whereas, Kumar *et al.* (2019) studied the efficacy of seven insecticides against aphids (*Aphis craccivora*) infesting groundnut (*Arachis hypogaea*). The results of the experiment suggested that, among the different treatments, spraying of diflubenzuron 25% WP @ 300 g a.i./ha resulted in 61.49 % reduction in aphid population at 10 DAS.

The present findings regarding efficacy of NSKE 5% are in accordance with the results of earlier worker Karkar *et al.* (2014) reported that among the seven botanical products evaluated, the spray of neem seed kernel extract @ 5% was found effective against sucking pests (aphid, leaf hopper and whiteflies) of brinjal. However, they noticed that population of aphids on brinjal plant after first spray was found to at minimum level (1.89/leaf) in NSKE 5% treated plots as against untreated control (2.69/leaf). Similarly, Meena *et al.* (2013) assessed the field efficacy of microbial agents and plant products against mustard aphids. The result showed the highest mean per cent reduction of aphids (83.20%) in NSKE @ 5% over untreated control. The earlier worker Hole *et al.* (2015) noticed that, the application of NSE 5% @ 2 litre per hectare proved effective against cotton aphids.

**4.5. Efficacy of IGR's against cotton leafhoppers after first spray.**

The data on leafhopper population recorded a day before the first spray in different plots found statistically non-significant indicating the uniform distribution of the pest in the experimental plots. The population in the different treatment plots ranged between 1.12 to 1.52 leafhoppers per leaf.

**4.5.1 Three days after first spray**

The data tabulated in Table 5 (Fig.6) revealed that all the treatments except diflubenzuron 25% WP + NSE 5% (1.35/leaf) and diflubenzuron 25% WP (1.41/leaf) were significantly effective over untreated control (1.42/leaf) in reducing population of leafhoppers at three days after first spray. The treatment with buprofezin 25% SC recorded the lowest population of leafhoppers (0.54/leaf). However, this treatment was found at par with pyriproxyfen 10% EC (0.67/leaf). The latter treatment in turn found statistically equal to buprofezin 25% SC + NSE 5% (0.89/leaf), pyriproxyfen 10% EC + NSE 5% (0.93/leaf) and NSE 5% (0.95/leaf).

### 4.5.2 seven days after first spray

The data displayed in Table 5 (Fig.6) pertaining to leafhopper population at seven days after first spray was found statistically significant. Among the different treatments imposed buprofezin 25% SC, pyriproxyfen 10% EC and buprofezin 25% SC + NSE 5% proved statistically equal in recording minimum population of leafhoppers i.e. 0.48, 0.60 and 0.71 per leaf, respectively. The latter two treatments in turn also found at par with pyriproxyfen 10% EC + NSE 5% (0.75/leaf) and NSE 5 % (0.77/leaf). Whereas, diflubenzuron 25% WP + NSE 5% (1.25/leaf) and diflubenzuron 25% WP (1.52/leaf) proved less effective against leafhoppers and found at par with untreated control (1.57 leaf hoppers/leaf).

### 4.5.3 Fourteen days after first spray

Among the different treatments, population of leafhoppers recorded at fourteen days after first spray (Table 5 and Fig.6) was minimum in the plots treated with buprofezin 25% SC (0.92 leafhopper /leaf) However, this treatment was found statistically equal with pyriproxyfen 10% EC (1.02/leaf), buprofezin 25% SC + NSE 5% (1.13/leaf), NSE 5% (1.18/leaf) and pyriproxyfen 10% EC + NSE 5% (1.19/leaf). Whereas, treatment of diflubenzuron 25% WP + NSE 5% (1.54/leaf) and diflubenzuron 25% WP (1.63/leaf) proved less effective and found at par with untreated control (1.88 leafhoppers /leaf).

### 4.5.4 Mean

The data depicted in Table 5 (Fig.6) regarding mean population of leafhoppers after first spray was significant. Amongst the treatments buprofezin 25% SC (0.65 leafhoppers /leaf), pyriproxyfen 10% EC (0.76 leafhoppers /leaf), buprofezin 25% SC + NSE 5% (0.91 leafhoppers /leaf) found statistically equal in recording minimum population of leafhoppers. The next effective treatments were pyriproxyfen 10% EC +

NSE 5% and NSE 5% with 0.96 and 0.97 leafhoppers per leaf, respectively found at par with each other. However, diflubenzuron 25% WP + NSE 5% (1.38/leaf) and diflubenzuron 25% WP (1.52/leaf) recorded comparatively higher number of leafhoppers were found at par with untreated control (1.62/leaf)

### 4.6. Efficacy of IGR's against cotton leafhoppers after second spray

#### 4.6.1 Three days after second spray

The data pertaining to efficacy of IGR's against leafhoppers at three days after second spray presented in Table 6 (Fig.7) revealed that lowest population of leafhoppers (0.76 /leaf) was recorded in plots treated with buprofezin 25% SC. However, this treatment was found at par with pyriproxyfen 10% EC (0.96/leaf) and buprofezin 25% SC + NSE 5% (1.03/leaf). The next treatments in order of efficacy were pyriproxyfen 10% EC + NSE 5%, NSE 5% and diflubenzuron 25% WP + NSE 5% in which population ranged between 1.09 to 1.28 leafhoppers/leaf. The highest population of leaf hoppers was observed in diflubenzuron 25% WP (1.69/leaf) which was found at par with untreated control (1.91/leaf).

#### 4.6.2 Seven days after second spray

Among the different treatments the leafhopper population recorded at seven days after second spray (Table 6 and Fig.7) was minimum in the plots treated with buprofezin 25% SC + NSE 5% SC (0.76 leafhoppers/leaf). This treatment was found statistically equal with buprofezin 25% SC (0.81/leaf) and pyriproxyfen 10% EC (1.03/leaf). The next effective treatment pyriproxyfen 10% EC + NSE 5% (1.40/leaf) was found at par with NSE 5% (1.42/leaf). This was followed by diflubenzuron 25% WP + NSE 5% (1.84/leaf) which proved moderately effective against leafhoppers. Whereas, diflubenzuron 25 % WP (2.08/leaf) found at par with untreated control (2.36/leaf).

#### 4.6.3 Fourteen days after second spray

The data on the efficacy of various treatments against leafhoppers at fourteen days after second spray (Table 6 and Fig.7) revealed that the treatment with buprofezin 25% SC recorded minimum population of leafhoppers (1.34/leaf). This treatment was followed by pyriproxyfen 10% EC (1.50/leaf) and buprofezin 25% SC + NSE 5% (1.76/leaf). However, all these treatments were found at par with each other. The treatment with pyriproxyfen 10% EC + NSE 5%, NSE 5% and diflubenzuron 25% WP + NSE 5% recorded 1.97, 2.15 and 2.25 leafhoppers per leaf and proved moderately effective.

**Table 5: Efficacy of IGR's against cotton leafhoppers after first spray**

| Sr. No. | Treatments | Conc. | Number of leafhoppers /leaf at | | | | Mean |
|---|---|---|---|---|---|---|---|
| | | | 1DBS | 3 DAS | 7 DAS | 14 DAS | |
| 1 | Buprofezin 25% SC | 0.05% | 1.12 (1.06) | 0.54 (0.73) | 0.48 (0.69) | 0.92 (0.95) | 0.65 (0.79) |
| 2 | Pyriproxyfen 10% EC | 0.02% | 1.23 (1.11) | 0.67 (0.82) | 0.60 (0.77) | 1.02 (1.00) | 0.76 (0.86) |
| 3 | Diflubenzuron 25 % WP | 0.015 % | 1.31 (1.14) | 1.41 (1.18) | 1.52 (1.23) | 1.63 (1.27) | 1.52 (1.23) |
| 4 | NSE | 5% | 1.87 (1.37) | 0.95 (0.97) | 0.77 (0.88) | 1.18 (1.08) | 0.97 (0.98) |
| 5 | Buprofezin 25% SC + NSE | 0.05 % + 5% | 1.19 (1.09) | 0.89 (0.94) | 0.71 (0.84) | 1.13 (1.06) | 0.91 (0.95) |
| 6 | Pyriproxyfen 10% EC + NSE | 0.02 % +5% | 0.96 (0.98) | 0.93 (0.96) | 0.75 (0.87) | 1.19 (1.09) | 0.96 (0.97) |
| 7 | Diflubenzuron 25% WP + NSE | 0.015 % + 5% | 1.52 (1.23) | 1.35 (1.16) | 1.25 (1.11) | 1.54 (1.24) | 1.38 (1.17) |
| 8 | Untreated control | - | 1.34 (1.16) | 1.42 (1.19) | 1.57 (1.25) | 1.88 (1.37) | 1.62 (1.27) |
| | F test | - | NS | Sig | Sig | Sig | Sig |
| | SE (m) ± | - | | 0.05 | 0.05 | 0.05 | 0.05 |
| | CD @ 5% | - | | 0.18 | 0.15 | 0.16 | 0.16 |
| | CV (%) | - | | 10.12 | 8.80 | 8.25 | 9.05 |

Note: Figures in parentheses are corresponding square root transformation value, DBS- Day Before Spraying, DAS- Days After Spraying

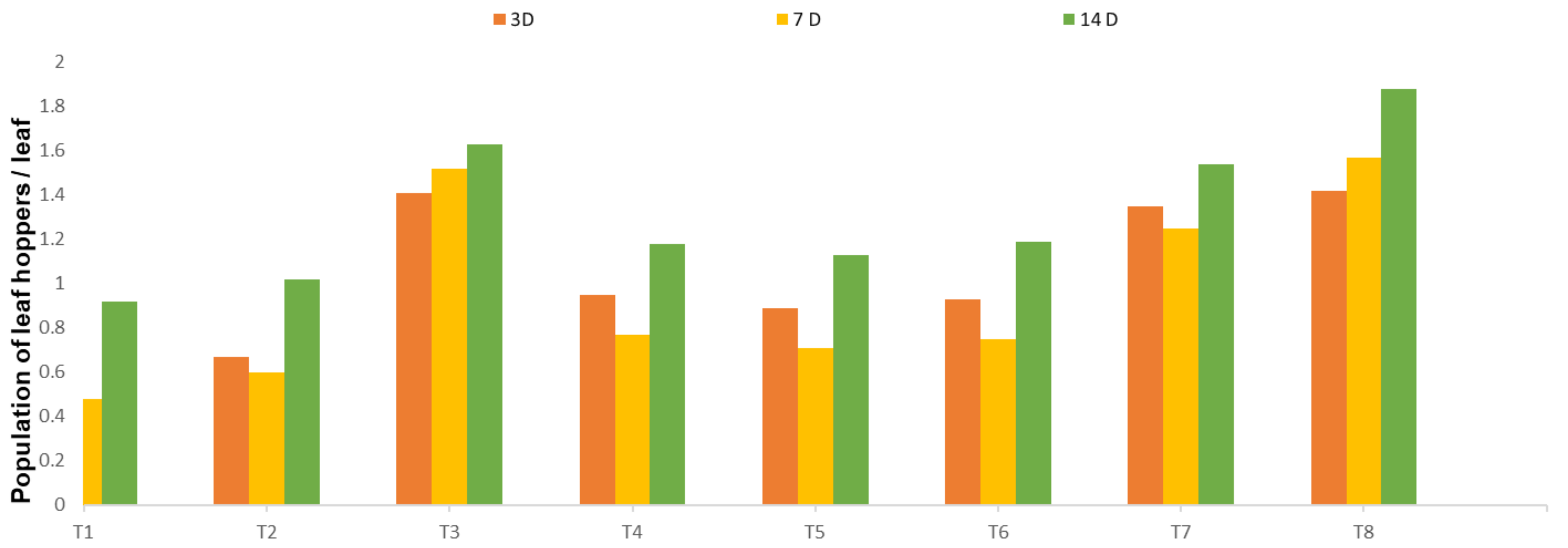


**Fig. 6 Efficacy of IGR's against cotton leafhoppers after first spray**

**T1: Buprofezin 25% SC** **T2: Pyriproxyfen 10% EC** **T3: Diflubenzuron 25% WP** **T4: NSE 5%**

**T5: Buprofezin 25% SC + NSE 5%** **T6: Pyriproxyfen 10% EC + NSE 5%** **T7: Diflubenzuron 25% WP + NSE 5%**

**T8: Untreated control**

However, diflubenzuron 25% WP recorded comparatively highest number of leafhoppers (2.93/leaf) and found at par with untreated control (3.10/leaf).

### 4.6.4 Mean

It is evident from the mean data presented in Table 6 and illustrated under Fig.7 that after second spray treatment with buprofezin 25% SC proved effective with minimum number of leafhoppers (0.97/leaf). However, this treatment was found at par with pyriproxyfen 10% EC (1.16/leaf) and buprofezin 25% SC + NSE 5% (1.18/leaf). These were followed by pyriproxyfen 10% EC + NSE 5% (1.49/leaf), NSE 5% (1.58/leaf) and diflubenzuron 25% WP + NSE 5% (1.79/leaf). These treatments were found at par with each other. The treatment with diflubenzuron 25% WP (2.23/leaf) proved less effective and found statistically equal to untreated control (2.45/leaf).

## 4.7 Efficacy of IGR's against cotton leafhoppers after third spray.

### 4.7.1 Three days after third spray

The leafhopper population recorded at three days after third spray presented in Table 7 (Fig.8) revealed that all the treatments found significantly effective in reducing the leafhoppers as against untreated control. Among the treatments, buprofezin 25% SC recorded minimum leafhoppers (0.73/leaf) and found statistically equal to pyriproxyfen 10% EC (0.84/leaf) and pyriproxyfen 10% EC + NSE 5% (0.98/leaf). The remaining treatments showed their efficacy in descending order i.e. NSE, buprofezin 25% SC + NSE 5%, diflubenzuron 25% WP + NSE 5% and diflubenzuron 25% WP with 1.12, 1.18, 1.21 and 1.53 leafhoppers per leaf, respectively. The highest number of leafhoppers was recorded in untreated control (2.56/leaf).

### 4.7.2 Seven days after third spray

The Table 7 (Fig.8) pertaining to leafhopper population recorded at seven days after third spray showed that the minimum number of leafhoppers were observed in plots treated with buprofezin 25% SC

(0.87/leaf). However, this treatment was found at par with NSE 5% (0.87/leaf), pyriproxyfen 10% EC (0.91/leaf), buprofezin 25% SC + NSE 5% (0.93/leaf), pyriproxyfen 10% EC + NSE 5 % (1.08/leaf) and diflubenzuron 25% WP + NSE 5% (1.09/leaf). Whereas, diflubenzuron 25% WP was found moderately effective recorded 1.37 leafhoppers per leaf. Maximum leafhopper population was recorded in untreated control (2.61/leaf).

**Table 6: Efficacy of IGR's against cotton leafhoppers after second spray**

| Sr. No | Treatments | Conc. | Number of leafhoppers /leaf at | | | Mean |
|---|---|---|---|---|---|---|
| | | | 3 DAS | 7 DAS | 14 DAS | |
| 1 | Buprofezin 25% SC | 0.05% | 0.76 (0.87) | 0.81 (0.90) | 1.34 (1.16) | 0.97 (0.98) |
| 2 | Pyriproxyfen 10% EC | 0.02% | 0.96 (0.98) | 1.03 (1.01) | 1.50 (1.22) | 1.16 (1.07) |
| 3 | Diflubenzuron 25 % WP | 0.015 % | 1.69 (1.29) | 2.08 (1.44) | 2.93 (1.71) | 2.23 (1.48) |
| 4 | NSE | 5% | 1.17 (1.08) | 1.42 (1.19) | 2.15 (1.46) | 1.58 (1.24) |
| 5 | Buprofezin 25% SC + NSE | 0.05 % + 5% | 1.03 (1.01) | 0.76 (0.87) | 1.76 (1.32) | 1.18 (1.07) |
| 6 | Pyriproxyfen 10% EC + NSE | 0.02 % +5% | 1.09 (1.04) | 1.40 (1.18) | 1.97 (1.40) | 1.49 (1.21) |
| 7 | Diflubenzuron 25% WP + NSE | 0.015 % + 5% | 1.28 (1.12) | 1.84 (1.35) | 2.25 (1.50) | 1.79 (1.32) |
| 8 | Untreated control | - | 1.91 (1.38) | 2.36 (1.54) | 3.10 (1.76) | 2.45 (1.56) |
| | F test | - | Sig | Sig | Sig | Sig |
| | SE (m) ± | - | 0.05 | 0.05 | 0.06 | 0.05 |
| | CD @ 5% | - | 0.16 | 0.15 | 0.19 | 0.16 |
| | CV (%) | - | 8.61 | 7.38 | 7.89 | 7.96 |

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

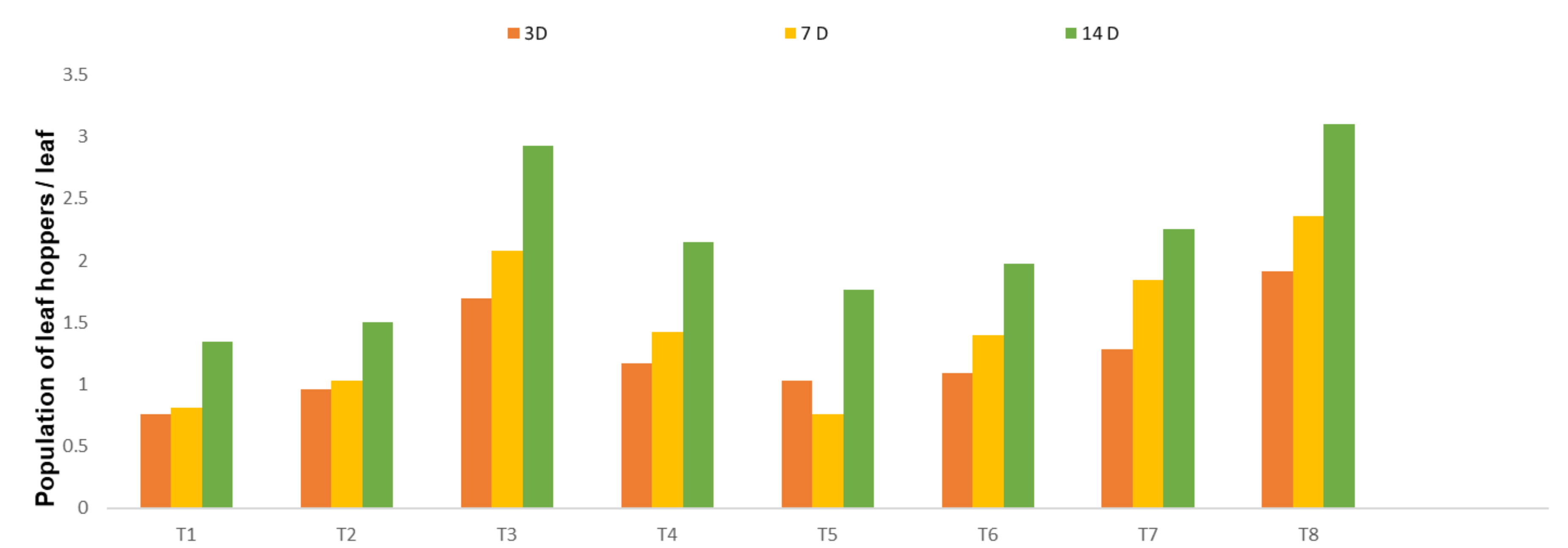


**Fig. 7 Efficacy of IGR's against cotton leafhoppers after second spray**

**$T_1$: Buprofezin 25% SC** **$T_2$: Pyriproxyfen 10% EC** **$T_3$: Diflubenzuron 25% WP** **$T_4$: NSE 5%**

**$T_5$: Buprofezin 25% SC + NSE 5%** **$T_6$: Pyriproxyfen 10% EC + NSE 5%** **$T_7$: Diflubenzuron 25% WP + NSE 5%**

**$T_8$: Untreated control**

### 4.7.3 Fourteen days after third spray

The data on efficacy of different treatments against leafhoppers at fourteen days after third spray (Table 7 and Fig.8) revealed that application of buprofezin 25% SC recorded minimum number of leafhoppers (1.23/leaf). This was followed by pyriproxyfen 10% EC (1.37/leaf) and buprofezin 25% SC + NSE 5% (1.47/leaf).

