"EVALUATION OF DIFFERENT INSECTICIDES AGAINST DEFOLIATORS AND HEAD BORERS OF SUNFLOWER"

By

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B.Sc. (Agri.)

MASTER OF SCIENCE

(Agriculture)

IN

AGRICULTURAL ENTOMOLOGY

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY
COLLEGE OF AGRICULTURE, BADNAPUR
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PARBHANI- 431 402 (M.S.) (INDIA)

2017

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DISSERTATION

Submitted to
The Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani
in partial fulfilment of the requirements for the Degree of

MASTER OF SCIENCE

(AGRICULTURE)

IN

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DEPARTMENT OF AGRICULTURAL ENTOMOLOGY
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VASANTRAO NAIK MARATHWADA KRISHI VIDYAPEETH, PARBHANI

2017

DEDICATION

Dedicated

to

Beloved

My Sweet Family,

Friends

and

Research Guide

CANDIDATE'S DECLARATION

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hereby

declare that the

dissertation or part thereof,

has not been previously submitted

by me for a degree of any

University.

Place: Badnapur
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CERTIFICATE - I

This is to certify that the dissertation entitled **"EVALUATION OF DIFFERENT INSECTICIDES AGAINST DEFOLIATORS AND HEAD BORERS OF SUNFLOWER"** submitted by Mr .**RANJEET ASHOKRAO DESHMUKH** to the Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (Agriculture)** in the subject of **AGRICULTURAL ENTOMOLOGY** is record of original and *bonafide* research work carried out by him under my guidance and supervision. It is of sufficiently high standard to warrant its presentation for the award of the said degree.

I also certify that the dissertation or part thereof has not been previously submitted by him for a degree of any university.

Place: Badnapur
Date: 30/ 5 /2017

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Advisory Committee

CERTIFICATE – II

This is to certify that the dissertation entitled **"EVALUATION OF DIFFERENT INSECTICIDES AGAINST DEFOLIATORS AND HEAD BORERS OF SUNFLOWER"** submitted by Mr **RANJEET ASHOKRAO DESHMUKH** to the Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (Agriculture)** in the subject of **AGRICULTURAL ENTOMOLOGY** has been approved by the student's advisory committee after viva-voce examination in collaboration with the external examiner.

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ACKNOWLEDGEMENT

"Education is the milk of tigress who will drink he can't stay without roaring "

OR

"Life is not really measured in how many years you live its measured in how greatly you lived"

Achievement is of no mean, without the sense of gratefulness and the recognition of this is beginning of wisdom.

Thanks to the Almighty God for giving me this opportunity to express my heartfelt gratitude to all the dedicated people whose moral support and kind co-operation encouraged me during the course of investigation.

I think it is the matter of pleasure to glance back and recall the way one pass through, the days of hard work and perseverance. It is still great at the juncture to recall the faces and spirits in the form of teachers, friends, near and dear once. In my opinion, this work is nothing more than incomplete, without attending to the task acknowledge mending, to overwhelming help I received during this endeavour of mine.

Inspiration is the best medicine which can make it possible to run for crippled one and it is variable gold of mine to get the talented and inspiring wilful guidance of ***B.V. Patil,*** *Associate Prof., Department of Agricultural Entomology, College of Agriculture, Badnapur and Chairman of my advisory committee, who in this unique way, provided me with constant encouragement inspiring, scholastic guidance, love and affection offered to me during the course of my study and research works would be a poor vehicle to communicate him my sense of gratitude.*

I wish to express my sincere thanks to ***Dr. B. Venkateswarlu,*** *hon. Vice- Chancellor, V.N.M.K.V., Parbhani.* ***Dr. A. S. Dhawan,*** *Director of Instruction and Dean (F/A) V.N.M.K.V., Parbhani.* ***Dr. D.P. Waskar,*** *Director of Research, V.N.M.K.V., Parbhani.* ***Dr. B. B. Bhosale,*** *Director of Extention Education and Head Department of Agricultural Entomology, V.N.M.K.V., Parbhani.* ***Dr. D. N. Gokhale,*** *Associate Dean (PG), V.N.M.K.V., Parbhani.* ***Dr. G.M.Waghmare*** *Associate Dean and Principal, College of Agriculture, Badnapur. And* ***Dr. R. S. Patil*** *(former Associate Dean and Principal, College of Agriculture, Badnapur.) for providing necessary facilities during the cource of investigations.* ***Dr. D. K. Patil,*** *Officers In-charge, ARS, Badnapur.*