**Table 7: Efficacy of IGR's against cotton leafhoppers after third spray**

| Sr. No | Treatments | Conc. | Number of leafhoppers /leaf at | | | Mean |
|---|---|---|---|---|---|---|
| | | | 3 DAS | 7 DAS | 14 DAS | |
| 1 | Buprofezin 25% SC | 0.05% | 0.73 (0.85) | 0.87 (0.93) | 1.23 (1.11) | 0.94 (0.97) |
| 2 | Pyriproxyfen 10% EC | 0.02% | 0.84 (0.92) | 0.91 (0.95) | 1.37 (1.15) | 1.04 (1.01) |
| 3 | Diflubenzuron 25% WP | 0.015 % | 1.53 (1.24) | 1.37 (1.17) | 2.12 (1.45) | 1.67 (1.29) |
| 4 | NSE | 5% | 1.12 (1.05) | 0.87 (0.93) | 1.97 (1.40) | 1.32 (1.13) |
| 5 | Buprofezin 25% SC + NSE | 0.05 % + 5% | 1.18 (1.09) | 0.93 (0.96) | 1.47 (1.21) | 1.19 (1.09) |
| 6 | Pyriproxyfen 10% EC + NSE | 0.02 % +5% | 0.98 (0.99) | 1.08 (1.03) | 1.73 (1.31) | 1.26 (1.11) |
| 7 | Diflubenzuron 25% WP + NSE | 0.015 % + 5% | 1.21 (1.10) | 1.09 (1.04) | 1.87 (1.37) | 1.39 (1.17) |
| 8 | Untreated control | - | 2.56 (1.60) | 2.61 (1.61) | 2.92 (1.71) | 2.70 (1.64) |
| | F test | - | Sig | Sig | Sig | Sig |
| | SE (m) ± | - | 0.05 | 0.05 | 0.06 | 0.06 |
| | CD @ 5% | - | 0.17 | 0.18 | 0.19 | 0.18 |
| | CV (%) | - | 8.67 | 9.49 | 8.22 | 8.79 |

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

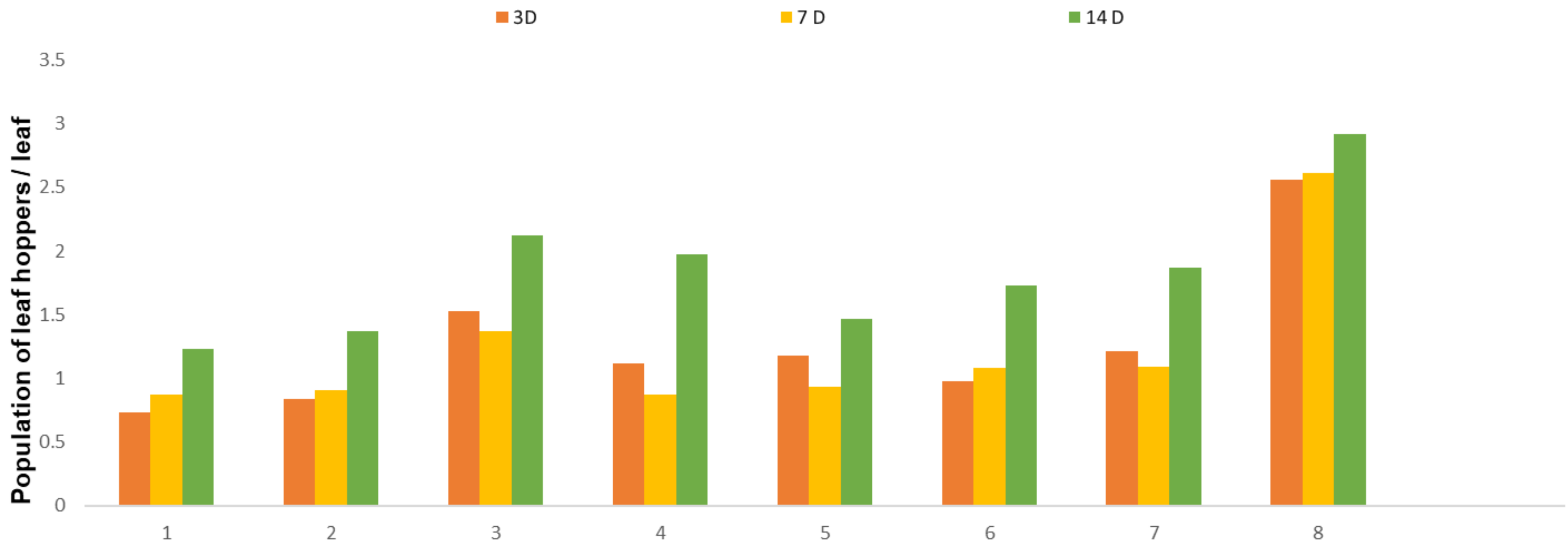


**Fig. 8 Efficacy of IGR's against cotton leafhoppers after third spray**

**$T_1$: Buprofezin 25% SC** **$T_2$: Pyriproxyfen 10% EC** **$T_3$: Diflubenzuron 25% WP** **$T_4$: NSE 5%**

**$T_5$: Buprofezin 25% SC + NSE 5%** **$T_6$: Pyriproxyfen 10% EC + NSE 5%** **$T_7$: Diflubenzuron 25% WP + NSE 5%**

**$T_8$: Untreated control**

However, all this treatments were found at par with each other. The next in order of efficacy were the treatment of pyriproxyfen 10% EC + NSE 5% (1.73/leaf), diflubenzuron 25% WP + NSE 5% (1.87/leaf), NSE 5% (1.97/leaf) and diflubenzuron 25% WP (2.12/leaf). Whereas, untreated control recorded highest number of leafhoppers i.e. 2.92 leafhoppers/leaf.

### 4.7.4 Mean

The data on mean population of leafhoppers after third spray (Table 7 and Fig.8) revealed that all the treatments were significantly superior over untreated control. Among the various treatments, buprofezin 25% SC recorded lowest leafhopper population (0.94/leaf). However, this treatment was found statistically equal with pyriproxyfen 10% EC (1.04/leaf), buprofezin 25% SC + NSE 5% (1.19/leaf), pyriproxyfen 10% EC + NSE 5% (1.26/leaf) and NSE 5% (1.32/leaf). The treatment diflubenzuron 25% WP + NSE 5% (1.39/leaf) and diflubenzuron 25% WP (1.67/leaf) proved moderately effective against leafhoppers. Significantly highest number of leafhoppers was recorded in untreated control (2.70/leaf).

## 4.8 Efficacy of IGR's against cotton leafhoppers after fourth spray

### 4.8.1 Three days after fourth spray

The data presented in Table 8 (Fig.9) pertaining to population of leafhoppers at three days after fourth spray was found statistically significant. The minimum number of leafhoppers (1.08/leaf) was recorded in plot treated with buprofezin 25% SC. However, this treatment was found at par with pyriproxyfen 10% EC, buprofezin 25% SC + NSE 5%, pyriproxyfen 10% EC + NSE 5% and NSE 5% with 1.17, 1.33, 1.38 and 1.52 leafhoppers/leaf, respectively. Whereas, the treatment of diflubenzuron 25% WP + NSE 5% recorded 2 leafhoppers per leaf proved moderately effective. The plots treated with diflubenzuron 25% WP recorded comparatively more number of leafhoppers (2.87/leaf) found at par with untreated control (3.03/leaf).

### 4.8.2 Seven days after fourth spray.

The data tabulated in Table 8 (Fig.9) revealed that at seven days after fourth spray the treatment buprofezin 25% SC recorded minimum leafhoppers (1.13/leaf). However, this treatment was found statistically equal to pyriproxyfen 10% EC (1.22) and buprofezin 25% SC + NSE 5% (1.38/leaf).

**Table 8: Efficacy of IGR's against cotton leafhoppers after fourth spray**

| Sr. No | Treatments | Conc. | Number of leafhoppers /leaf at | | | Mean |
|---|---|---|---|---|---|---|
| | | | 3 DAS | 7 DAS | 14 DAS | |
| 1 | Buprofezin 25% SC | 0.05% | 1.08 (1.04) | 1.13 (1.06) | 1.37 (1.17) | 1.19 (1.09) |
| 2 | Pyriproxyfen 10% EC | 0.02% | 1.17 (1.08) | 1.22 (1.10) | 1.41 (1.19) | 1.27 (1.12) |
| 3 | Diflubenzuron 25% WP | 0.015 % | 2.87 (1.69) | 2.75 (1.66) | 2.97 (1.72) | 2.86 (1.69) |
| 4 | NSE | 5% | 1.52 (1.23) | 1.83 (1.34) | 2.16 (1.47) | 1.84 (1.35) |
| 5 | Buprofezin 25% SC + NSE | 0.05 % + 5% | 1.33 (1.15) | 1.38 (1.17) | 1.94 (1.38) | 1.55 (1.23) |
| 6 | Pyriproxyfen 10% EC + NSE | 0.02 % +5% | 1.38 (1.17) | 1.64 (1.27) | 2.01 (1.42) | 1.68 (1.29) |
| 7 | Diflubenzuron 25% WP + NSE | 0.015 % + 5% | 2.00 (1.41) | 2.15 (1.47) | 2.85 (1.68) | 2.33 (1.52) |
| 8 | Untreated control | - | 3.03 (1.74) | 3.17 (1.78) | 3.21 (1.79) | 3.14 (1.77) |
| | F test | - | Sig | Sig | Sig | Sig |
| | SE (m) ± | - | 0.06 | 0.06 | 0.07 | 0.06 |
| | CD @ 5% | - | 0.19 | 0.20 | 0.21 | 0.20 |
| | CV (%) | - | 8.33 | 8.41 | 8.48 | 8.41 |

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

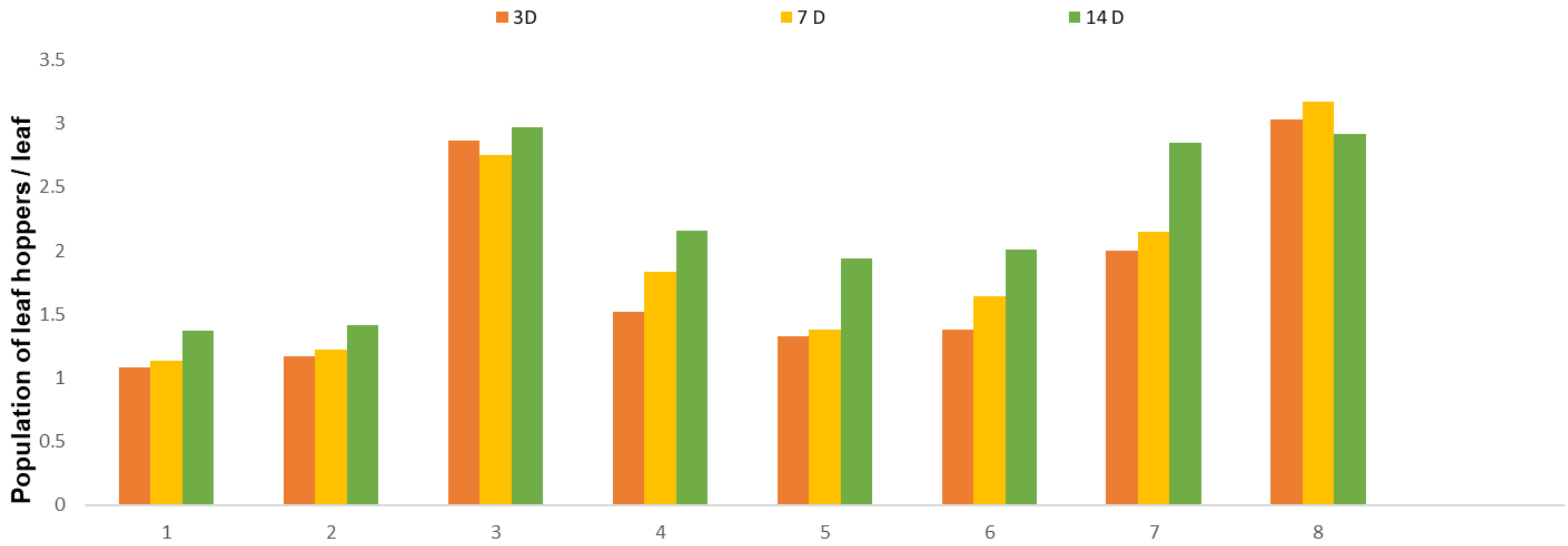

Fig. 9 Efficacy of IGR's against cotton leafhoppers after fourth spray

**$T_1$: Buprofezin 25% SC** **$T_2$: Pyriproxyfen 10% EC** **$T_3$: Diflubenzuron 25% WP** **$T_4$: NSE 5%**

**$T_5$: Buprofezin 25% SC + NSE 5%** **$T_6$: Pyriproxyfen 10% EC + NSE 5%** **$T_7$: Diflubenzuron 25% WP + NSE 5%**

**$T_8$: Untreated control**

The next effective treatments were pyriproxyfen 10% EC + NSE 5% (1.64/leaf), NSE (1.83/leaf) and diflubenzuron 25% WP + NSE 5% (2.15/leaf). All these treatments were found at par with each other. The maximum population of leafhoppers was recorded in diflubenzuron 25% WP (2.75/leaf) found statistically equal to untreated control (3.17/leaf).

#### 4.8.3 Fourteen days after fourth spray.

The data on leafhopper population recorded at fourteen days after fourth spray presented in Table 8 (Fig.9) was found statistically significant. Among the treatments buprofezin 25% SC recorded minimum leafhopper population i.e. 1.37 hoppers/leaf. This treatment was followed by pyriproxyfen 10% EC (1.41/leaf) and buprofezin 25% SC + NSE 5% (1.94/leaf). However, all these treatments were found at par with each other. Latter treatment was in turn found at par with pyriproxyfen 10% EC + NSE 5% (2.01/leaf) and NSE 5% (2.16/leaf). Whereas, the diflubenzuron 25% WP + NSE 5% and diflubenzuron 25% WP recorded comparatively more number of leafhoppers i.e., 2.85 and 2.97 leafhoppers/leaf, respectively and found at par with untreated control (3.21/leaf).

#### 4.8.4 Mean

The data on mean population of leafhoppers after fourth spray (Table 8 and Fig.9) was found statistically significant. Amongst the treatments imposed minimum number of leafhoppers were observed in plots treated with buprofezin 25% SC (1.19 leafhoppers /leaf). However, this treatment was found statistically equal to pyriproxyfen 10% EC (1.27/leaf), buprofezin 25% SC + NSE 5% (1.55/leaf) and pyriproxyfen 10% EC + NSE 5% (1.68/leaf). The treatment of NSE 5% (1.84/leaf) and diflubenzuron 25% WP + NSE (2.33/leaf) proved moderately effective in this respect. Whereas, the maximum population of leafhoppers was recorded in diflubenzuron 25% WP (2.86/leaf) which was found statistically equal with untreated control (3.13/leaf).

### 4.9 Cumulative effect of IGR’s against cotton leafhoppers

#### 4.9.1 Three days after spray

The data depicted in Table 9 (Fig.10) regarding cumulative effect of IGR's at three days after spray on the population of leafhoppers revealed that treatment with buprofezin 25% SC, pyriproxyfen 10% EC and pyriproxyfen 10% EC + NSE 5% recorded 0.78, 0.91 and 1.09 leafhoppers per leaf and proved statistically equal with each other. Whereas, buprofezin 25% SC + NSE 5% (1.11/leaf), NSE 5% (1.19/leaf) and diflubenzuron 25% WP + NSE 5% (1.46/leaf) showed moderate effect in this respect. The highest number of leafhoppers were recorded in diflubenzuron 25% WP (1.87/leaf) which was found at par with untreated control (2.23/leaf).

### 4.9.2 Seven days after spray

The cumulative data at seven days after spray presented in Table 9 (Fig.10) found statistically significant. However, minimum number of leafhoppers were recorded in the plots treated with buprofezin 25% SC, pyriproxyfen 10% EC and buprofezin 25% SC + NSE 5% i.e. 0.82, 0.94 and 0.94 leafhoppers/leaf, respectively. However, all these treatments were found at par with each other. The next effective treatments in order of efficacy were pyriproxyfen 10% EC + NSE 5% (1.22/leaf), NSE 5% (1.22/leaf) and diflubenzuron 25% WP + NSE 5% (1.58/leaf) which proved statistically equal to each other. The treatment of diflubenzuron 25% WP found comparatively less effective recorded 1.93 leafhoppers/leaf and was at par with untreated control (2.43/leaf).

### 4.9.3 Fourteen days after spray

The cumulative data pertaining to leafhopper population recorded at fourteen days after each spray (Table 9 and Fig.10) was found statistically significant. Among the treatments the lowest leafhoppers were observed in the plots treated with buprofezin 25% SC (1.22/leaf). However, this treatment was found at par with pyriproxyfen 10% EC (1.33/leaf) and buprofezin 25% SC + NSE 5% (1.57/leaf). These were followed by pyriproxyfen 10% EC + NSE 5% (1.72/leaf), NSE 5 % (1.86/leaf) and diflubenzuron 25% WP + NSE 5% (2.13/leaf). Whereas, diflubenzuron 25% WP recorded 2.41 leafhoppers /leaf and found at par with untreated control (2.78 leafhoppers /leaf).

### 4.9.4 Mean

The cumulative mean data (Table 9 and Fig.10) of four sprays regarding the population of leafhoppers revealed that buprofezin 25% SC recorded minimum number of leafhoppers (0.94/leaf). However, this treatment was found statistically equal with pyriproxyfen 10% EC (1.06/leaf) and buprofezin 25% SC + NSE 5% (1.21/leaf).

**Table 9: Cumulative effect of IGR's against cotton leafhoppers**

| Sr. No | Treatments | Conc. | Number of leafhoppers /leaf at | | | Mean |
|---|---|---|---|---|---|---|
| | | | 3 DAS | 7 DAS | 14 DAS | |
| 1 | Buprofezin 25% SC | 0.05% | 0.78 (0.87) | 0.82 (0.90) | 1.22 (1.10) | 0.94 (0.96) |
| 2 | Pyriproxyfen 10% EC | 0.02% | 0.91 (0.95) | 0.94 (0.96) | 1.33 (1.14) | 1.06 (1.02) |
| 3 | Diflubenzuron 25% WP | 0.015 % | 1.87 (1.35) | 1.93 (1.38) | 2.41 (1.54) | 2.07 (1.42) |
| 4 | NSE | 5% | 1.19 (1.08) | 1.22 (1.09) | 1.86 (1.35) | 1.42 (1.17) |
| 5 | Buprofezin 25% SC + NSE | 0.05 % + 5% | 1.11 (1.05) | 0.94 (0.96) | 1.57 (1.24) | 1.21 (1.08) |
| 6 | Pyriproxyfen 10% EC + NSE | 0.02 % +5% | 1.09 (1.04) | 1.22 (1.09) | 1.72 (1.30) | 1.34 (1.14) |
| 7 | Diflubenzuron 25% WP + NSE | 0.015 % + 5% | 1.46 (1.20) | 1.58 (1.24) | 2.13 (1.45) | 1.72 (1.30) |
| 8 | Untreated control | - | 2.23 (1.48) | 2.43 (1.54) | 2.78 (1.66) | 2.48 (1.56) |
| | F test | - | Sig | Sig | Sig | Sig |
| | SE (m) ± | - | 0.05 | 0.05 | 0.06 | 0.05 |
| | CD @ 5% | - | 0.17 | 0.17 | 0.19 | 0.18 |
| | CV (%) | - | 8.93 | 8.52 | 8.21 | 8.55 |

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

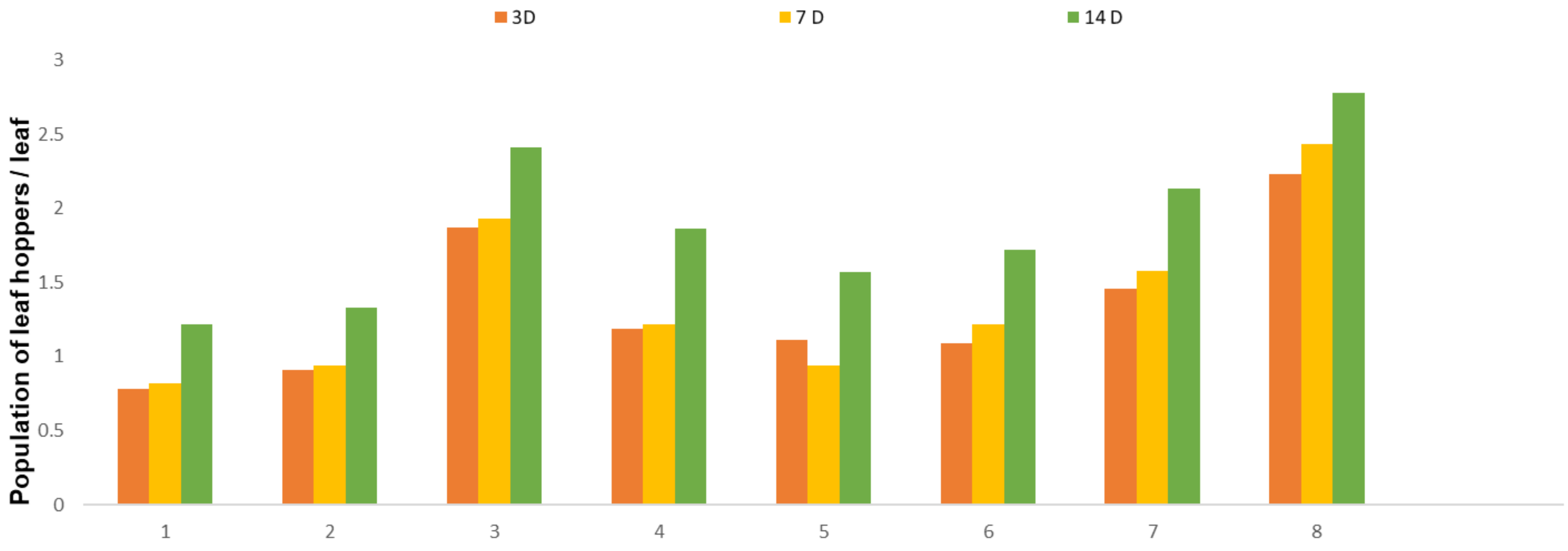

Fig. 10 Cumulative effect of IGR's against cotton leafhoppers

**$T_1$: Buprofezin 25% SC** **$T_2$: Pyriproxyfen 10% EC** **$T_3$: Diflubenzuron 25% WP** **$T_4$: NSE 5%**

**$T_5$: Buprofezin 25% SC + NSE 5%** **$T_6$: Pyriproxyfen 10% EC + NSE 5%** **$T_7$: Diflubenzuron 25% WP + NSE 5%**

**$T_8$: Untreated control**

The treatment of pyriproxyfen 10% EC + NSE 5% (1.34/leaf), NSE 5% (1.42/leaf) and diflubenzuron 25% WP + NSE 5% (1.72/leaf) proved moderately effective in reducing the leafhopper population. However, all these treatments were found at par with each other. The treatment of diflubenzuron 25% WP recorded comparatively more number of leafhoppers (2.07/leaf) and was found at par with untreated control which recorded maximum population of leafhoppers (2.48/leaf).