My cordial thanks is to member of my advisory committee, ***Dr. D. G. Hingole,*** *Assistant Professor, Deparment of Plant Pathology, College of Agriculture, Badnapur,* ***Dr. S. D. Bantewad*** *senior Scientist ARS, Badnapur and may be regarded as the light hours for the* *ocean liners who have been kindly navigate my ship of academic pursuit and I would like to mention my gratitude to them.*

My sincere thanks to ***Mr. Vishnu mama, Dagadu mama*** *and* ***Sawant mama*** *for hands of co-operation during the research work.*

No words are enough to express the great sacrifice, devotion, constant encouragement and inspiration of my respected and adorable my dear father ***Shr.Deshmukh Ashokrao Yashwntrao,*** *mother* ***Sau. Shaila Ashokrao Deshmukh*** *and my brother* ***Amarjeet Deshmukh ,Sister in law Neeta Amarjeet Deshmukh*** *and Brother in law* ***Mr.Maheshrao*** *and* ***Ravindra*** *without their support, affection, love and guidance I would not have successful in this difficult endeavour of post graduation studies.*

My humble thankful are towards my seniors Shankar, Sandeep, Sharad, Neha, Chiranjeevi, Shriram, Satish and my room partners Sachin , Gaurav, Pandu, Balu ,Ankush, Chandu, and batchment friends Sudham, Pandu, Rahul, Kunal, Prakash, Sadar sir, Raju, Pravin, Vikas, Raju, Gavhane, Akshay, Tirupati, and Rupali, Madhushri, Chaitali, Shrivarsha , Shubhangi, Sarika, Shital, Pooja, Akshata and najneen, who supported me strongly and beliefly to carry out this research work. My sincere thanks for extending hands of co-operation to my juniors Charu, Suraj, Mahesh, Swami, Sangram, Sagar and Kanchan, Nirma, Sukanya, Priyanka during the research work.

I not missing to my friends Sachin, , Gaurav, Pandu, Balu ,Sudham, Ankush, Rahul, Kunal, Prakash, Raju, Antariksh and pravin his guidance and supports for completed my education.

I special thanks to Pravin Huse for providing to daily ***(special poha & chaha)*** *and anather one is Santosh bhau for providing to daily* ***(Samosa with souse).***

I also express my sincere thanks to myself to support me physically and mentally during the programme of research work and its success.

In advertently I might have forgotten to mention the names of invisible hand for their help, I am thankful to them as well.

Last but not least my warm acknowledgements to farmers, soldiers, scientists and great social workers, who have devoted their whole life for the country.

Thanks…….

Place: Badnapur

Date: 30/ 5 /2017 ***(Deshmukh R.A.)***

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Introduction

Chapter - I

INTRODUCTION

Sunflower (*Helianthus annuus* L.) belongs to family compositae originated in Mexico and Peru, introduced into India in the 16th century. The phenomenal increase in area and production of sunflower in the country since its introduction is due to wide adaptation, photo insensitivity and good quality of edible oil (Virupakshappa and Somasekhara, 1997).

Among the four major oilseed crops in the world *viz*., soybean, brassicas, sunflower and groundnut, sunflower ranks third in the total area cultivated and fourth in total production. In India, during 2014-15 sunflower was cultivated on an area of 0.69 million hectares with 0.55 million tonne of production and 705 kg per hectare of productivity. The major States growing sunflower are Karnataka, Andhra Pradesh, Maharashtra, Odisha, Bihar, Haryana, Punjab, Tamil Nadu and West Bengal. Karnataka was leading State in sunflower production (52.16 per cent) followed by Andhra Pradesh(17.93 per cent) and Maharashtra (3.44 per cent). But highest productivity of 1198 kg per hectare was recorded from Tamil Nadu. Maharashtra ranked third in area and production of sunflower.

In Maharashtra, during 2013-2014 sunflower was grown on an area of 0.06 million hectare with 0.04 million tonne of production and 382 kg per hectare of productivity (Anonymous, 2014). It is one of the major oilseed crops of Marathwada region of Maharashtra state.

Modern cultivated varieties of sunflower reach a plant height between 1.5 and 2.5 m at flowering and have strong taproot, from which deeply-penetrating lateral roots develop. There is one apical inflorescence on a stem of 20-30 leaves. Leaves are large, dark green and roughly heart shaped, they have a wrinkled surface and prominent veins.