The present findings regarding effectiveness of buprofezin against leafhoppers finds support in the research carried out by earlier workers like Adhikari et al*.* (2019) who reported the highest reduction (86.58%) of green leafhopper population in paddy by application of buprofezin 25 SC @ 0.20 kg a.i./ha. Similarly, Kalyan et al. (2017) evaluated the efficacy of new molecules and reported that the maximum per cent reduction in cotton jassids i.e. 56.85 and 54.54% was recorded in buperofezin 25 SC during the two years of experimentation, respectively. Further they reported that in NSE 5% treated plots 46.86 and 46.20 per cent reduction of jassids was recorded, respectively. Similar findings were also reported by Naik et al. (2017) evaluated the efficacy of different insecticides and biopesticides against cotton insect pests. The result showed that, the lowest leafhopper population was recorded in the buprofezin 25 SC with 3.31/3leaves. Whereas, NSKE treated plots recorded 5 leafhoppers/ 3 leaves. Similarly, Hedge et al. (2009) studied the efficacy of buprofezin 25 SC at different concentrations against rice planthoppers (Brown planthopper and white backed planthopper). The results clearly indicated that, buprofezin 25 SC @ 1 ml/l recorded the lowest planthopper population at 10 days after spray. Das et al. (2014) evaluated the efficacy of different insecticides and reported that among the treatments, buprofezin 40 SC @ 2 ml/l provided the best efficacy with 83.04% reduction in jassids population over untreated control in brinjal. Similar results were also obtained by Halappa and patil (2014) with buprofeizin 25 EC (1ml/l) against cotton leafhopper.

Moreover, Swami et al. (2018) reported the highest per cent reduction in the population of jassids, *Amrasca biguttula biguttula* (Ishida) infesting chilli crop in case of two spray of pyriproxyfen 10% EC @ 1250 ml/ha during *Kharif*, 2016 and 2017. The earlier workers Ambarish et al. (2017) studied the bio-efficacy of new insecticide molecules against insect pests of cotton. The result of the field trial showed that, pyriproxyfen 5% EC exhibited additive action, recorded lowest population of leafhoppers i.e,1.69 per leaf. Whereas, Choudhary et al. (2015) evaluate the efficacy of pyriproxyfen 10 EC with different doses against sucking pests of cotton. They found that, application of pyriproxyfen @ 125 g a.i./ha recorded significantly lower population of leafhopper i.e.12.53/3 leaves after third spray during 2010-11.

### 4.10 Efficacy of IGR's against cotton whiteflies after first spray

The data on whiteflies population recorded a day before the first spray in different plots found statistically non-significant indicating the uniform distribution of the pest in the experimental plots. The population in the different treatment plots ranged from 1.03 to 1.53 whiteflies per leaf.

#### 4.10.1 Three days after first spray

The data presented in Table 10 (Fig.11) pertaining to population of whiteflies at three days after first spray revealed that all the treatments found significantly superior over untreated control. The lowest population of whiteflies was recorded in plots treated with pyriproxyfen 10% EC (0.47/leaf). However, this treatment was found at par with buprofezin 25% SC (0.59/leaf) and pyriproxyfen 10% EC + NSE 5% (0.61/leaf). The latter two treatments in turn found at par with buprofezin 25% SC + NSE 5% (0.67/leaf) and NSE 5% (0.71/leaf). Whereas, the treatments *viz.,* diflubenzuron 25% WP + NSE 5% (0.91/leaf) and diflubenzuron 25% WP (1.10/leaf) proved moderately effective in this respect. However, both these treatments were found at par with each other. The highest population of whiteflies were observed in untreated control plots (1.43/leaf).

#### 4.10.2 seven days after first spray

The data on population of whiteflies seven days after first spray tabulated in Table 10 (Fig.11) found statistically significant. Among the treatments pyriproxyfen 10% EC recorded minimum number of whiteflies (0.49/leaf). However, this treatment was found statistically equal to buprofezin 25% SC, pyriproxyfen 10% EC + NSE 5% and buprofezin 25% SC + NSE 5% in which the population of whiteflies ranged between 0.51 to 0.69 per leaf.

**Table 10: Efficacy of IGR's against cotton whiteflies after first spray**

| Sr. No | Treatments | Conc. | Number of whiteflies /leaf at | | | | Mean |
|---|---|---|---|---|---|---|---|
| | | | 1 DBS | 3 DAS | 7 DAS | 14 DAS | |
| 1 | Buprofezin 25% SC | 0.05% | 1.28 (1.13) | 0.59 (0.76) | 0.51 (0.71) | 0.95 (0.97) | 0.68 (0.81) |
| 2 | Pyriproxyfen 10% EC | 0.02% | 1.16 (1.08) | 0.47 (0.68) | 0.49 (0.70) | 0.91 (0.95) | 0.62 (0.78) |
| 3 | Diflubenzuron 25% WP | 0.015 % | 1.26 (1.12) | 1.10 (1.05) | 1.41 (1.19) | 1.84 (1.35) | 1.45 (1.20) |
| 4 | NSE | 5% | 1.47 (1.21) | 0.71 (0.84) | 0.87 (0.93) | 1.30 (1.14) | 0.96 (0.97) |
| 5 | Buprofezin 25% SC + NSE | 0.05 % + 5% | 1.53 (1.24) | 0.67 (0.82) | 0.69 (0.83) | 0.97 (0.98) | 0.78 (0.88) |
| 6 | Pyriproxyfen 10% EC + NSE | 0.02 % +5% | 1.03 (1.01) | 0.61 (0.78) | 0.53 (0.72) | 0.93 (0.96) | 0.69 (0.82) |
| 7 | Diflubenzuron 25% WP + NSE | 0.015 % + 5% | 1.18 (1.09) | 0.91 (0.95) | 1.19 (1.09) | 1.46 (1.20) | 1.19 (1.08) |
| 8 | Untreated control | - | 1.31 (1.14) | 1.43 (1.19) | 1.48 (1.22) | 1.98 (1.41) | 1.63 (1.27) |
| | F test | - | NS | Sig | Sig | Sig | Sig |
| | SE (m) ± | - | | 0.04 | 0.04 | 0.05 | 0.04 |
| | CD @ 5% | - | | 0.13 | 0.13 | 0.14 | 0.13 |
| | CV (%) | - | | 8.42 | 8.34 | 7.95 | 8.24 |

Note: Figures in parentheses are corresponding square root transformation value DBS- Day Before Spraying, DAS- Days After Spraying

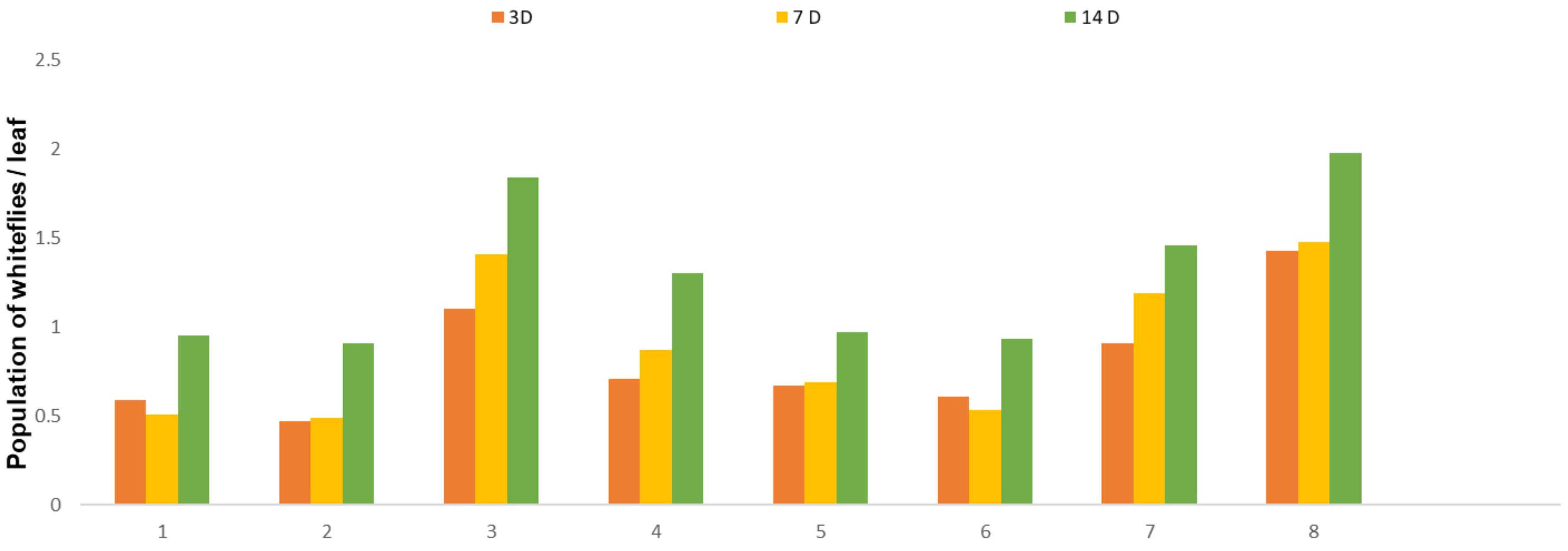

Fig. 11 Efficacy of IGR's against cotton whiteflies after first spray

**$T_1$: Buprofezin 25% SC** **$T_2$: Pyriproxyfen 10% EC** **$T_3$: Diflubenzuron 25% WP** **$T_4$: NSE 5%**

**$T_5$: Buprofezin 25% SC + NSE 5%** **$T_6$: Pyriproxyfen 10% EC + NSE 5%** **$T_7$: Diflubenzuron 25% WP + NSE 5%**

**$T_8$: Untreated control**

The treatment of NSE 5% proved moderately effective with 0.87 whiteflies per leaf. Whereas, comparatively highest population of whiteflies were recorded in plots treated with diflubenzuron 25% WP + NSE 5% (1.19/leaf) and diflubenzuron 25% WP (1.41/leaf). Both these treatments were found statistically equal to untreated control (1.48/leaf).

#### 4.10.3 Fourteen days after first spray

It is evident from the data presented in Table 10 (Fig.11) that among the different treatments under the trial the treatment with pyriproxyfen 10% EC recorded minimum number of whiteflies (0.91/leaf) at fourteen days after first spray. This treatment was followed by pyriproxyfen 10% EC + NSE 5% (0.93/leaf), buprofezin 25% SC (0.95/leaf) and buprofezin 25% SC + NSE 5% (0.97/leaf). However, all these treatments were found at par with each other. The next treatments in order of efficacy were NSE 5% (1.30/leaf) and diflubenzuron 25% WP + NSE 5% (1.46/leaf) found at par with each other. Whereas, the treatment diflubenzuron 25% WP recorded comparatively highest population of whiteflies i.e. 1.84/leaf and found at par with untreated control (1.98/leaf).

#### 4.10.4 Mean

The mean data regarding the population of whiteflies after first spray depicted in Table 10 (Fig.11) found statistically significant. Amongst the various treatments, pyriproxyfen 10% EC recorded minimum population of whiteflies (0.62/leaf). However, this treatment was found statistically equal with buprofezin 25 % SC (0.68/leaf), pyriproxyfen 10% EC + NSE 5% (0.69/leaf) and buprofezin 25% SC + NSE 5% (0.78/leaf). These were followed by treatment of NSE 5% (0.96/leaf) and diflubenzuron 25% WP + NSE 5% (1.19/leaf). Whereas, diflubenzuron 25% WP (1.45/leaf) was found at par with untreated control which recorded highest population i.e. 1.63 whiteflies/leaf.

### 4.11 Efficacy of IGR’s against cotton whiteflies after second spray

#### 4.11.1 Three days after second spray

The data on whitefly population presented in Table 11 (Fig.12) revealed that at three days after second spray the plots treated with pyriproxyfen 10% EC, buprofezin 25% SC and pyriproxyfen 10% EC + NSE 5% proved statistically equal in recording minimum population i.e., 0.49, 0.65, 0.66 whiteflies/leaf, respectively. Next in order of efficacy were buprofezin 25% SC + NSE 5% and NSE 5% with 0.95 and 1.13 whiteflies/leaf, respectively. Both treatments were found at par with each other. Whereas, the treatment diflubenzuron 25% WP + NSE 5% (1.66/leaf) proved moderately effective. The plots treated with diflubenzuron 25% WP recorded comparatively higher population of whiteflies i.e.1.89/leaf and found at par with untreated control (2.26/leaf).

**4.11.2 Seven days after second spray**

The data given in Table 11 (Fig.12) revealed that all the treatments proved significantly effective over untreated control in recording minimum population of whiteflies seven days after second spray. Amongst the treatments pyriproxyfen 10% EC recorded minimum whiteflies population (0.47/leaf). However, this treatment was found at par with pyriproxyfen 10% EC + NSE 5% (0.64/leaf). Moreover, the latter treatment was also in turn found at par with buprofezin 25% SC (0.73/leaf) and buprofezin 25% SC + NSE 5% (0.81/leaf). Whereas, remaining treatments i.e. NSE 5% (1.18/leaf), diflubenzuron 25% WP + NSE 5% (1.38/leaf) and diflubenzuron 25% WP (1.76/leaf) showed efficacy in descending order. The highest numbers of whiteflies were recorded in untreated control (2.51/leaf).

**4.11.3 Fourteen days after second spray**

The data recorded at fourteen days after second spray given in Table 11 (Fig.12) revealed that the treatment pyriproxyfen 10% EC and pyriproxyfen 10% EC + NSE 5% proved significantly effective recorded minimum whitefly population i.e. 1.33 and 1.44 whiteflies /leaf, respectively. These were closely followed by buprofezin 25% SC (1.92/leaf) and buprofezin 25% SC + NSE 5% (1.94/leaf). The treatment NSE 5% (2.35/leaf) was found moderately effective in this respect. Whereas, the plots treated with diflubenzuron 25% WP + NSE 5% (2.85/leaf) and diflubenzuron 25% WP (3.13/leaf) recorded comparatively highest number of whiteflies and found at par with untreated control plot (3.26/leaf).

#### 4.11.4 Mean

The data on mean population of whiteflies after second spray (Table 11 and Fig.12) was found statistically significant. Amongst the treatments pyriproxyfen 10% EC (0.76/leaf), pyriproxyfen 10% EC + NSE 5% (0.91/leaf) and buprofezin 25% SC (1.10/leaf) were the most promising treatments in recording lowest whitefly population. These were followed by buprofezin 25% SC + NSE 5% (1.23/leaf) and NSE 5% (1.55/leaf). However, both these treatments were found at par with each other. Whereas, treatment diflubenzuron 25% WP + NSE 5% (1.96/leaf) proved moderately effective. The treatment diflubenzuron 25% WP (2.26/leaf) found less effective and was at par with untreated control (2.68/leaf).

### 4.12. Efficacy of IGR’s against cotton whiteflies after third spray

#### 4.12.1 Three days after third spray

The population of whiteflies recorded at three days after third spray (Table 12 and Fig.13) revealed that plots treated with pyriproxyfen 10% EC and pyriproxyfen 10% EC + NSE 5% proved significantly effective over other treatments in recording minimum population of whiteflies i.e., 0.86 and 1.04 whiteflies/leaf, respectively. The next effective treatments were buprofezin 25 % SC (1.40/leaf) and buprofezin 25% SC + NSE 5% (1.50/leaf) found at par with each other. These were followed of NSE 5% (1.97/leaf) found moderately effective in this respect. The treatment of diflubenzuron 25% WP + NSE 5% (2.53/leaf) and diflubenzuron 25% WP (2.89/leaf) proved comparatively less effective in reducing the whiteflies. Whereas, diflubenzuron 25% WP was also found statistically equal with untreated control (3.18/leaf).

#### 4.12.2 Seven days after third spray

The data on effect of different treatments against whiteflies at seven days after third spray (Table 12 and Fig.13) showed that plots treated with pyriproxyfen 10% EC, pyriproxyfen 10% EC + NSE 5%, buprofezin 25% SC and buprofezin 25% SC + NSE 5% recorded significantly lower whitefly population of 0.84, 0.93, 1.12 and 1.25/leaf, respectively and found statistically equal with each other. Whereas, NSE 5% and diflubenzuron 25% WP + NSE 5% which recorded 1.53, 2.00 whiteflies/leaf, respectively proved moderately effective in reducing the whitefly population.

**Table 11: Efficacy of IGR's against cotton whiteflies after second spray**

| Sr. No | Treatments | Conc. | Number of whiteflies /leaf at | | | Mean |
|---|---|---|---|---|---|---|
| | | | 3 DAS | 7 DAS | 14 DAS | |
| 1 | Buprofezin 25% SC | 0.05% | 0.66 (0.81) | 0.73 (0.85) | 1.92 (1.37) | 1.10 (1.01) |
| 2 | Pyriproxyfen 10% EC | 0.02% | 0.49 (0.70) | 0.47 (0.68) | 1.33 (1.15) | 0.76 (0.84) |
| 3 | Diflubenzuron 25% WP | 0.015 % | 1.89 (1.37) | 1.76 (1.32) | 3.13 (1.77) | 2.26 (1.49) |
| 4 | NSE | 5% | 1.13 (1.06) | 1.18 (1.08) | 2.35 (1.53) | 1.55 (1.22) |
| 5 | Buprofezin 25% SC + NSE | 0.05 % + 5% | 0.95 (0.98) | 0.81 (0.90) | 1.94 (1.39) | 1.23 (1.09) |
| 6 | Pyriproxyfen 10% EC + NSE | 0.02 % +5% | 0.65 (0.81) | 0.64 (0.79) | 1.44 (1.20) | 0.91 (0.93) |
| 7 | Diflubenzuron 25% WP + NSE | 0.015 % + 5% | 1.66 (1.29) | 1.38 (1.17) | 2.85 (1.69) | 1.96 (1.38) |
| 8 | Untreated control | - | 2.26 (1.50) | 2.51 (1.58) | 3.26 (1.80) | 2.68 (1.63) |
| | F test | - | Sig | Sig | Sig | Sig |
| | SE (m) ± | - | 0.05 | 0.05 | 0.07 | 0.06 |
| | CD @ 5% | - | 0.15 | 0.16 | 0.21 | 0.17 |
| | CV (%) | - | 8.23 | 8.80 | 8.21 | 8.41 |

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

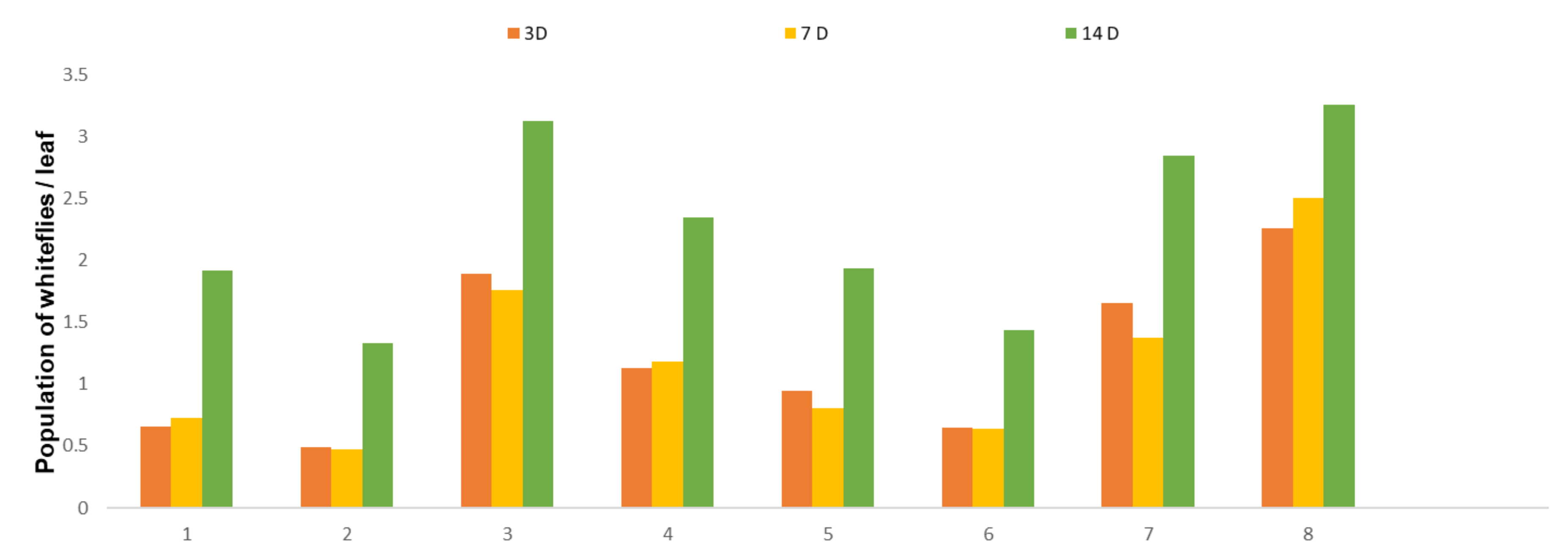


**Fig. 12 Efficacy of IGR's against cotton whiteflies after second spray**

**$T_1$: Buprofezin 25% SC** **$T_2$: Pyriproxyfen 10% EC** **$T_3$: Diflubenzuron 25% WP** **$T_4$: NSE 5%**

**$T_5$: Buprofezin 25% SC + NSE 5%** **$T_6$: Pyriproxyfen 10% EC + NSE 5%** **$T_7$: Diflubenzuron 25% WP + NSE 5%**

**$T_8$: Untreated control**

Highest number of whiteflies were recorded in diflubenzuron 25% WP (2.60/leaf) which was found statistically equal to untreated control (3.12/leaf).