Sunflower is one of the most important oilseed crops. Sunflower contains 32 to 44 per cent oil, 20 to 24 per cent vitamins, 18 to 22 per cent carbohydrates and 4 to 6 per cent salts. Its oil is considered as premium because of its high polyunsaturated fatty acid content with high level of linoleic acid and absence of linolenic acid. Sunflower oil is a rich source of linoleic acid (64 per cent) which helps in washing out cholesterol deposition in the coronary arteries of the heart and thus good for heart patients. The oil is used for culinary purposes, in the preparation of margarine and in the manufacture of paints, soaps and cosmetics. The oil cake contains 40-44 per cent high quality protein. It is ideally suited for manufacturing baby foods, poultry and livestock rations.

The flower head typically has a diameter of 15-30 cm which consists of mostly yellow and sterile ligulate or ray flowers and the fertile disc or tube flowers. The flowers tend to be cross-pollinating and the best temperature range for the production of seed is 20-25°C. Seed and oil yield are reduced under conditions of stress. Oilseed producing varieties have a 1000 seed weight of 40 to 60g and non-oilseed varieties have a 1000 seed weight of sometimes over 100g.

In spite of importance of this crop in Indian economy, the work on insect-pests of sunflower was more or less neglected. Being photo insensitive, it is grown in *kharif, rabi* and summer seasons. The cultivation of sunflower round the year has led to an increase in number of pests. Sandhu *et al.* (1973) reported 43 insect species feeding on sunflower in Punjab. Rangrajan *et al.* (1975) reported 25 insect-pests feeding on sunflower in tamil Nadu. Bilapate *et al.* (1994) reported 20 insect-pests feeding on sunflower in Marathwada region of Maharashtra State.

Sunflower serves as a host for more than fifty insect species in India, out of which capitulum borer, *Helicoverpa armigera* (Hubner), Tobacco caterpillar , *Spodoptera litura* (Fabricius), Red hairy caterpillar, *Amsacta moorie* (Buttler) and Bihar hairy caterpillar, *Spilosoma obliqua* (Walker) are reported as regular and key pests of sunflower in Marathwada region of Maharashtra state.

Several insecticides have been recommended against sunflower insect-pests for their effective management. But according to several reports many of these label claimed insecticides could not gave effective results. Hence, these label claimed insecticides with some new insecticides should have to be reevaluated against sunflower insect-pests for effective management. In addition, the residual toxicity resulting from foliar spray of insecticides could be of great significance in indicating an effective periods over which an insecticide could persist in biologically active stage and their periodic evaluation for the effectiveness is also essential under field condition.

Infestation of sucking insect-pests is becoming a major concern in obtaining expected yield from sunflower crop because it's incidence start from seedling stage and prevail through the entire plant life. Both nymphs and adults of jassid desap the plant and shows symptoms like stunted growth, burning of leaf margins, cupped and crinkled leaves. In severe case if infestation occurs, characteristic "hopper burn" symptoms are noticed. Both nymphs and adults of aphid suck the cell sap from leaves and stem and make the plant weak. Besides this, they also secrete honey dew like substance on plant surface which attracts black sooty mould and interferes in the photosynthetic activity. However, whitefly nymphs and adults also desap the plant and shows symptoms like stunted growth and yellowing of leaves. Besides these sucking insect-pests are known as vector for carrying different diseases. Sucking insect-pests of sunflower reported to incur 44 per cent of yield losses (Kakakhel *et al.*, 2000).

The climatic factors such as temperature, rainfall and humidity usually act in an independent manner influencing insects to a greater or lesser extent. The studies on population dynamics are envisaged to have an insight into the predisposing ecological factors for occurrence of the pest. Keeping this fact in mind the present investigations were undertaken with following objectives

OBJECTIVES

1. To study the bioefficacy of different Insecticides against major pests of sunflower.
2. To study the population dynamics of major pests of sunflower.
3. To study the effect of insecticides on natural enemies.

Review of Literature

Chapter - II

REVIEW OF LITERATURE

The pertinent literature to various aspect of investigation has been reviewed and grouped under the following heads.