### 4.12.3 Fourteen days after third spray

The Table 12 (Fig.13) pertaining to whitefly population recorded at fourteen days after third spray showed that the minimum number of whiteflies were observed in plots treated with pyriproxyfen 10% EC (1.67/leaf). However, this treatment was found at par with pyriproxyfen 10% EC + NSE 5% (1.77/leaf), buprofezin 25 % SC (2.22/leaf) and buprofezin 25% SC + NSE 5% (2.27/leaf). The treatment of NSE 5% (2.70 whiteflies/leaf) proved moderately effective. Whereas, diflubenzuron 25% WP + NSE 5% (2.92/leaf) and diflubenzuron 25% WP (3.21/leaf) were found less effective against whiteflies and proved statistically equal with untreated control (3.59/leaf).

### 4.12.4 Mean

The data regarding the mean population of whiteflies after third spray displayed in Table 12 and Fig.13 revealed that pyriproxyfen 10% EC (1.12/leaf) and pyriproxyfen 10% EC + NSE 5% (1.25/leaf) were the most effective treatments recorded significantly less number of whiteflies. However, latter treatment was also found at par with buprofezin 25% SC (1.58/leaf) and buprofezin 25% SC + NSE 5% (1.67/leaf). These were followed by NSE 5% with 2.06 whiteflies/leaf. Whereas, the treatment with diflubenzuron 25% WP + NSE 5% (2.48 whiteflies/leaf) proved moderately effective. The diflubenzuron 25% WP proved less effective with maximum number of whiteflies (2.90/leaf) and found at par with untreated control (3.30/leaf).

## 4.13 Efficacy of IGR's against cotton whiteflies after fourth spray

### 4.13.1 Three days after fourth spray

Results on the efficacy of various treatments against whitefly population at three days after fourth spray (Table 12 and Fig.13) revealed that pyriproxyfen 10% EC and pyriproxyfen 10% EC + NSE 5% recorded minimum population i.e. 1.11 and 1.21 whiteflies/leaf, respectively and proved most effective. These were followed by buprofezin 25 % SC (1.64/leaf) and buprofezin 25% SC + NSE 5% (1.72/leaf). However, both these treatments were at par with each other and proved moderately effective. Whereas, the NSE 5% (2.26/leaf) and diflubenzuron 25% WP + NSE 5% (2.58/leaf) appeared as next better treatments. Maximum population of whiteflies were recorded in diflubenzuron 25% WP (2.92/leaf) was found statistically equal to untreated control plots (3.57/leaf).

**Table 12: Efficacy of IGR's against cotton whitefly after third spray**

| Sr. No | Treatments | Conc. | Number of whiteflies /leaf at | | | Mean |
|---|---|---|---|---|---|---|
| | | | 3 DAS | 7 DAS | 14 DAS | |
| 1 | Buprofezin 25% SC | 0.05% | 1.40 (1.18) | 1.12 (1.06) | 2.22 (1.48) | 1.58 (1.24) |
| 2 | Pyriproxyfen 10% EC | 0.02% | 0.86 (0.93) | 0.84 (0.91) | 1.67 (1.29) | 1.12 (1.04) |
| 3 | Diflubenzuron 25% WP | 0.015% | 2.89 (1.70) | 2.60 (1.61) | 3.21 (1.79) | 2.90 (1.70) |
| 4 | NSE | 5% | 1.97 (1.40) | 1.53 (1.23) | 2.70 (1.64) | 2.06 (1.42) |
| 5 | Buprofezin 25% SC + NSE | 0.05 % + 5% | 1.50 (1.21) | 1.25 (1.10) | 2.27 (1.50) | 1.67 (1.27) |
| 6 | Pyriproxyfen 10% EC + NSE | 0.02 % +5% | 1.04 (1.01) | 0.93 (0.96) | 1.77 (1.33) | 1.25 (1.10) |
| 7 | Diflubenzuron 25% WP + NSE | 0.015 % + 5% | 2.53 (1.59) | 2.00 (1.41) | 2.92 (1.71) | 2.48 (1.57) |
| 8 | Untreated control | - | 3.18 (1.78) | 3.12 (1.77) | 3.59 (1.89) | 3.30 (1.81) |
| | F test | - | Sig | Sig | Sig | Sig |
| | SE (m) ± | - | 0.06 | 0.06 | 0.07 | 0.06 |
| | CD @ 5% | - | 0.18 | 0.19 | 0.21 | 0.19 |
| | CV (%) | - | 8.00 | 8.87 | 7.92 | 8.26 |

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

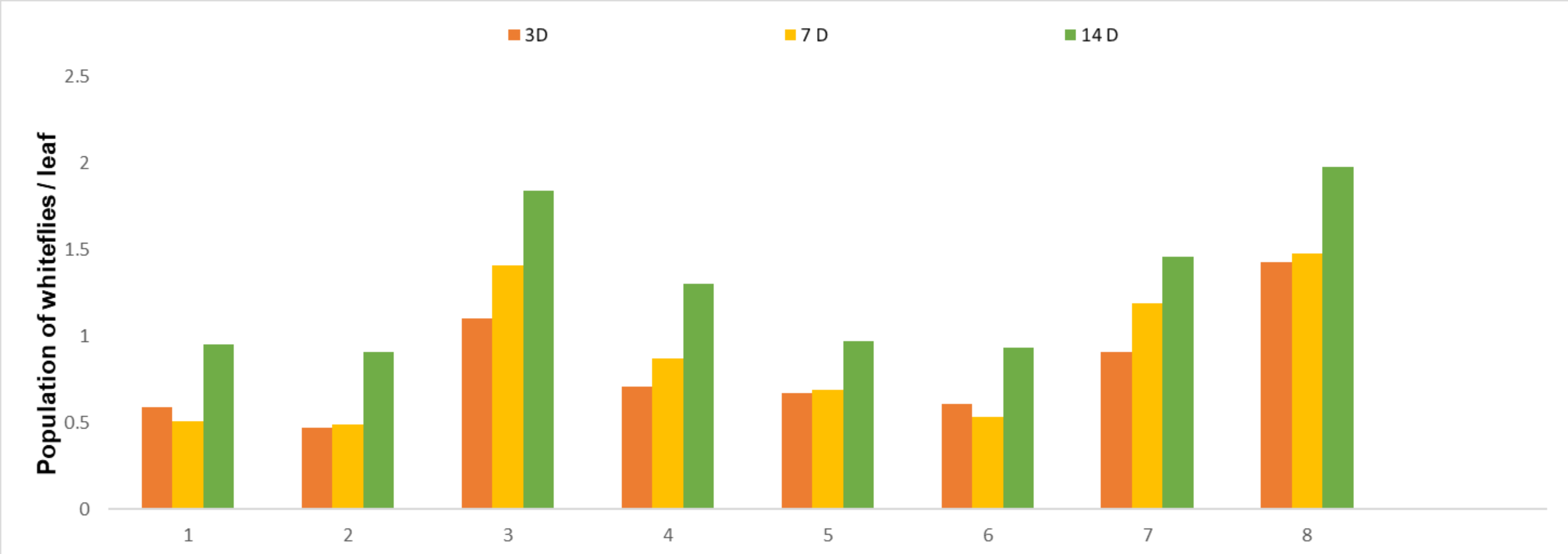

Fig. 13 Efficacy of IGR's against cotton whiteflies after third spray

**$T_1$: Buprofezin 25% SC** **$T_2$: Pyriproxyfen 10% EC** **$T_3$: Diflubenzuron 25% WP** **$T_4$: NSE 5%**

**$T_5$: Buprofezin 25% SC + NSE 5%** **$T_6$: Pyriproxyfen 10% EC + NSE 5%** **$T_7$: Diflubenzuron 25% WP + NSE 5%**

**$T_8$: Untreated control**

### 4.13.2 seven days after fourth spray

The data displayed in Table 13 (Fig.14) revealed that plots treated with pyriproxyfen 10% EC and pyriproxyfen 10% EC + NSE 5% recorded significantly less number of whiteflies i.e. 1.37 and 1.41 per leaf, respectively at seven days after fourth spray. The treatments *viz.,* buprofezin 25 % SC (1.91/leaf), buprofezin 25% SC + NSE 5% (2.04/leaf) and NSE 5% (2.46/leaf) appeared as next effective treatments against whiteflies. Whereas, diflubenzuron 25% WP + NSE 5% and diflubenzuron 25% WP were found less effective with 2.95 and 3.26 whiteflies/leaf, respectively and found at par with untreated control (3.63/leaf).

### 4.13.3 Fourteen days after fourth spray

Results on the efficacy of various treatments against whitefly population at fourteen days after fourth spray (Table 13 and Fig.13) revealed that amongst the different treatments pyriproxyfen 10% EC (1.61/leaf) and pyriproxyfen 10% EC + NSE 5% (1.70/leaf) proved significantly effective against whiteflies. The treatments *viz.,* buprofezin 25% SC, buprofezin 25% SC + NSE 5% and NSE 5% showed their efficacy in descending order with 2.27, 2.32 and 2.54 whiteflies/leaf, respectively. The highest population of whiteflies were observed in the plots treated with diflubenzuron 25% WP + NSE 5% (3.19/leaf) and diflubenzuron 25% WP (3.64/leaf) which were found at par with untreated control (3.74/leaf).

### 4.13.4 Mean

The data depicted in Table 13 (Fig.14) regarding mean population of whiteflies after fourth spray was found statistically significant. The treatment of pyriproxyfen 10% EC recorded minimum population of whiteflies (1.36/leaf). However, this treatment was found statistically equal with pyriproxyfen 10% EC + NSE 5% (1.44/leaf). These were followed buprofezin 25% SC (1.94/leaf), buprofezin 25% SC + NSE 5% (2.04/leaf) and NSE 5% (2.42/leaf). However, all these treatments were found at par with each other. The treatment of NSE 5% was also in turn found at par with diflubenzuron 25% WP + NSE 5% (2.91/leaf). The plots treated with diflubenzuron 25% WP recorded comparatively more number of whiteflies i.e. 3.27/leaf. This treatment was found at par with untreated control (3.65/leaf).

**Table 13: Efficacy of IGR's against cotton whiteflies after fourth spray**

| Tr. No | Treatments | Conc. | Number of whiteflies /leaf at | | | Mean |
|---|---|---|---|---|---|---|
| | | | 3 DAS | 7 DAS | 14 DAS | |
| 1 | Buprofezin 25% SC | 0.05 % | 1.64 (1.27) | 1.91 (1.38) | 2.27 (1.51) | 1.94 (1.39) |
| 2 | Pyriproxyfen 10% EC | 0.02 % | 1.11 (1.05) | 1.37 (1.16) | 1.61 (1.26) | 1.36 (1.15) |
| 3 | Diflubenzuron 25% WP | 0.015 % | 2.92 (1.71) | 3.26 (1.80) | 3.64 (1.91) | 3.27 (1.81) |
| 4 | NSE | 5% | 2.26 (1.50) | 2.46 (1.57) | 2.54 (1.59) | 2.42 (1.55) |
| 5 | Buprofezin 25% SC + NSE | 0.05 % + 5% | 1.72 (1.31) | 2.04 (1.41) | 2.32 (1.52) | 2.04 (1.41) |
| 6 | Pyriproxyfen 10% EC + NSE | 0.02 % +5% | 1.21 (1.10) | 1.41 (1.18) | 1.70 (1.30) | 1.44 (1.19) |
| 7 | Diflubenzuron 25% WP + NSE | 0.015 % + 5% | 2.58 (1.60) | 2.95 (1.72) | 3.19 (1.79) | 2.91 (1.70) |
| 8 | Untreated control | - | 3.57 (1.89) | 3.63 (1.90) | 3.74 (1.93) | 3.65 (1.91) |
| | F test | - | Sig | Sig | Sig | Sig |
| | SE (m) ± | - | 0.06 | 0.07 | 0.07 | 0.07 |
| | CD @ 5% | - | 0.20 | 0.21 | 0.20 | 0.20 |
| | CV (%) | - | 8.10 | 8.02 | 7.45 | 7.86 |

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

### 4.14 Cumulative effect of IGR's against cotton whiteflies

#### 4.14.1 Three days after spray

The cumulative data tabulated in Table 14 (Fig.15) revealed that at three days after the spray the treatments *viz.,* pyriproxyfen 10% EC, pyriproxyfen 10% EC + NSE 5% and buprofezin 25% SC emerged as the most effective treatments against whiteflies with minimum number

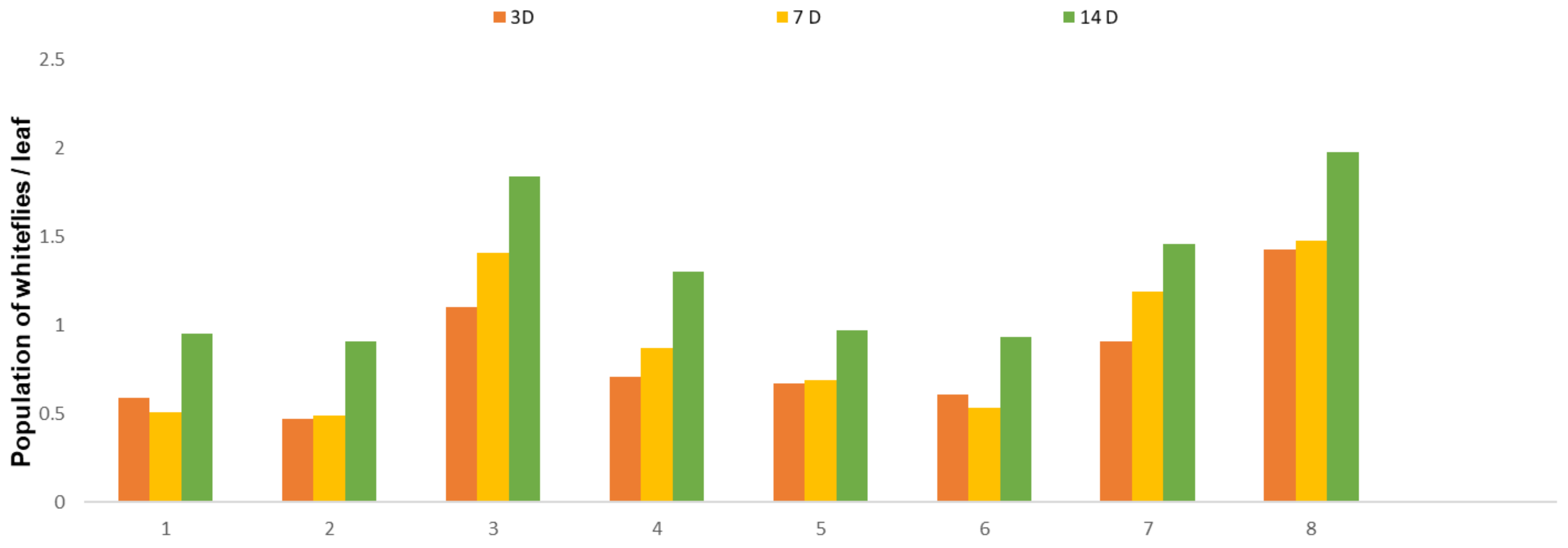

Fig. 14 Efficacy of IGR's against cotton whiteflies after fourth spray

**$T_1$: Buprofezin 25% SC** **$T_2$: Pyriproxyfen 10% EC** **$T_3$: Diflubenzuron 25% WP** **$T_4$: NSE 5%**

**$T_5$: Buprofezin 25% SC + NSE 5%** **$T_6$: Pyriproxyfen 10% EC + NSE 5%** **$T_7$: Diflubenzuron 25% WP + NSE 5%**

**$T_8$: Untreated control**

i.e. 0.73, 0.88 and 1.07 whiteflies/leaf, respectively. Whereas, the buprofezin 25% SC + NSE 5% (1.21/leaf) and NSE 5% (1.52/leaf) appeared as next better treatments in this respect. However, latter treatment was in turn also found at par with diflubenzuron 25% WP + NSE 5% (1.92/leaf). The treatment with diflubenzuron 25% WP (2.20/leaf) proved comparatively less effective against whiteflies and found at par with untreated control (2.61/leaf).

**4.14.2 Seven days after spray**

The cumulative data on whitefly population seven days after sprays (Table 14 and Fig.15) revealed that minimum number of whiteflies were recorded in the plots treated with pyriproxyfen 10% EC (0.79/leaf). This treatment was followed by pyriproxyfen 10% EC + NSE 5% (0.87/leaf) and buprofezin 25% SC (1.06/leaf). All this treatment were found at par with each other. The treatment buprofezin 25% SC + NSE 5% (1.20/leaf) and NSE 5% (1.51/leaf) were the next effective treatments at par with each other. The treatment of NSE 5% was also in turn found statistically equal with diflubenzuron 25% WP + NSE 5% (1.88/leaf). Whereas, plots treated with diflubenzuron 25% WP recorded 2.26 whiteflies/leaf and found at par with untreated control (2.68/leaf).

**4.14.3 Fourteen days after spray**

The cumulative data pertaining to whitefly population recorded at fourteen days after each spray (Table 14 and Fig.15) was found statistically significant. Among the treatments the minimum number of whiteflies was observed in the plots treated with pyriproxyfen 10% EC (1.38/leaf). However, this treatment was found statistically equal to pyriproxyfen 10% EC + NSE 5%, buprofezin 25% SC and buprofezin 25% SC + NSE 5%, in which 1.46, 1.84 and 1.87 whiteflies/leaf, were recorded respectively. These were followed by NSE 5% with 2.22 whiteflies/leaf which was found statistically equal to diflubenzuron 25% WP + NSE 5% (2.61/leaf). The treatment of diflubenzuron 25% WP (2.95/leaf) proved least effective found at par with untreated control (3.14/leaf).

**4.14.4 Mean**

The results on cumulative mean population of whiteflies after fourth spray (Table 14 and Fig.15) revealed that all the treatments were found statistically superior over untreated control except diflubenzuron 25% WP. The application of pyriproxyfen 10% EC (0.97/leaf), pyriproxyfen 10% EC + NSE 5% (1.07/leaf) and buprofezin 25% SC (1.32/leaf) proved statistically equal in reducing whiteflies population. The treatment buprofezin 25% SC + NSE 5% (1.43/leaf) and NSE 5% (1.75/leaf) proved moderately effective. These were followed by diflubenzuron 25% WP + NSE 5% (2.14/leaf). Maximum population of whiteflies were recorded in untreated control (2.81 whiteflies/leaf).

The present findings pertaining to whiteflies population are in agreement with the results of earlier workers Sahito et al. (2015) reported that, when sprayed with pyriproxyfen 10 EC the post-treatment data showed the overall reduction of 67.31±1.27% in whitefly, *Bemesia tabaci* population on cotton when compared with the control (un-sprayed) plot. Similar observations were also noticed by Thumar et al. (2018) reported that, the pyriproxyfen 10% EC (marketed sample) @ 1000 ml/ha found more effective against whiteflies infesting *Bt* cotton with 2.13 whiteflies per leaf. Moreover, Kumar et al. (2016) recorded maximum reduction (56.07%) in whitefly population on cotton offered by pyriproxyfen 10 EC @ 1000 ml/ha in comparison of standard check thiomethoxam 25 WG @ 200 g/ha (44.46%). Qureshi et al. (2009) observed that, the pyriproxyfen was effective in controlling whitefly populations in bitter melons, and both pyriproxyfen and buprofezin may have the potential to increase yield.

The present results on the effectiveness of buprofezin 25 SC against whiteflies are in accordance with research findings of Yadav and Raghuraman (2014) who evaluated new molecules against brinjal whiteflies. The result revealed that, buprofezin 25 SC recorded 46.8% reduction in whitefly population over untreated control. Similarly, the earlier worker Kalyan et al. (2017) evaluated new molecules against whiteflies of *Bt* cotton and reported that, among the different treatments the maximum reduction of whiteflies with a mean of 55.77 and 58.45 % was recorded in buprofezin 25 SC at seven days after second spray during 2014 and 2015, respectively. Similar results were also obtained by Das and Isalam (2014) with buprofezin 40 SC @ 2 ml/L against *Bemisia tabaci* on brinjal.

**Table 14: Cumulative effect of IGR's against cotton whiteflies**

| Sr. No | Treatments | Conc. | Number of whiteflies /leaf at | | | Mean |
|---|---|---|---|---|---|---|
| | | | 3 DAS | 7 DAS | 14 DAS | |
| 1 | Buprofezin 25% SC | 0.05% | 1.07 (1.00) | 1.06 (1.00) | 1.84 (1.33) | 1.32 (1.11) |
| 2 | Pyriproxyfen 10% EC | 0.02% | 0.73 (0.84) | 0.79 (0.87) | 1.38 (1.16) | 0.97 (0.96) |
| 3 | Diflubenzuron 25% WP | 0.015% | 2.20 (1.46) | 2.26 (1.48) | 2.95 (1.70) | 2.47 (1.55) |
| 4 | NSE | 5% | 1.52 (1.20) | 1.51 (1.20) | 2.22 (1.47) | 1.75 (1.29) |
| 5 | Buprofezin 25% SC + NSE | 0.05 % + 5% | 1.21 (1.08) | 1.20 (1.06) | 1.87 (1.34) | 1.43 (1.16) |
| 6 | Pyriproxyfen 10% EC + NSE | 0.02 % +5% | 0.88 (0.92) | 0.87 (0.91) | 1.46 (1.20) | 1.07 (1.01) |
| 7 | Diflubenzuron 25% WP + NSE | 0.015 % + 5% | 1.92 (1.36) | 1.88 (1.35) | 2.61 (1.60) | 2.14 (1.44) |
| 8 | Untreated control | - | 2.61 (1.59) | 2.68 (1.62) | 3.14 (1.75) | 2.81 (1.65) |
| | F test | - | Sig | Sig | Sig | Sig |
| | SE (m) ± | - | 0.05 | 0.05 | 0.06 | 0.05 |
| | CD @ 5% | - | 0.16 | 0.17 | 0.19 | 0.17 |
| | CV (%) | - | 8.19 | 8.51 | 7.88 | 8.19 |

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

Whereas, Nboyine et al. (2013) evaluate the field efficacy of neem based biopesticides for the management of insect pests of cotton. The results showed that, NSKE 5% significantly reduced the abundance of whiteflies i.e. (2.54/plant) as against untreated control (6.75 /plant). Similar findings were also reported by Noonari et al. (2016) who studied the efficacy of biopesticide for management of sucking pests of cotton. The results with regards to whiteflies revealed that, Neem seed extract

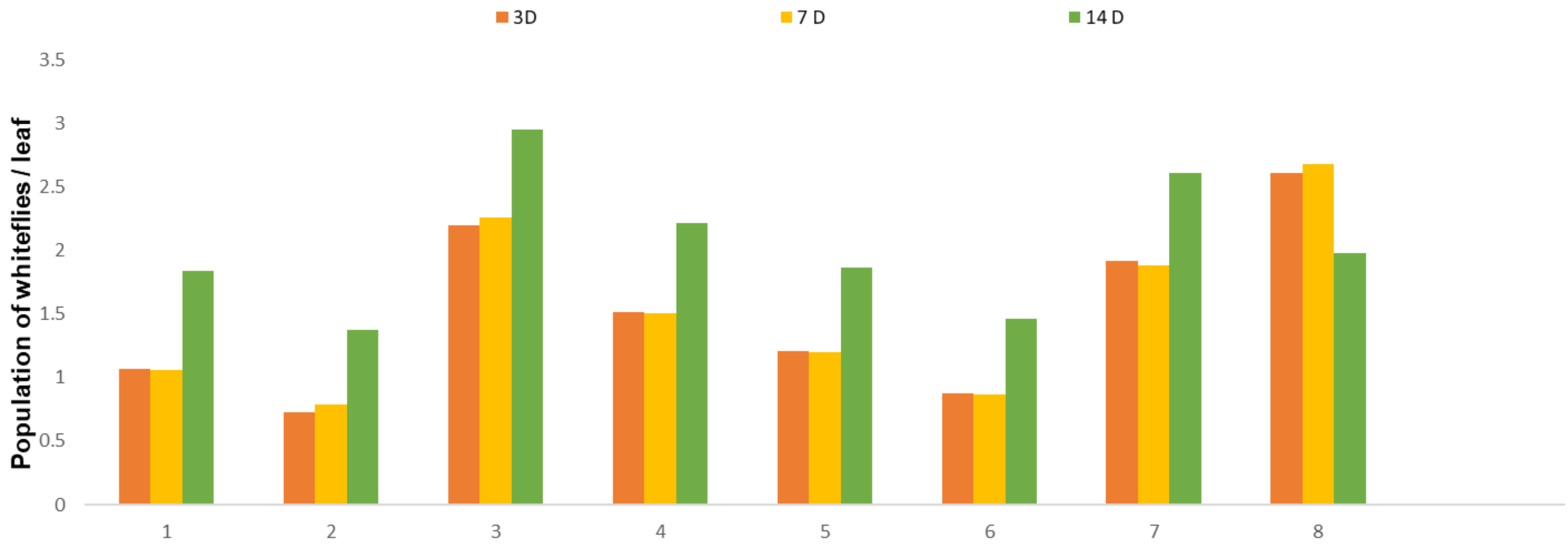


**Fig. 15 Cumulative effect of IGR's against cotton whiteflies**

**$T_1$: Buprofezin 25% SC** **$T_2$: Pyriproxyfen 10% EC** **$T_3$: Diflubenzuron 25% WP** **$T_4$: NSE 5%**

**$T_5$: Buprofezin 25% SC + NSE 5%** **$T_6$: Pyriproxyfen 10% EC + NSE 5%** **$T_7$: Diflubenzuron 25% WP + NSE 5%**

**$T_8$: Untreated control**

recorded 59.38 per cent reduction after 96 h. of spray application. Similarly, Karkar et al. (2014) evaluated botanicals for their bio efficacy against pests of brinjal. The pooled data showed that among the seven botanical products tested relatively less number of whiteflies were recorded in NSKE 5% (2.25/leaf) as against untreated control (3.16/leaf).

### 4.15 Efficacy of IGR's 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 between 6.97 to 10.23 thrips per leaf.

#### 4.15.1 Three days after first spray

The results on the efficacy of various treatments against thrips population at three days after first spray (Table 15 and Fig.16) revealed that amongst the treatments buprofezin 25% SC recorded minimum population of thrips (5.53/leaf). However, this treatment was found at par with buprofezin 25% SC + NSE 5% (5.91/leaf), pyriproxyfen 10% EC (6.68/leaf), NSE 5% (6.78/leaf) and pyriproxyfen 10% EC + NSE 5% (7.09/leaf). Whereas, treatments *viz.,* diflubenzuron 25% WP + NSE 5% (9.11/leaf) and diflubenzuron 25% WP (9.82/leaf) proved moderately effective in this respect. The untreated control plots recorded maximum number of thrips (13.24/leaf).

#### 4.15.2 seven days after first spray

Amongst the various treatments under the trial the plot treated with buprofezin 25% SC recorded significantly minimum number of thrips (4.49/leaf) at seven days after first spray (Table 15 and Fig.16). This treatment was found at par with buprofezin 25% SC + NSE 5% (5.72/leaf) and pyriproxyfen 10% EC (6.20/leaf). Whereas, pyriproxyfen 10% EC + NSE 5%, and NSE 5% were the next effective treatments with 6.80 and 7.35 thrips/leaf, respectively. The treatment diflubenzuron 25% WP + NSE 5% (9.52/leaf) and diflubenzuron 25% WP (10.96/leaf) proved moderately effective. The highest population of thrips was recorded in untreated control (18.78/leaf).

### 4.15.3 Fourteen days after first spray

The data displayed in Table 15 (Fig.16) pertaining to thrips population at fourteen days after first spray showed that lowest population of thrips was recorded in the plot treated with buprofezin 25% SC (5.73/leaf). However, this treatment proved statistically equal to pyriproxyfen 10% EC (5.98/leaf), buprofezin 25% SC + NSE 5% (6.65/leaf), pyriproxyfen 10% EC + NSE 5% (7.29/leaf) and NSE 5% (7.57/leaf). These were followed by diflubenzuron 25% WP + NSE 5% (9.24/leaf) and diflubenzuron 25% WP (11.04/leaf) found moderately effective. Whereas, untreated control recorded higher number of thrips (18.92/leaf).

### 4.15.4 Mean

The mean data on population of thrips after first spray (Table 15 and Fig.16) revealed that the treatment with buprofezin 25% SC, buprofezin 25% SC + NSE 5%, pyriproxyfen 10% EC, pyriproxyfen 10% EC + NSE 5% and NSE 5% recorded 5.25, 6.09, 6.29, 7.06 and 7.23 thrips/leaf, respectively. However, all these treatments were found at par with each other. Whereas, diflubenzuron 25% WP + NSE 5% (9.29/leaf) and diflubenzuron 25% WP (10.61/leaf) were the next effective treatments. The untreated control recorded highest number of thrips (16.98/leaf).

## 4.16 Efficacy of IGR's against cotton thrips after second spray.

### 4.16.1 Three days after second spray

The data presented in Table 16 (Fig.17) regarding the efficacy of different IGR's against thrips at three days after second spray was found statistically significant. The minimum thrips population was observed due to application of buprofezin 25% SC (5.23/leaf). This treatment was found at par with pyriproxyfen 10% EC (5.91/leaf), buprofezin 25% SC + NSE 5% (6.17/leaf) and pyriproxyfen 10% EC + NSE 5% (6.63/leaf). The remaining treatments *viz.,* NSE 5%, diflubenzuron 25% WP + NSE 5% and diflubenzuron 25% WP showed their efficacy in descending order with 7.74, 9.36 and 10.45 thrips/leaf, respectively. The maximum population of thrips were recorded in untreated control (19.00/leaf).

### 4.16.2 Seven days after second spray

Among the treatments, the thrips population recorded at seven days after second spray (Table 16 and Fig.17) was lowest in the plots treated with buprofezin 25% SC i.e., 4.87 thrips /leaf.

**Table 15: Efficacy of IGR's against cotton thrips after first spray**

| Sr. No | Treatments | Conc. | Number of thrips /leaf at | | | | Mean |
|---|---|---|---|---|---|---|---|
| | | | 1DBS | 3 DAS | 7 DAS | 14 DAS | |
| 1 | Buprofezin 25% SC | 0.05% | 7.79 (2.79) | 5.53 (2.34) | 4.49 (2.10) | 5.73 (2.38) | 5.25 (2.27) |
| 2 | Pyriproxyfen 10% EC | 0.02% | 8.27 (2.87) | 6.68 (2.57) | 6.20 (2.49) | 5.98 (2.43) | 6.29 (2.50) |
| 3 | Diflubenzuron 25% WP | 0.015% | 9.29 (3.04) | 9.82 (3.12) | 10.96 (3.29) | 11.04 (3.32) | 10.61 (3.24) |
| 4 | NSE | 5% | 8.11 (2.84) | 6.78 (2.60) | 7.35 (2.71) | 7.57 (2.74) | 7.23 (2.68) |
| 5 | Buprofezin 25% SC + NSE | 0.05 % + 5% | 6.97 (2.64) | 5.91 (2.43) | 5.72 (2.39) | 6.65 (2.58) | 6.09 (2.47) |
| 6 | Pyriproxyfen 10% EC + NSE | 0.02 % +5% | 7.86 (2.80) | 7.09 (2.66) | 6.80 (2.61) | 7.29 (2.69) | 7.06 (2.65) |
| 7 | Diflubenzuron 25% WP + NSE | 0.015 % + 5% | 8.73 (2.95) | 9.11 (3.02) | 9.52 (3.08) | 9.24 (3.04) | 9.29 (3.05) |
| 8 | Untreated control | - | 10.23 (3.20) | 13.24 (3.63) | 18.78 (4.33) | 18.92 (4.35) | 16.98 (4.10) |
| | F test | - | NS | Sig | Sig | Sig | Sig |
| | SE (m) ± | - | | 0.13 | 0.14 | 0.13 | 0.13 |
| | CD @ 5% | - | | 0.39 | 0.43 | 0.41 | 0.41 |
| | CV (%) | - | | 8.13 | 8.46 | 8.07 | 8.22 |

Note: Figures in parentheses are corresponding square root transformation value DBS- Day Before Spraying, DAS- Days After Spraying

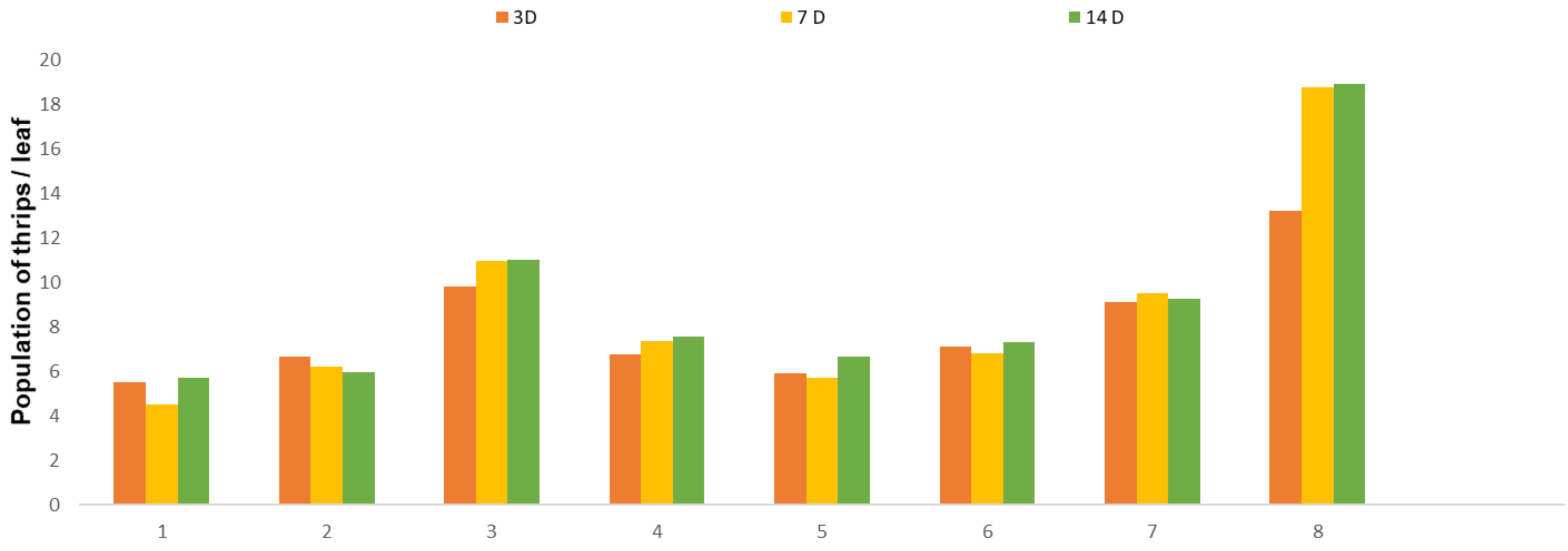

Fig. 16 Efficacy of IGR's against cotton thrips after first spray

**$T_1$: Buprofezin 25% SC** **$T_2$: Pyriproxyfen 10% EC** **$T_3$: Diflubenzuron 25% WP** **$T_4$: NSE 5%**

**$T_5$: Buprofezin 25% SC + NSE 5%** **$T_6$: Pyriproxyfen 10% EC + NSE 5%** **$T_7$: Diflubenzuron 25% WP + NSE 5%**

**$T_8$: Untreated control**

However, this treatment was found statistically equal to pyriproxyfen 10% EC (5.06/leaf), buprofezin 25% SC + NSE 5% (5.53/leaf). pyriproxyfen 10% EC + NSE 5% (5.86/leaf) and NSE 5% (6.58/leaf). Whereas, diflubenzuron 25% WP + NSE 5% (10.45/leaf) and diflubenzuron 25% WP (12.52/leaf) proved moderately effective. The highest number of thrips was recorded in untreated control (19.17/leaf).

**Table 16: Efficacy of IGR's against cotton thrips after second spray**

| Sr. No | Treatments | Conc. | Number of thrips /leaf at | | | Mean |
|---|---|---|---|---|---|---|
| | | | 3 DAS | 7 DAS | 14 DAS | |
| 1 | Buprofezin 25% SC | 0.05% | 5.23 (2.27) | 4.87 (2.20) | 5.18 (2.26) | 5.09 (2.24) |
| 2 | Pyriproxyfen 10% EC | 0.02% | 5.91 (2.41) | 5.06 (2.23) | 6.30 (2.50) | 5.76 (2.38) |
| 3 | Diflubenzuron 25% WP | 0.015 % | 10.45 (3.23) | 12.52 (3.53) | 13.44 (3.66) | 12.14 (3.47) |
| 4 | NSE | 5% | 7.74 (2.77) | 6.58 (2.56) | 7.53 (2.74) | 7.28 (2.69) |
| 5 | Buprofezin 25% SC + NSE | 0.05 % + 5% | 6.17 (2.48) | 5.53 (2.35) | 6.46 (2.54) | 6.05 (2.46) |
| 6 | Pyriproxyfen 10% EC + NSE | 0.02 % +5% | 6.63 (2.57) | 5.86 (2.42) | 7.09 (2.66) | 6.53 (2.55) |
| 7 | Diflubenzuron 25% WP + NSE | 0.015 % + 5% | 9.36 (3.05) | 10.45 (3.22) | 10.51 (3.24) | 10.11 (3.17) |
| 8 | Untreated control | - | 19.00 (4.36) | 19.17 (4.38) | 19.47 (4.41) | 19.21 (4.38) |
| | F test | - | Sig | Sig | Sig | Sig |
| | SE (m) ± | - | 0.14 | 0.14 | 0.13 | 0.14 |
| | CD @ 5% | - | 0.43 | 0.42 | 0.40 | 0.42 |
| | CV (%) | - | 8.51 | 8.55 | 7.58 | 8.21 |

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

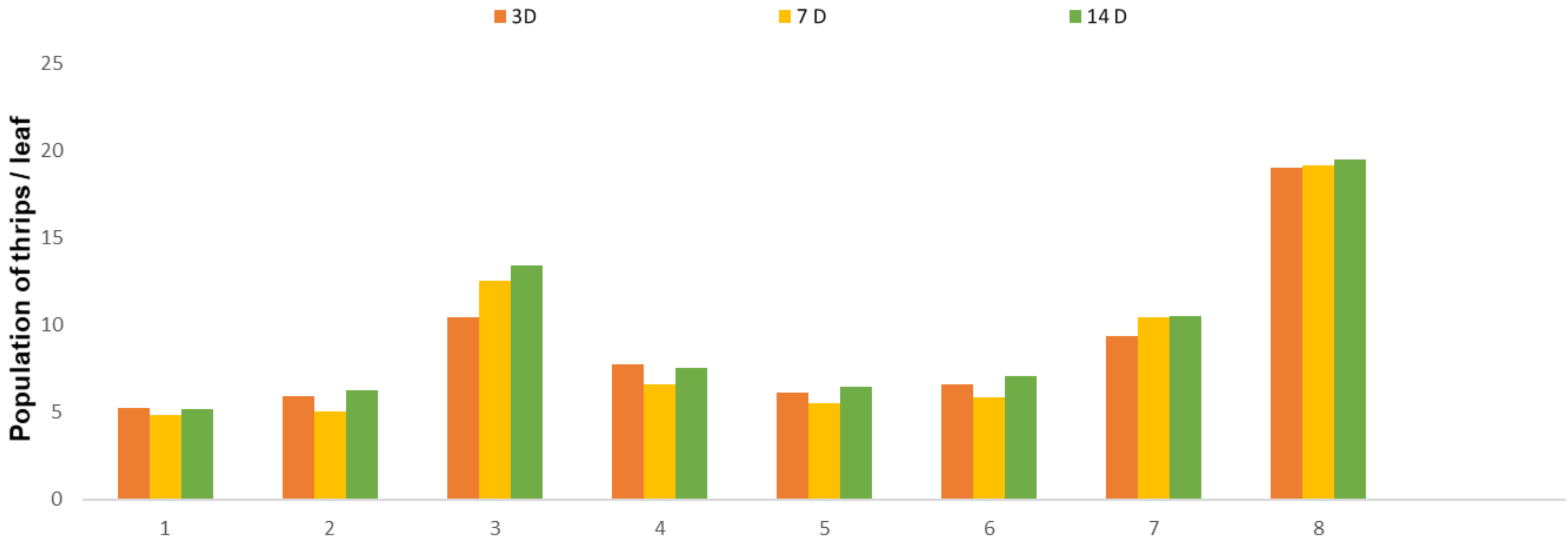


**Fig. 17 Efficacy of IGR's against cotton thrips after second spray**

**$T_1$: Buprofezin 25% SC** **$T_2$: Pyriproxyfen 10% EC** **$T_3$: Diflubenzuron 25% WP** **$T_4$: NSE 5%**

**$T_5$: Buprofezin 25% SC + NSE 5%** **$T_6$: Pyriproxyfen 10% EC + NSE 5%** **$T_7$: Diflubenzuron 25% WP + NSE 5%**

**$T_8$: Untreated control**

### 4.16.3 Fourteen days after second spray

The results on the efficacy of various treatments against thrips population at fourteen day after second spray (Table 16 Fig.17) revealed that buprofezin 25% SC recorded minimum population of thrips (5.18/leaf). This treatment was followed by pyriproxyfen 10% EC (6.30/leaf), buprofezin 25% SC + NSE 5% (6.46/leaf) and pyriproxyfen 10% EC + NSE 5% (7.09/leaf). However, all this treatment were found at par with each other. The treatment of NSE 5% proved moderately effective with 7.53 thrips per leaf. Whereas, diflubenzuron 25% WP + NSE 5% and diflubenzuron 25% WP recorded 10.51 and 13.44 thrips/leaf, respectively and found comparatively less effective against thrips. The maximum population of thrips was recorded in untreated control (19.47/leaf).

### 4.16.4 Mean

The results on the efficacy of various treatments against thrips population after second spray (Table 16 and Fig.17) revealed that all the treatments were found significantly effective in recording minimum thrips as against untreated control. The treatments *viz.,* buprofezin 25% SC (5.09/leaf), pyriproxyfen 10% EC (5.76/leaf), buprofezin 25% SC + NSE 5% (6.05/leaf) and pyriproxyfen 10% EC + NSE 5% (6.53/leaf) proved statistically equal with each other in recording lowest number of thrips at different intervals of observations. Whereas, the treatments *viz.,* NSE 5%, diflubenzuron 25% WP + NSE 5% and diflubenzuron 25% WP recorded 7.28, 10.11 and 12.14 thrips/leaf, respectively. Whereas, untreated control recorded maximum population of thrips (19.21/leaf).

## 4.17. Efficacy of IGR's against cotton thrips after third spray.

### 4.17.1 Three days after third spray

The data tabulated in Table 17 (Fig.18) pertaining to thrips population three days after third spray was found statistically significant. Among the treatments, buprofezin 25% SC recorded minimum number of thrips (4.57/leaf). However, this treatment was found at par with buprofezin 25% SC + NSE 5% (5.73/leaf), pyriproxyfen 10% EC + NSE 5% (5.97/leaf) and pyriproxyfen 10% EC (6.03/leaf). Whereas, NSE 5% (6.78/leaf), diflubenzuron 25% WP + NSE 5% (7.86/leaf) and diflubenzuron 25% WP (8.02/leaf) were the next effective treatments. Maximum population of thrips was recorded in untreated control plots (12.47thrips/leaf).

### 4.17.2 Seven days after third spray

The data displayed in Table 17 (Fig.18) regarding thrips population recorded at seven days after third spray revealed that all the treatments proved significantly effective over untreated control. Among the treatments buprofezin 25% SC (4.13/leaf), buprofezin 25% SC + NSE 5% (4.86/leaf), pyriproxyfen 10% EC (5.16/leaf), NSE 5% (5.34/leaf) and pyriproxyfen 10% EC + NSE 5% (5.43/leaf) recorded minimum population of thrips and were found at par with each other. These were followed by diflubenzuron 25% WP + NSE 5% (7.13/leaf) and diflubenzuron 25% WP (8.23/leaf) which proved moderately effective in this respect. Whereas, maximum number of thrips were recorded in untreated control plots (13.18thrips/leaf).

### 4.17.3 Fourteen days after third spray

It is evident from the data presented in Table 17 (Fig.18) that all the treatments were found significantly superior over untreated control in reducing the thrips population at fourteen days after third spray. Among the different treatments under the trial buprofezin 25% SC recorded minimum number of thrips (4.48/leaf). This treatment was followed by buprofezin 25% SC + NSE 5% (5.31/leaf), pyriproxyfen 10% EC (5.39/leaf), pyriproxyfen 10% EC + NSE 5% (5.86/leaf) and NSE 5% (6.00/leaf). However, all this treatment were found at par with each other. The next effective treatment diflubenzuron 25% WP + NSE 5% (7.66/leaf) was found at par with diflubenzuron 25% WP (8.91/leaf). Maximum population of thrips was recorded in untreated control plots (14.20thrips/leaf).

### 4.17.4 Mean

The mean data regarding the population of thrips after third spray depicted in Table 17 (Fig.18) showed that the data was statistically significant. Amongst the various treatments, buprofezin 25% SC recorded minimum population of thrips (4.39/leaf). However, this treatment was found statistically equal with buprofezin 25% SC + NSE 5%, pyriproxyfen 10% EC, pyriproxyfen 10% EC + NSE 5% and NSE 5% with 5.30, 5.53, 5.75 and 6.04 thrips per leaf, respectively. These were followed by diflubenzuron 25% WP + NSE 5% (7.55/leaf) and diflubenzuron 25% WP (8.39/leaf) found statistically superior over untreated control (13.28 thrips/leaf).

**Table 17: Efficacy of IGR's against cotton thrips after third spray**

| Sr. No. | Treatments | Conc. | Number of thrips /leaf at | | | |
|---|---|---|---|---|---|---|
| | | | 3 DAS | 7 DAS | 14 DAS | MEAN |
| 1 | Buprofezin 25% SC | 0.05% | 4.57 (2.13) | 4.13 (2.03) | 4.48 (2.10) | 4.39 (2.09) |
| 2 | Pyriproxyfen 10% EC | 0.02% | 6.03 (2.44) | 5.16 (2.25) | 5.39 (2.31) | 5.53 (2.33) |
| 3 | Diflubenzuron 25% WP | 0.015% | 8.02 (2.81) | 8.23 (2.86) | 8.91 (2.97) | 8.39 (2.88) |
| 4 | NSE | 5% | 6.78 (2.60) | 5.34 (2.31) | 6.00 (2.45) | 6.04 (2.45) |
| 5 | Buprofezin 25% SC + NSE | 0.05 % + 5% | 5.73 (2.39) | 4.86 (2.20) | 5.31 (2.30) | 5.30 (2.30) |
| 6 | Pyriproxyfen 10% EC + NSE | 0.02 % +5% | 5.97 (2.44) | 5.43 (2.33) | 5.86 (2.42) | 5.75 (2.40) |
| 7 | Diflubenzuron 25% WP + NSE | 0.015 % + 5% | 7.86 (2.80) | 7.13 (2.67) | 7.66 (2.76) | 7.55 (2.74) |
| 8 | Untreated control | - | 12.47 (3.53) | 13.18 (3.63) | 14.20 (3.77) | 13.28 (3.64) |
| | F test | - | Sig | Sig | Sig | Sig |
| | SE (m) ± | - | 0.14 | 0.12 | 0.13 | 0.13 |
| | CD @ 5% | - | 0.41 | 0.36 | 0.41 | 0.39 |
| | CV (%) | - | 8.90 | 8.24 | 8.83 | 8.65 |

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

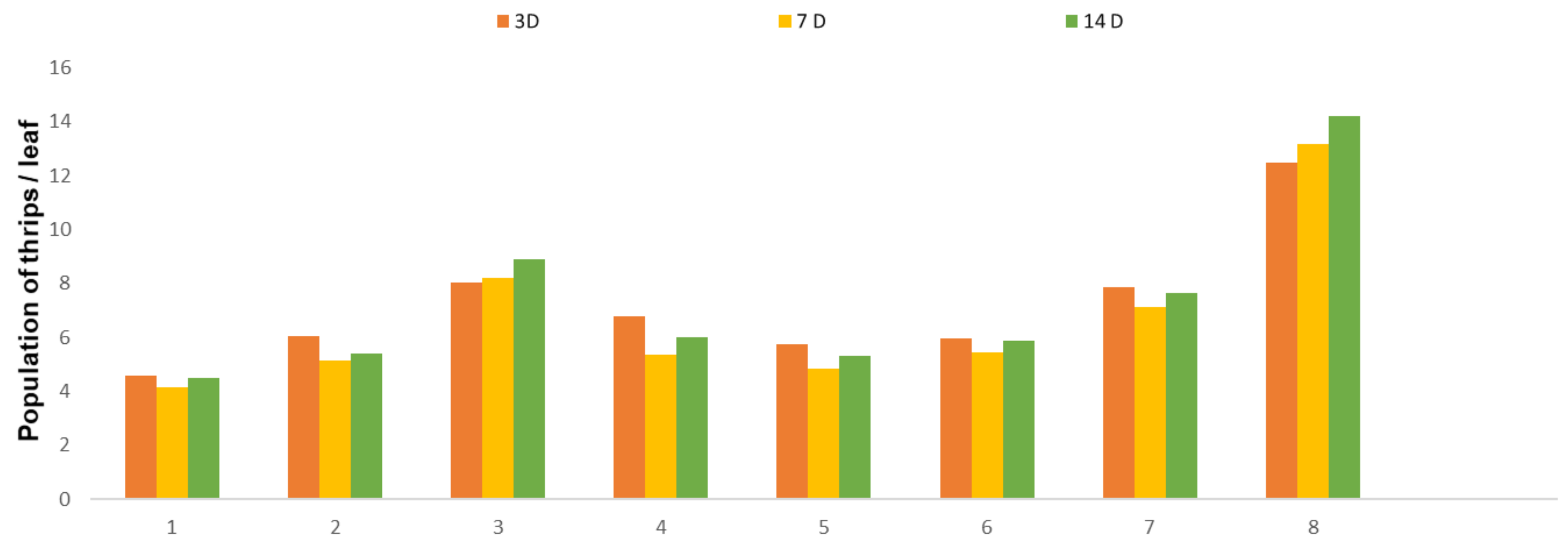

Fig. 18 Efficacy of IGR's against cotton thrips after third spray

**$T_1$: Buprofezin 25% SC** **$T_2$: Pyriproxyfen 10% EC** **$T_3$: Diflubenzuron 25% WP** **$T_4$: NSE 5%**

**$T_5$: Buprofezin 25% SC + NSE 5%** **$T_6$: Pyriproxyfen 10% EC + NSE 5%** **$T_7$: Diflubenzuron 25% WP + NSE 5%**

**$T_8$: Untreated control**

### 4.18 Efficacy of IGR's against cotton thrips after fourth spray

#### 4.18.1 Three days after fourth spray

The data (Table 18 and Fig.19) pertaining to thrips population recorded at three days after fourth spray revealed that minimum number of thrips were recorded due to application of buprofezin 25% SC (3.97thrips/leaf). However, this treatment was found at par with NSE 5%, pyriproxyfen 10% EC + NSE 5%, pyriproxyfen 10% EC and buprofezin 25% SC + NSE 5% in which population ranged between 4.53 to 4.86 thrips/leaf. The next effective treatments were diflubenzuron 25% WP + NSE 5% (6.87/leaf) and diflubenzuron 25% WP (7.03/leaf). However, maximum number of thrips were recorded in untreated control (14.88 thrips/leaf).

#### 4.18.2 Seven days after fourth spray

The data recorded on thrips population at seven days after fourth spray presented in Table 18 (Fig.19) showed that the plots treated with buprofezin 25% SC were observed with minimum number of thrips (3.17/leaf). However, this treatment was found at par with pyriproxyfen 10% EC (3.53/leaf), pyriproxyfen 10% EC + NSE 5% (3.86/leaf) and buprofezin 25% SC + NSE 5% (4.13/leaf). Next in order of efficacy were NSE 5% (4.89/leaf), diflubenzuron 25% WP + NSE 5% (6.03/leaf) and diflubenzuron 25% WP (6.57/leaf). The maximum number of thrips was recorded in untreated control (15.71/leaf).

#### 4.18.3 Fourteen days after fourth spray

The data on thrips population at fourteen days after fourth spray (Table 18 and Fig.19) revealed that the treatment buprofezin 25% SC recorded lowest number of thrips (3.76/leaf). However, this treatment was found statistically equal with pyriproxyfen 10% EC, pyriproxyfen 10% EC + NSE 5%, buprofezin 25% SC + NSE 5% and NSE 5% in which 4.12, 4.13, 4.67 and 5.12 thrips/leaf were recorded, respectively. The treatment of diflubenzuron 25% WP (6.13/leaf) and diflubenzuron 25% WP + NSE 5% (6.43/leaf) proved moderately effective in this respect. However, the maximum number of thrips was observed in untreated control plots (17.33/leaf).

#### 4.18.4 Mean

The mean data regarding the population of thrips after fourth spray depicted in Table 18 (Fig.19) showed that the data was significant. Among the various treatments, buprofezin 25% SC recorded the minimum number of thrips (3.63/leaf). However, this treatment was found at par with pyriproxyfen 10% EC (4.17/leaf), pyriproxyfen 10% EC + NSE 5% (4.22/leaf), buprofezin 25% SC + NSE 5% (4.55/leaf) NSE 5% (4.85/leaf). The next effective treatment diflubenzuron 25% WP + NSE 5% (6.44/leaf) was found statistically equal to diflubenzuron 25% WP (6.58/leaf). Highest population of thrips were recorded in untreated control (15.97/leaf).

### 4.19 Cumulative effect of IGR's against cotton thrips.

#### 4.19.1 Three days after spray

The cumulative data presented in Table 19 (Fig.20) regarding efficacy of different IGR's against thrips at three days after sprays was found statistically significant. However, minimum number of thrips was observed due to application of buprofezin 25% SC (4.82/leaf). This treatment was found at par with buprofezin 25% SC + NSE 5% (5.66/leaf), pyriproxyfen 10% EC (5.87/leaf), pyriproxyfen 10% EC + NSE 5% (6.09/leaf) and NSE 5% (6.46/leaf). Whereas, the plots treated with diflubenzuron 25% WP + NSE 5% and diflubenzuron 25% WP recorded 8.30 and 8.83 thrips/leaf, respectively. Maximum numbers of thrips were observed in untreated control plots with the population of 14.89 /leaf.

#### 4.19.2 Seven days after spray

The data depicted in Table 19 (Fig.20) regarding thrips population at seven days after four sprays showed that the treatment with buprofezin 25% SC recorded minimum number of thrips (4.17/leaf). However, this treatment was found statistically equal with pyriproxyfen 10% EC, buprofezin 25% SC + NSE 5% and pyriproxyfen 10% EC + NSE 5% in which 4.99, 5.06 and 5.49 thrips/leaf, were recorded respectively. The treatment of NSE 5% with 6.04 thrips/leaf proved moderately effective. Next in order of efficacy were diflubenzuron 25% WP + NSE 5% and diflubenzuron 25% WP with 8.28 and 9.57 thrips/leaf, respectively as against untreated control in which highest number of thrips i.e.16.70/leaf were recorded.

**Table 18: Efficacy of IGR's against cotton thrips after fourth spray**

| **Sr. No.** | **Treatments** | **Conc.** | **Number of thrips /leaf at** | | | |
|---|---|---|---|---|---|---|
| | | | **3 DAS** | **7 DAS** | **14 DAS** | **Mean** |
| 1 | Buprofezin 25% SC | 0.05% | 3.97 (1.98) | 3.17 (1.77) | 3.76 (1.92) | 3.63 (1.89) |
| 2 | Pyriproxyfen 10% EC | 0.02% | 4.87 (2.19) | 3.53 (1.85) | 4.12 (2.03) | 4.17 (2.02) |
| 3 | Diflubenzuron 25% WP | 0.015 % | 7.03 (2.65) | 6.57 (2.56) | 6.13 (2.47) | 6.58 (2.56) |
| 4 | NSE | 5% | 4.53 (2.13) | 4.89 (2.21) | 5.12 (2.25) | 4.85 (2.20) |
| 5 | Buprofezin 25% SC + NSE | 0.05 % + 5% | 4.86 (2.20) | 4.13 (2.03) | 4.67 (2.16) | 4.55 (2.13) |
| 6 | Pyriproxyfen 10% EC + NSE | 0.02 % +5% | 4.67 (2.16) | 3.86 (1.96) | 4.13 (2.03) | 4.22 (2.05) |
| 7 | Diflubenzuron 25% WP + NSE | 0.015 % + 5% | 6.87 (2.62) | 6.03 (2.45) | 6.43 (2.53) | 6.44 (2.53) |
| 8 | Untreated control | - | 14.88 (3.86) | 15.71 (3.96) | 17.33 (4.16) | 15.97 (3.99) |
| | F test | - | Sig | Sig | Sig | Sig |
| | SE (m) ± | - | 0.12 | 0.11 | 0.12 | 0.12 |
| | CD @ 5% | - | 0.35 | 0.34 | 0.38 | 0.36 |
| | CV (%) | - | 8.13 | 8.35 | 8.82 | 8.43 |

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

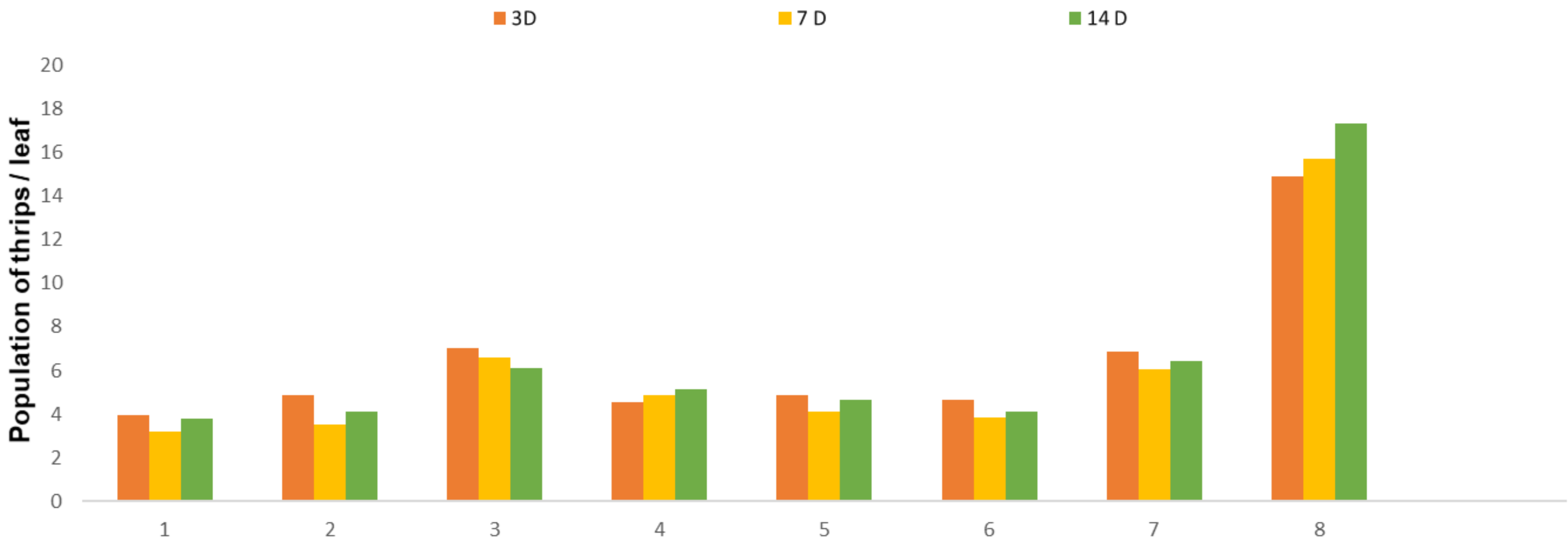


**Fig. 19 Efficacy of IGR's against cotton thrips after fourth spray**

**$T_1$: Buprofezin 25% SC** **$T_2$: Pyriproxyfen 10% EC** **$T_3$: Diflubenzuron 25% WP** **$T_4$: NSE 5%**

**$T_5$: Buprofezin 25% SC + NSE 5%** **$T_6$: Pyriproxyfen 10% EC + NSE 5%** **$T_7$: Diflubenzuron 25% WP + NSE 5%**

**$T_8$: Untreated control**

### 4.19.3 Fourteen days after spray

The cumulative data on thrips population at fourteen days after spray presented in Table 19 and illustrated under Fig.20 was found statistically significant. Minimum number of thrips were seen due to application of buprofezin 25% SC (4.79/leaf). This was followed by pyriproxyfen 10% EC (5.45/leaf), buprofezin 25% SC + NSE 5% (5.77/leaf), pyriproxyfen 10% EC + NSE 5% (6.09/leaf) and NSE 5% (6.56/leaf). However, all these treatments were found at par with each other. The treatment diflubenzuron 25% WP + NSE 5% (8.46/leaf) and diflubenzuron 25% WP (9.88/leaf) proved moderately effective against thrips. Whereas, highest number of thrips were recorded in untreated control (17.48/leaf).

### 4.19.4 Mean

The data on cumulative mean of thrips population after four sprays (Table 19 and Fig.20) showed that buprofezin 25% SC recorded the minimum number of thrips (4.60/leaf). This treatment was found at par with pyriproxyfen 10% EC, buprofezin 25% SC + NSE 5%, pyriproxyfen 10% EC + NSE 5% and NSE 5% in which 5.44, 5.50, 5.89 and 6.35 thrips/leaf, were recorded, respectively. The treatment diflubenzuron 25% WP + NSE 5% and diflubenzuron 25 % WP recorded 8.35 and 9.43 thrips/leaf, respectively and found moderately effective. The Maximum number of thrips were observed in untreated control plots (16.36 /leaf).

The present results regarding efficacy of IGR's against thrips find support in the work carried out by the earlier worker like Swami et al. (2018) evaluated the efficacy of pyriproxyfen 10% EC against thrips, *Thrips tabaci* (Ishida) infesting chilli crop and reported that, two sprays of pyriproxyfen 10% EC @ 1250 ml/ha resulted in 69.56 and 71.51% reduction in thrips population at 14 days after first and second spray during *Kharif* 2016 and 2017, respectively. Similar findings were also reported by Thumar et al. (2018) reported that the plots treated with pyriproxyfen 10% EC @ 1000 ml/ha (marketed sample) recorded lowest population of thrips i.e. 3.32 /leaf on cotton. Similarly, Choudhary et al. (2015) evaluated the bioefficacy of pyriproxyfen 10 EC with different doses (75, 100 and 125 g a.i./ha.) against sucking pest of cotton. They recorded significantly lower population of thrips i.e. 13.06 per 3 leaves in plots treated with pyriproxyfen 10 EC @ 125 g a.i./ha. Whereas, Kumar et al. (2016) reported that the plots treated with pyriproxyfen 10 EC recorded maximum reduction of thrips 56.98% on cotton. Similarly, Ambarish et al. (2017) evaluated bio-efficacy of new insecticide molecules against insect pests of cotton and reported that, the treatment pyriproxyfen 5% EC @ 37.5 g ai/ha recorded lowest population of thrips i.e. 3.59/leaf.

**Table 19: Cumulative effect of IGR's against cotton thrips**

| Sr. No. | Treatments | Conc. | Number of thrips /leaf at | | | |
|---|---|---|---|---|---|---|
| | | | 3 DAS | 7 DAS | 14 DAS | Mean |
| 1 | Buprofezin 25% SC | 0.05% | 4.82 (2.18) | 4.17 (2.02) | 4.79 (2.17) | 4.60 (2.12) |
| 2 | Pyriproxyfen 10% EC | 0.02% | 5.87 (2.40) | 4.99 (2.20) | 5.45 (2.32) | 5.44 (2.31) |
| 3 | Diflubenzuron 25% WP | 0.015 % | 8.83 (2.95) | 9.57 (3.06) | 9.88 (3.11) | 9.43 (3.04) |
| 4 | NSE | 5% | 6.46 (2.52) | 6.04 (2.45) | 6.56 (2.55) | 6.35 (2.51) |
| 5 | Buprofezin 25% SC + NSE | 0.05 % + 5% | 5.66 (2.37) | 5.06 (2.24) | 5.77 (2.40) | 5.50 (2.34) |
| 6 | Pyriproxyfen 10% EC + NSE | 0.02 % +5% | 6.09 (2.46) | 5.49 (2.33) | 6.09 (2.45) | 5.89 (2.41) |
| 7 | Diflubenzuron 25% WP + NSE | 0.015 % + 5% | 8.30 (2.87) | 8.28 (2.85) | 8.46 (2.89) | 8.35 (2.87) |
| 8 | Untreated control | - | 14.89 (3.85) | 16.70 (4.08) | 17.48 (4.17) | 16.36 (4.03) |
| | F test | - | Sig | Sig | Sig | Sig |
| | SE (m) ± | - | 0.13 | 0.13 | 0.13 | 0.13 |
| | CD @ 5% | - | 0.40 | 0.39 | 0.40 | 0.40 |
| | CV (%) | - | 8.42 | 8.40 | 8.33 | 8.38 |

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

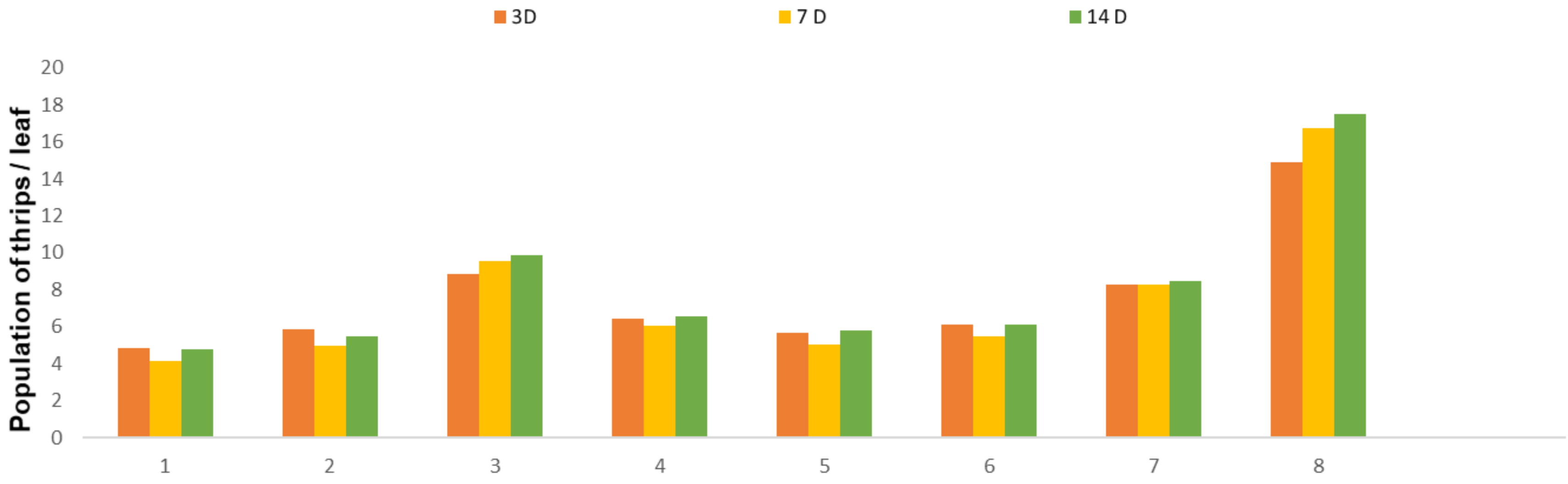


**Fig. 20 Cumulative effect of IGR's against cotton thrips**

**$T_1$: Buprofezin 25% SC** **$T_2$: Pyriproxyfen 10% EC** **$T_3$: Diflubenzuron 25% WP** **$T_4$: NSE 5%**

**$T_5$: Buprofezin 25% SC + NSE 5%** **$T_6$: Pyriproxyfen 10% EC + NSE 5%** **$T_7$: Diflubenzuron 25% WP + NSE 5%**

**$T_8$: Untreated control**

Moreover, Nemade et al. (2017) evaluated new molecules against sucking pests of *Bt* cotton. Among the different insecticides buprofezin 25 SC recorded the minimum population of thrips (3.13, 1.33 and 0.27/3 leaves) as against untreated control (5.6, 3.53 and 1.00/3 leaves) during all three sprays. Whereas, Ananthi et al. (2017) reported that, NSKE 5% was the most effective in controlling the thrips on chilli during both the seasons of experimentation. Similarly, Iqbal et al. (2015) evaluated the field efficacy of indigenous plant extracts against sucking pests of okra. It was revealed that, neem extract significantly reduces the mean population of thrips. Noonari et al. (2016) conducted experiment consecutively for two years, (2006 and 2007) for management of cotton insect pests through eco-friendly measures. The result showed that among all bio-pesticides, the highest percent reduction of thrips (67.65%) was recorded in Neem seed extract. Thus, the above finding confirms the present results.

### 4.20 Cumulative effect of IGR's on population of natural enemies

The cumulative data from Table 20 on the ladybird beetle population at different intervals of observations after each treatment spray indicated non-significant differences among the treatments**.** The population of ladybird beetle was observed in the range of 1.02 to 1.35 per plant. However, numerically a greater number of ladybird beetles were recorded in untreated control plots (1.48/plant).

**Table 20: Cumulative effect of IGR's on population of ladybird beetle**

| Sr. No | Treatments | Conc. | Number of lady bird beetle/plant | | | Mean |
|---|---|---|---|---|---|---|
| | | | 3 DAS | 7 DAS | 14 DAS | |
| 1 | Buprofezin 25% SC | 0.05% | 1.12 (1.05) | 1.15 (1.19) | 1.24 (1.11) | 1.17 (1.12) |
| 2 | Pyriproxyfen 10% EC | 0.02% | 0.97 (0.98) | 1.12 (1.15) | 1.27 (1.13) | 1.12 (1.09) |
| 3 | Diflubenzuron 25% WP | 0.015 % | 0.91 (0.94) | 1.02 (1.19) | 1.13 (1.06) | 1.02 (1.06) |
| 4 | NSE | 5% | 1.39 (1.17) | 1.20 (1.38) | 1.47 (1.21) | 1.35 (1.25) |
| 5 | Buprofezin 25% SC + NSE | 0.05 % + 5% | 1.22 (1.10) | 1.34 (1.34) | 1.41 (1.19) | 1.32 (1.21) |
| 6 | Pyriproxyfen 10% EC + NSE | 0.02 % +5% | 1.27 (1.12) | 1.18 (1.03) | 1.36 (1.16) | 1.27 (1.10) |
| 7 | Diflubenzuron 25% WP + NSE | 0.015 % + 5% | 1.11 (1.05) | 1.17 (1.08) | 1.28 (1.13) | 1.19 (1.09) |
| 8 | Untreated control | - | 1.48 (1.22) | 1.43 (1.19) | 1.53 (1.24) | 1.48 (1.22) |
| | F test | - | NS | NS | NS | NS |
| | SE (m) ± | | 0.06 | 0.07 | 0.03 | 0.05 |

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

**21: Cumulative effect of IGR's on population of chrysopids**

| Sr. No | Treatments | Conc. | Number of chrysopids/plant | | | Mean |
|---|---|---|---|---|---|---|
| | | | 3 DAS | 7 DAS | 14 DAS | |
| 1 | Buprofezin 25% SC | 0.05% | 0.84 (0.91) | 0.99 (0.99) | 1.17 (1.08) | 1.00 (0.99) |
| 2 | Pyriproxyfen 10% EC | 0.02% | 0.81 (0.90) | 0.93 (0.96) | 1.11 (1.05) | 0.95 (0.97) |
| 3 | Diflubenzuron 25% WP | 0.015 % | 0.69 (0.82) | 0.83 (0.89) | 0.97 (0.98) | 0.83 (0.90) |
| 4 | NSE | 5% | 1.14 (1.07) | 1.50 (1.22) | 1.63 (1.27) | 1.42 (1.18) |
| 5 | Buprofezin 25% SC + NSE | 0.05 % + 5% | 1.13 (1.06) | 1.47 (1.21) | 1.56 (1.24) | 1.39 (1.17) |
| 6 | Pyriproxyfen 10% EC + NSE | 0.02 % +5% | 0.97 (0.98) | 1.31 (1.14) | 1.57 (1.24) | 1.28 (1.12) |
| 7 | Diflubenzuron 25% WP + NSE | 0.015 % + 5% | 0.81 (0.89) | 1.23 (1.10) | 1.37 (1.17) | 1.14 (1.05) |
| 8 | Untreated control | - | 1.31 (1.14) | 1.60 (1.25) | 1.85 (1.36) | 1.59 (1.25) |
| | F test | | NS | NS | NS | NS |
| | SE (m) ± | | 0.06 | 0.08 | 0.08 | 0.07 |

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

The data presented in Table 21 regarding chrysopids population, recorded at different intervals of observation after each treatment spray was found non-significant. However, numerically a greater number of chrysopids were recorded in the untreated control plot (1.59/plant). Whereas, the population of chrysopids ranged between 0.83 to 1.59 per plant in the plots treated with different IGR's.

**Lady bird beetle**

**Chrysopa**

**Spider**

**Plate 3. Natural enemies observed on cotton**

**Table 22: Cumulative effect of IGR's on population of spider**

| Sr. No | Treatments | Conc. | Number of spider /plant | | | Mean |
|---|---|---|---|---|---|---|
| | | | 3 DAS | 7DAS | 14 DAS | |
| 1 | Buprofezin 25% SC | 0.05% | 1.21 (1.10) | 1.27 (1.13) | 1.39 (1.18) | 1.29 (1.13) |
| 2 | Pyriproxyfen 10% EC | 0.02% | 1.18 (1.09) | 1.21 (1.10) | 1.34 (1.16) | 1.24 (1.12) |
| 3 | Diflubenzuron 25% WP | 0.015% | 1.08 (1.04) | 1.18 (1.08) | 1.21 (1.10) | 1.11 (1.07) |
| 4 | NSE | 5% | 1.38 (1.17) | 1.43 (1.19) | 1.53 (1.24) | 1.45 (1.20) |
| 5 | Buprofezin 25% SC + NSE | 0.05 % + 5% | 1.34 (1.16) | 1.41 (1.19) | 1.49 (1.22) | 1.41 (1.19) |
| 6 | Pyriproxyfen 10% EC + NSE | 0.02 % +5% | 1.29 (1.13) | 1.38 (1.17) | 1.51 (1.23) | 1.39 (1.18) |
| 7 | Diflubenzuron 25% WP + NSE | 0.015 % + 5% | 1.26 (1.12) | 1.31 (1.14) | 1.47 (1.21) | 1.34 (1.16) |
| 8 | Untreated control | - | 1.43 (1.20) | 1.61 (1.27) | 1.56 (1.25) | 1.53 (1.24) |
| | F test | | NS | NS | NS | NS |
| | SE (m) ± | | 0.04 | 0.03 | 0.04 | 0.04 |

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

The results tabulated in Table 22 revealed non-significant differences among the treatments in respect of spider population recorded at different intervals of observations after each treatment sprays. The population of spider recorded in different plots treated with IGR's ranged between 1.11 to 1.53 spiders per plant. Whereas, in untreated control plots numerically higher number of spider were observed (1.53spiders/plant).

The results revealed that all the treatments under the present investigation proved less detrimental to the predatory fauna like spiders, chrysopids and coccinellids in cotton ecosystem. This results are in accordance with earlier worker Gogi et al. (2006) determined the effect of buprofezin @ 370 and 555 ml /ha on population of associated arthropod predators namely geocorids, chrysopids, coccinelids, formicides and arachnids. The result revealed that, at lower doses IGR's appeared safe to predator population which did not differed significantly in IGR's treated versus untreated control plots. Similarly, Ananthi et al. (2017) reported that, the plants sprayed with neem seed kernel extract 5% protected the population of natural enemies like spiders and coccinellids as against imidacloprid spray in chilli ecosystem. The plant products had no toxicity on eggs, larvae, adults and fecundity of the predator. The neem products must be ingested to be effective, therefore insects, which feed on plant tissues, are affected by the extract and those which feed on other insects rarely contact lethal concentrations, which may lead to their insensitivity to the neem extracts. Moreover, Khan et al. (2017) carried out the field experiment and concluded that, the four sprays of NSKE 5% at 2, 5, 7 and 11 weeks after transplanting of chilli crop harboured highest number of *Chrysoparla carnea* as against chemical pesticide practices. Dutta et al. (2016) conducted field trial with new generation insecticides and botanical against mustard aphids and their toxicity to coccinellid predators and foraging honeybees. They reported that, at 3 DAS among the treatments, significantly highest population of coccinellid beetles was observed in plots treated with Azadirachtin (7.12 beetles / 5 plants) followed by buprofezin (5.62 beetles/ 5 plants). Whereas, Naik et al. (2017) evaluated the impact of some insecticides, biopesticides and botanicals on sucking pest management in cotton under high density planting system. They recorded 0.69, 0.53 and 0.30/ plant population of spider, coccinellids and chrysopids in the plots treated with buprofezin 25 SC, respectively. Further they concluded this insecticide was found to be ecofriendly and safe to natural enemies. Similarly, Ravichandra et al. (2014) recorded higher population of mirid bugs and spiders/hill after 7 days of spray of buprofezin 25% SC @ 1.0 ml/l in paddy.

### 4.21 Effect of IGR's on seed cotton yield

The application of buprofezin 25% SC was found most promising treatment with seed cotton yield of 13.40 q/ha (Table 23 and Fig.21). However, this treatment was found at par with pyriproxyfen 10%

EC (12.39 q/ha) and buprofezin 25% SC + NSE 5% (11.09 q/ha). The treatments viz; pyriproxyfen 10% EC + NSE 5%, NSE 5%, diflubenzuron 25% WP + NSE 5% and diflubenzuron 25% WP recorded seed cotton yield of 11.37,11.09,10.70 and 9.77 q/ha, respectively. All these treatments were found statistically equal with each other. Whereas, lowest yield was harvested in untreated control (7.12 q/ha).

**Table 23: Cumulative effect of IGR's on seed cotton yield**

| Sr. No. | Treatments | Conc. | Seed cotton yield (q/ha) | | | |
|---|---|---|---|---|---|---|
| | | | RI | RII | RIII | Mean |
| 1 | Buprofezin 25% SC | 0.05% | 12.18 | 14.06 | 13.96 | 13.40 |
| 2 | Pyriproxyfen 10% EC | 0.02% | 13.12 | 11.12 | 13.03 | 12.39 |
| 3 | Diflubenzuron 25% WP | 0.015% | 8.96 | 11.03 | 9.32 | 9.77 |
| 4 | NSE | 5% | 10.15 | 12.04 | 11.09 | 11.09 |
| 5 | Buprofezin 25% SC + NSE | 0.05 % + 5% | 11.07 | 12.22 | 12.08 | 11.79 |
| 6 | Pyriproxyfen 10% EC + NSE | 0.02 % +5% | 11.13 | 12.03 | 10.96 | 11.37 |
| 7 | Diflubenzuron 25% WP + NSE | 0.015 % + 5% | 9.46 | 12.08 | 10.57 | 10.70 |
| 8 | Untreated control | - | 8.12 | 6.14 | 7.09 | 7.12 |
| | F test | - | | | | Sig |
| | SE (m) ± | - | | | | 0.56 |
| | CD @ 5% | - | | | | 1.72 |
| | CV (%) | - | | | | 8.98 |

**4.22 Incremental cost benefit ratio for different treatments**

The data presented in Table 24 revealed that, treatment with buprofezin 25% SC emerged as the most economically viable treatment giving the highest ICBR of 1:6.6. It was followed by the treatment NSE 5% (1:3.8) and buprofezin 25% SC + NSE 5% (1:3.6). The next better treatments *viz.,* pyriproxyfen 10% EC, pyriproxyfen 10% EC + NSE 5%, diflubenzuron 25% WP and diflubenzuron 25% WP + NSE 5% gave ICBR of 1:3.0, 1:1.8, 1:1.7 and 1:1.6, respectively.

The present results regards to the effect of different IGR's on seed cotton yield and cost effectiveness of different treatments against sucking pests finds support in the work carried out by the earlier worker like Nemade et al. (2017) in the field experiment on the evaluation of new molecules against sucking pests of *Bt* cotton obtained seed cotton yield of 1103.55 kg/ha from the plots treated with buprofezin 25 SC as against untreated control (715.28 kg/ha). Similarly, Kalyan et al. (2017) also recorded maximum seed cotton yield (2536 kg/ha) in buprofezin 25 SC @ 250 g a.i./ha with highest net profit of Rs. 35,708/ha as against untreated control (1735 kg/ha). Similar results were also reported by Hegde *et al.* (2009) evaluated the effect of newer insecticides on planthoppers and their mirid predators in rice ecosystem. They obtained higher yield with maximum net returns and benefit cost ratio with buprofezin 25 SC as against untreated control. Whereas, Kumar et al. (2018) evaluated the bio-efficacy of newer insecticides against thrips and leafhoppers in groundnut and reported that considering the cost effectiveness of various treatments, buprofezin 25 SC registered with highest net return of Rs. 24140/ ha and 22.2 benefit cost ratio.

However, the earlier worker Choudhary et al. (2015) evaluated the bioefficacy of pyriproxyfen 10 EC at different doses against sucking pest of cotton. Significantly highest seed cotton yield (1331 and 1327 kg/ha) was picked by pyriproxifen 10 EC @ 125 g a.i./ha during 2010 and 2011, respectively, proving it better than commercial check acetamiprid 20 SP @ 20g a.i./ha and difenthiuron 50 WP @ 300g a.i./ha. Whereas, Meena et al. (2013) reported that the treatment NSKE 5% recorded maximum mustard seed yield and cost benefit ratio as against untreated control. Similar results were also reported by Hole et al. (2015) who recorded seed cotton yield of 12.31 q/ha in treatment with NSE 5%. Moreover, Singh et al. (2013) evaluated the microbial agents and plant products against mustard aphid, *Lipaphis erysimi* (Kalt.) and reported the cost effectiveness of treatment NSKE 5%.

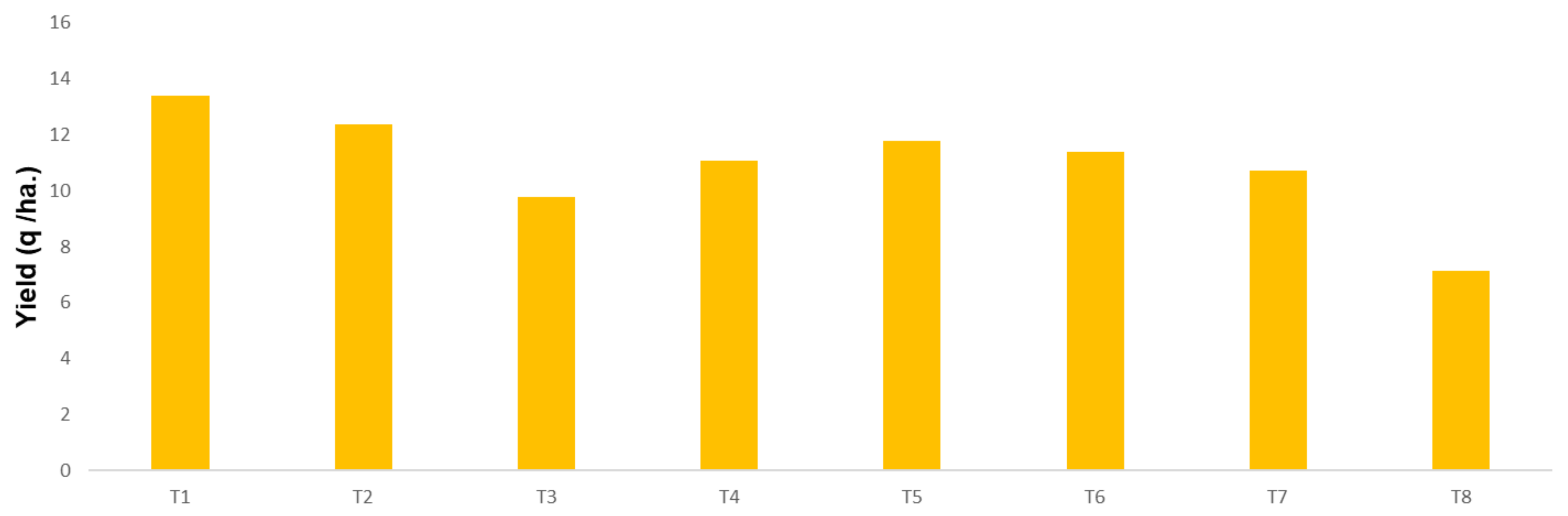


**Fig. 21. Effect of IGR's on seed cotton yeild**

**$T_1$: Buprofezin 25% SC** **$T_2$: Pyriproxyfen 10% EC** **$T_3$: Diflubenzuron 25% WP** **$T_4$: NSE 5%**

**$T_5$: Buprofezin 25% SC + NSE 5%** **$T_6$: Pyriproxyfen 10% EC + NSE 5%** **$T_7$: Diflubenzuron 25% WP + NSE 5%**

**$T_8$: Untreated control**

**Table 24: Incremental cost benefit ratio for different treatments**

| Sr. No. | Treatments | Quantity of pesticides (ml/g or kg/ha) | No. of sprays | Cost of pesticides (Rs/ha) | Labour and sprayer charges (Rs/ha) | Cost of plant protection (Rs/ha) (A) | Yeild of seed cotton (q/ha) | Increase in yield over control (q/ha) | Value of increased yield over control (Rs/ha) @ Rs. 5500 (B) | Net gain over control (C) (B-A) | ICBR | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Buprofezin 25% SC | 1000 | 4 | 2528 | 2040 | 4568 | 13.40 | 6.28 | 34540 | 29972 | 1:6.6 | I |
| 2 | Pyriproxyfen 10% EC | 1000 | 4 | 5200 | 2040 | 7240 | 12.39 | 5.27 | 28985 | 21745 | 1:3.0 | IV |
| 3 | Diflubenzuron 25% WP | 300 | 4 | 5256 | 2040 | 7296 | 10.70 | 3.58 | 19690 | 12394 | 1:1.7 | VI |
| 4 | NSE | 25 | 4 | 1000 | 2040 | 3040 | 9.77 | 2.65 | 14575 | 11535 | 1:3.8 | II |
| 5 | Buprofezin 25% SC + NSE | 1000 + 25 | 4 | 2528+1000 | 2040 | 5568 | 11.79 | 4.67 | 25685 | 20117 | 1:3.6 | III |
| 6 | Pyriproxyfen 10% EC + NSE | 1000 + 25 | 4 | 5200+1000 | 2040 | 8240 | 11.37 | 4.25 | 23375 | 15135 | 1:1.8 | V |
| 7 | Diflubenzuron 25% WP + NSE | 300 + 25 | 4 | 5256+1000 | 2040 | 8296 | 11.09 | 3.97 | 21835 | 13539 | 1:1.6 | VII |
| 8 | Untreated control | - | - | - | - | - | 7.12 | - | - | - | - | - |

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. 5500/qtl.

**Cost of Insecticides:** Buprofezin 25% SC @ 632/1000ml, Pyriproxyfen 10% EC @ 1300/1000ml, Diflubenzuron 25% WP @ 1314/300gm, NSE @ 250/25kg.

## CHAPTER V

# SUMMARY AND CONCLUSSION

The present investigation entitled "Evaluation of Insect growth regulators against cotton sucking pests'' was carried out on the field of Department of Agricultural Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *kharif* 2019-20. The experiment was laid out in randomized block design with three replications and eight treatments.

The treatments included *viz.,* buprofezin 25% SC, pyriproxyfen 10% EC, diflubenzuron 25% WP, NSE 5%, buprofezin 25% SC + NSE 5%, pyriproxyfen 10% EC + NSE 5% and diflubenzuron 25% WP + NSE% were tested against sucking pests *viz.,* aphids (*Aphis gossypii,* G.), leafhoppers (*Amrasca biguttulla biguttulla,* I.), whiteflies *(Bemisia tabaci,* G.) and thrips *(Thrips tabaci,* L.) along with untreated control. In all four treatment sprays were applied at 15 days interval, of which the first spray was initiated at ETL of sucking pest complex. The data were collected on the population of sucking pests at an interval of 3, 7 and 14 days after each 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. Finally, seed cotton yield was recorded in each of the net plot, so as to compare the effect of different treatments against the sucking pests of cotton. The results of investigations are summarized in this chapter.

### 5.1 Efficacy of IGR's against cotton aphids

The minimum population of aphids at different intervals of observation were recorded from the plots treated with buprofezin 25% SC after first spray. This treatment was found at par with pyriproxyfen 10% EC. However, the latter treatment was in turn found statistically equal to buprofezin 25% SC + NSE 5%, pyriproxyfen 10% EC + NSE 5% and NSE 5%. Whereas, diflubenzuron 25% WP + NSE 5% and diflubenzuron 25% WP showed moderate effect against aphids. The maximum population of aphids was recorded in untreated control.

Same trend of efficacy was also observed after second spray. The treatments *viz.,* buprofezin 25% SC, buprofezin 25% SC + NSE 5%, pyriproxyfen 10% EC, pyriproxyfen 10% EC + NSE 5% proved equally effective in recording minimum aphid population. Whereas, NSE 5% and diflubenzuron 25% WP + NSE 5% exhibited moderate impact in this respect as against diflubenzuron 25% WP and untreated control.

Significantly lowest number of aphids after third spray was recorded from the plots treated with buprofezin 25% SC. The treatment with pyriproxyfen 10% EC and buprofezin 25% SC + NSE 5% proved statistically equal with each other in recording minimum number of aphids. Whereas, pyriproxyfen 10% EC + NSE 5% and NSE 5% appeared as next better treatments in this respect. However, in plots treated with diflubenzuron 25% WP + NSE 5% and diflubenzuron 25% WP relatively more number of aphids was observed. The untreated control plots recorded highest number of aphids.

The cumulative effect of three sprays of different treatments inferred that, buprofezin 25% SC recorded the lowest population of aphids and found at par with pyriproxyfen 10% EC. However, the latter treatment was in turn found statistically equal to buprofezin 25% SC + NSE 5%, pyriproxyfen 10% EC + NSE 5% and NSE 5%. Whereas, the diflubenzuron 25% WP + NSE 5% and diflubenzuron 25% WP proved less effective against aphids. However, both this treatment were found at par with untreated control.

**5.2 Efficacy of IGR’s against cotton leafhoppers**

Among the different treatments tested significantly minimum number of leafhoppers was recorded in buprofezin 25% SC, pyriproxyfen 10% EC and buprofezin 25% SC + NSE 5% after first spray. Whereas, pyriproxyfen 10% EC + NSE 5% and NSE 5% appeared as next better treatments in this respect. However, diflubenzuron 25% WP + NSE 5% and diflubenzuron 25% WP recorded comparatively higher number of leafhoppers were found at par with untreated control.

Same trend of efficacy was also observed after second spray. The treatment buprofezin 25% SC proved effective with minimum number of leafhoppers. This treatment was found at par with pyriproxyfen 10% EC and buprofezin 25% SC + NSE 5%. The treatments pyriproxyfen 10% EC + NSE 5%, NSE 5% and diflubenzuron 25% WP + NSE 5% appeared as next better treatments in this respect. Highest number of leafhoppers was recorded in diflubenzuron 25% WP and untreated control.

Minimum population of leafhoppers after third spray was recorded from the plots treated with buprofezin 25% SC. However, this treatment proved statistically equal with pyriproxyfen 10% EC, buprofezin 25% SC + NSE 5%, pyriproxyfen 10% EC + NSE 5% and NSE 5%. Whereas, diflubenzuron 25% WP + NSE 5% and diflubenzuron 25% WP exhibited moderate impact in this respect. Significantly highest number of leafhoppers was recorded in untreated control.

After fourth spray, the treatment buprofezin 25% SC recorded minimum population of leafhoppers and found at par with pyriproxyfen 10% EC, buprofezin 25% SC + NSE 5% and pyriproxyfen 10% EC + NSE 5%. Whereas, the treatment NSE 5% and diflubenzuron 25% WP + NSE 5% exhibited moderate impact in this respect as against diflubenzuron 25 % WP and untreated control.

The cumulative effect of four sprays of different treatments inferred that, treatment buprofezin 25% SC recorded minimum population of leafhoppers. However, this treatment was found statistically equal with pyriproxyfen 10% EC and buprofezin 25% SC + NSE 5%. The treatment pyriproxyfen 10% EC + NSE 5%, NSE 5% and diflubenzuron 25% WP + NSE 5% proved moderately effective in reducing the population of leafhoppers. Maximum number of leafhoppers was observed in plots treated with diflubenzuron 25% WP and untreated control.

### 5.3 Efficacy of IGR’s against cotton whiteflies

The treatment pyriproxyfen 10% EC recorded minimum population of whiteflies at different intervals of observation after first spray. This treatment was found statistically equal with buprofezin 25% SC, pyriproxyfen 10% EC + NSE 5% and buprofezin 25% SC + NSE 5%. The treatment NSE 5% and diflubenzuron 25% WP + NSE 5% exhibited moderate impact in this respect as against diflubenzuron 25% WP and untreated control.

Same trend of efficacy was also observed after second spray. The plots treated with pyriproxyfen 10% EC, pyriproxyfen 10% EC + NSE 5% and buprofezin 25% SC recorded minimum whitefly population. Whereas, treatment buprofezin 25% SC + NSE 5% and NSE 5% appeared as next better treatments. The treatment diflubenzuron 25% WP + NSE 5% proved moderately effective. Maximum number of whiteflies was observed in plots treated with diflubenzuron 25% WP and untreated control.

Minimum population of whiteflies after third spray was observed in pyriproxyfen 10% EC and pyriproxyfen 10% EC + NSE 5%. However, latter treatment proved statistically equal with buprofezin 25% SC and buprofezin 25% SC + NSE 5%. Whereas, the treatment with NSE 5% and diflubenzuron 25% WP + NSE 5% proved moderately effective in this respect. Significantly highest number of whiteflies was recorded in diflubenzuron 25% WP which was found at par with untreated control.

After fourth spray, the treatment pyriproxyfen 10% EC recorded minimum population of whiteflies and found at par with pyriproxyfen 10% EC + NSE 5%. The treatment buprofezin 25% SC, buprofezin 25% SC + NSE 5% and NSE 5% appeared as next better treatment. Whereas, diflubenzuron 25% WP + NSE 5% exhibited moderate impact in this respect as against diflubenzuron 25% WP and untreated control.

The cumulative effect of four sprays of different treatments indicated that, the pyriproxyfen 10% EC, pyriproxyfen 10% EC + NSE 5% and buprofezin 25% SC were the most effective treatments in recording lower population of whiteflies. Whereas, buprofezin 25% SC + NSE 5%, NSE 5% and diflubenzuron 25% WP + NSE 5% appeared as next better treatments. The maximum population of whiteflies was recorded in diflubenzuron 25% WP treated plots which was found at par with untreated control.

**5.4 Efficacy of IGR's against cotton thrips.**

The treatment buprofezin 25% SC, buprofezin 25% SC + NSE 5%, pyriproxyfen 10% EC, pyriproxyfen 10% EC + NSE 5% and NSE 5% appeared as the best treatments in recording minimum population of thrips after first spray. Whereas, diflubenzuron 25% WP+ NSE 5% and diflubenzuron 25% WP proved next better treatments as against untreated control.

The treatment buprofezin 25% SC, pyriproxyfen 10% EC, buprofezin 25% SC+ NSE 5% and pyriproxyfen 10% EC + NSE 5% proved equally effective in recording lowest number of thrips at different intervals of observations after second spray. Whereas, NSE 5%, diflubenzuron 25% WP + NSE 5% and diflubenzuron 25% WP were found moderately effective. Maximum number of thrips were recorded in untreated control.

After third spray, the treatment buprofezin 25% SC recorded minimum population of thrips and found at par with buprofezin 25% SC + NSE 5%, pyriproxyfen 10% EC, pyriproxyfen 10% EC + NSE 5% and NSE 5%. Whereas, the treatment with diflubenzuron 25% WP + NSE 5% and diflubenzuron 25% WP exhibited moderate impact in this respect as against untreated control.

Minimum number of thrips were recorded from treatment buprofezin 25% SC after fourth spray. This treatment was found at par with pyriproxyfen 10% EC, pyriproxyfen 10% EC + NSE 5%, buprofezin 25% SC + NSE 5% and NSE 5%. Whereas, diflubenzuron 25% WP + NSE 5% and diflubenzuron 25% WP were found moderately effective as against untreated control.

The cumulative effect of four sprays of different treatments indicated that, the treatments with buprofezin 25% SC recorded minimum population of thrips. This treatment was found at par with pyriproxyfen 10% EC, buprofezin 25% SC + NSE 5%, pyriproxyfen 10% EC + NSE 5% and NSE 5%. Whereas, diflubenzuron 25% WP + NSE 5% and diflubenzuron

25% WP exhibited moderate impact in this respect as against untreated control.

### 5.5 Cumulative effect of IGR's 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.

### 5.7 Effect of IGR's on seed cotton yield

The result showed that, application of buprofezin 25% SC was the most promising treatment in increasing seed cotton yield. This treatment was found at par with pyriproxyfen 10% EC and buprofezin 25% SC + NSE 5%. The next effective treatments *viz.,* pyriproxyfen 10% EC + NSE 5%, NSE 5%, diflubenzuron 25% WP + NSE 5% and diflubenzuron 25% WP recorded seed cotton yield in descending order and found superior over untreated control.

### 5.8 ICBR

The economics of different treatment sprays indicated that application of buprofezin 25% SC proved to be the most economically viable treatment with maximum ICBR. While, NSE 5% and buprofezin 25% SC + NSE 5% emerged as the next best treatments in this respect. The other treatments *viz.,* pyriproxyfen 10% EC, pyriproxyfen 10% EC + NSE 5%, diflubenzuron 25% WP and diflubenzuron 25% WP + NSE 5% appeared to be moderately economical.

### Conclusions

Finally, it is concluded that the treatment buprofezin 25% SC and pyriproxyfen 10% EC alone and in combination with NSE 5% proved effective in combating the menace of sucking pest complex *viz.,* aphids, leafhoppers, whiteflies and thrips and resulted in to highest seed cotton yield. Moreover, the treatment of buprofezin 25% SC proved as the most economically viable treatment giving the highest ICBR. It was followed by the treatment NSE 5% and buprofezin 25% SC + NSE 5%. Whereas, all the treatments proved less detrimental in respect of predatory fauna like coccinellids, chrysopids and spiders.

Thus, these IGR's 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 natural enemies.

# CHAPTER VI

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## Appendix
## Weekly weather data for the year 2019 recorded at Agro-meteorological observatory, Dr PDKV., Akola

| Weeks | Dates | Temp MAX (°C) | Temp MIN (°C) | BSH (hrs) | Ws (Km/h) | RH Morn. (%) | RH Even. (%) | Evap (mm) | RF (mm) | Rainy Days |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1-7 Jan | 29.8 | 9.4 | 8.4 | 0.7 | 68 | 22 | 4.0 | 0.0 | 0.0 |
| 2 | 8-14 | 28.1 | 10.0 | 7.8 | 1.2 | 72 | 30 | 5.0 | 0.0 | 0.0 |
| 3 | 15-21 | 29.4 | 10.4 | 7.6 | 1.2 | 66 | 24 | 5.2 | 0.0 | 0.0 |
| 4 | 22-28 | 28.1 | 14.0 | 6.1 | 1.7 | 75 | 36 | 5.0 | 0.0 | 0.0 |
| 5 | 29-4 Feb | 28.1 | 10.7 | 7.9 | 1.5 | 61 | 22 | 5.3 | 0.0 | 0.0 |
| 6 | 5-11 | 29.6 | 13.3 | 8.2 | 3.6 | 49 | 20 | 6.3 | 0.0 | 0.0 |
| 7 | 12-18 | 32.2 | 15.9 | 7.9 | 2.3 | 54 | 24 | 5.9 | 0.0 | 0.0 |
| 8 | 19-25 | 35.5 | 18.6 | 8.6 | 2.4 | 55 | 21 | 6.1 | 1.9 | 0.0 |
| 9 | 26-4 Mar | 33.2 | 17.7 | 8.9 | 4.0 | 47 | 23 | 7.8 | 0.0 | 0.0 |
| 10 | 5-11 | 33.7 | 16.2 | 9.1 | 3.2 | 48 | 21 | 7.5 | 0.0 | 0.0 |
| 11 | 12-18 | 36.8 | 16.9 | 8.5 | 3.1 | 43 | 21 | 8.1 | 0.0 | 0.0 |
| 12 | 19-25 | 37.9 | 15.9 | 8.9 | 2.2 | 47 | 18 | 8.4 | 0.0 | 0.0 |
| 13 | 26-1 | 41.2 | 18.9 | 9.1 | 3.1 | 34 | 15 | 9.6 | 0.0 | 0.0 |
| 14 | 2-8 | 42.1 | 21.3 | 8.9 | 4.4 | 39 | 20 | 10.0 | 0.0 | 0.0 |
| 15 | 9-15 | 43.1 | 23.3 | 9.4 | 4.6 | 43 | 24 | 10.8 | 0.0 | 0.0 |
| 16 | 16-22 | 38.4 | 19.7 | 7.3 | 2.5 | 53 | 31 | 8.6 | 13.5 | 1.0 |
| 17 | 23-29 | 44.3 | 24.0 | 9.6 | 3.3 | 32 | 15 | 11.4 | 0.0 | 0.0 |
| 18 | 30-6 | 42.7 | 25.5 | 8.8 | 9.9 | 42 | 23 | 13.9 | 0.0 | 0.0 |
| 19 | 7-13 | 42.0 | 25.6 | 9.5 | 7.9 | 43 | 22 | 15.4 | 0.0 | 0.0 |
| 20 | 14-20 | 42.9 | 25.7 | 9.7 | 7.9 | 37 | 17 | 15.1 | 0.0 | 0.0 |
| 21 | 21-27 | 44.4 | 27.7 | 9.7 | 7.4 | 38 | 17 | 15.6 | 0.0 | 0.0 |
| 22 | 28-3 | 44.6 | 27.9 | 9.3 | 9.7 | 39 | 16 | 15.9 | 0.0 | 0.0 |
| 23 | 4-10 | 43.2 | 26.2 | 7.6 | 11.4 | 54 | 22 | 16.8 | 4.7 | 1.0 |
| 24 | 11-17 | 41.6 | 26.3 | 9.1 | 10.3 | 49 | 25 | 15.2 | 2.8 | 1.0 |
| 25 | 18-24 | 38.5 | 23.3 | 6.6 | 9.8 | 66 | 40 | 10.6 | 47.7 | 1.0 |
| 26 | 25-1 | 33.8 | 21.2 | 5.2 | 5.5 | 84 | 54 | 8.0 | 34.4 | 3.0 |
| 27 | 2-8 | 30.2 | 20.0 | 0.7 | 9.4 | 89 | 68 | 4.6 | 53.8 | 6.0 |
| 28 | 9-15 | 33.5 | 21.5 | 4.5 | 8.3 | 78 | 49 | 6.3 |  | 1.0 |
| 29 | 16-22 | 34.9 | 21.8 | 7.1 | 6.2 | 79 | 48 | 7.6 | 27.3 | 2.0 |
| 30 | 23-29 | 31.6 | 20.9 | 4.7 | 7.8 | 88 | 69 | 5.0 | 106. | 5.0 |
| 31 | 30-5 | 27.6 | 19.6 | 0.7 | 9.0 | 92 | 82 | 2.9 | 118. | 5.0 |
| 32 | 6-12 | 29.1 | 20.1 | 2.2 | 8.5 | 90 | 73 | 4.4 |  | 2.0 |
| 33 | 13-19 | 30.5 | 20.1 | 4.2 | 6.0 | 88 | 67 | 4.5 | 10.9 | 2.0 |
| 34 | 20-26 | 29.6 | 20.0 | 3.1 | 7.7 | 90 | 76 | 4.3 | 28.5 | 3.0 |
| 35 | 27-2 | 29.1 | 19.9 | 3.3 | 4.6 | 91 | 72 | 4.0 | 54.5 | 3.0 |
| 36 | 3-9 | 29.6 | 20.6 | 1.9 | 4.0 | 92 | 77 | 2.7 | 9.0 | 1.0 |
| 37 | 10-16 | 29.0 | 19.9 | 1.7 | 8.0 | 90 | 75 | 2.9 | 18.0 | 3.0 |
| 38 | 17-23 | 30.3 | 19.4 | 2.8 | 1.2 | 94 | 70 | 2.2 | 118. | 4.0 |
| 39 | 24-30 | 30.6 | 19.5 | 4.5 | 1.3 | 94 | 67 | 3.1 | 82.0 | 4.0 |
| 40 | 1-7 Oct | 32.3 | 20.0 | 7.6 | 1.5 | 90 | 57 | 4.7 | 6.4 | 1.0 |
| 41 | 8-14 | 32.3 | 17.9 | 8.1 | 0.6 | 88 | 48 | 4.3 | 0.0 | 0.0 |
| 42 | 15-21 | 30.5 | 16.5 | 5.0 | 0.8 | 91 | 58 | 3.9 | 11.2 | 1.0 |
| 43 | 22-28 | 26.8 | 17.6 | 0.7 | 0.8 | 95 | 79 | 2.2 | 67.5 | 5.0 |
| 44 | 29-4 | 30.3 | 18.0 | 4.9 | 0.5 | 93 | 61 | 3.1 | 11.8 | 1.0 |
| 45 | 5-11 | 31.3 | 16.4 | 7.5 | 0.5 | 90 | 50 | 3.5 | 0.0 | 0.0 |
| 46 | 12-18 | 30.2 | 11.9 | 8.0 | 0.9 | 90 | 40 | 3.9 | 0.0 | 0.0 |
| 47 | 19-25 | 30.3 | 13.4 | 7.8 | 0.5 | 89 | 40 | 3.8 | 0.0 | 0.0 |
| 48 | 26-2 | 30.3 | 15.6 | 7.2 | 0.7 | 90 | 44 | 3.5 | 0.0 | 0.0 |
| 49 | 3-9 | 29.0 | 14.8 | 7.0 | 1.0 | 83 | 37 | 4.2 | 0.0 | 0.0 |
| 50 | 10-16 | 29.5 | 16.6 | 5.9 | 0.7 | 89 | 49 | 3.1 | 1.2 | 0.0 |
| 51 | 17-23 | 27.2 | 15.8 | 4.1 | 0.2 | 90 | 49 | 2.9 | 0.0 | 0.0 |
| 52 | 24-31 | 25.9 | 13.5 | 3.9 | 1.1 | 81 | 47 | 3.7 | 13.0 | 2.0 |