2.1 To study the bioefficacy of different Insecticides against major pests of sunflower.

2.2 To study the population dynamics of major pests of sunflower.

2.3 To study the effect of insecticides on natural enemies.

2.1 To study the bioefficacy of different Insecticides against major pests of sunflower.

Kumar *et.al.,* in (2015) carried out investigation on Bioefficacy of nine modern insecticides under field condition against *S. litura* on groundnut and revealed that emamectin benzoate 0.005 per cent, chlorpyriphos 0.05 per cent, cypermethrin 0.016 per cent and chlorantraniliprole 0.006 per cent were found to be the more effective. On the other hand, indoxacarb 0.008 per cent and spinosad 0.009 per cent were found to be the less effective. Looking to the efficacy of all the insecticides emamectin benzoate 0.005 per cent, chlorpyriphos 0.05 per cent, cypermethrin 0.016 per cent and chlorantraniliprole 0.006 per cent can be suggested to the farmers for the management of *S. litura* in groundnut.

Gadhiya *et al.* (2014) conducted field trial to evaluate efficacy of emamectin benzoate 5 WG at the rate of 0.002 per cent , thiodicarb 75 WP at the rate of 0.075 per cent , indoxacarb 14.5 SC at the rate of 0.007 per cent, spinosad 45 SC at the rate of 0.018 per cent, novaluron 10 EC at the rate of 0.01 per cent, lufenuron 5 EC at the rate of 0.005 per cent, flubendiamide 480 SC at the rate of 0.014 per cent, chlorantraniliprole 20 SC at the rate of 0.006 per cent and metaflumizone 22 SC at the rate of 0.044 per cent against *Helicoverpa armigera* (Hubner) and *Spodoptera litura* (Fabricius) infesting groundnut. Among nine insecticides, chlorantraniliprole (0.006 per cent), spinosad (0.018 per cent) and emamectin benzoate (0.002 per cent) were noticed more effective and statistically at par with each other in protecting the groundnut crop from the infestation of both pests. Highest cost benefit ratio of 1:3.3 was observed in chlorantraniliprole (0.006 per cent) followed by indoxacarb (1:2.39), emamectin benzoate (1:1.69), spinosad (1:1.46) and flubendiamide (1:1.13)

Khan *et al.* (2014) conducted a field experiment to compare the efficacy of new chemistries (emamectin benzoate, spinosad) and conventional insecticides (bifenthrin, chlorpyriphos, profenophos) against *Helicoverpa armigera* (Hubner) on sunflower hybrid FH-385. The emamectin benzoate and spinosad proved to be highly effective against *H. armigera*. After 72 hours of treatment emamectin benzoate showed 95.93 per cent and 93.75 per cent, while, spinosad showed 93.02 per cent and 91.04 per cent mortality in 2010 and 2011, respectively. Whereas, the conventional insecticides i.e. bifenthrin and profenophos showed lesser mortality. Moderately effective response was observed for chlorpyriphos. The new chemistry insecticides have proven better in controlling *H. armigera* as compared to tpihe conventional ones.

Kolhe (2014) reported that among different insecticides, imidacloprid 0.003 per cent and dimethoate 0.04 per cent exhibited highest efficacy against groundnut jassids and thrips. Whereas, quinalphos 0.07 per cent followed by methomyl 0.06 per cent proved highly effective against larvae of groundnut leaf miner. Significantly highest pod yield was achieved in quinalphos 0.07 per cent (1242.85 kg per ha) followed by imidacloprid 0.003 per cent (1204.76 kg per ha) and dimethoate 0.04 per cent (1161.90 kg per ha). Based on incremental cost benefit ratio imidacloprid 0.003 per cent (1:16.52) and dimethoate 0.04 per cent (1:12.75) were found to be effective and economical treatments.

Patel *et al.* (2014) determined relative efficacy of eleven insecticides against *S. litura* infesting groundnut. Among the eleven insecticides, chlorantraniliprole 0.006 per cent caused maximum mortality of larvae to the tune of 93 per cent, followed flubendiamide 0.01 per cent (92 per cent mortality), methomyl 0.05 per cent (88 per cent mortality) and emamectin benzoate 0.0025 per cent (87 per cent mortality).

Patil *et al.,* (2014).The field experiment was conducted on the evaluation of novel insecticides *viz.*, chlorantraniliprole 18.5 per cent SC at the rate of 30 g a.i./ha, methomyl

40 per cent SP at the rate of 300 g a.i./ha, spinosad 45 per cent SC at the rate of 75 g a.i./ha, indoxacarb15.8 per cent EC at the rate of 30 g a.i./ha, thiodicarb 75 per cent WP at the rate of 7 50 g a.i./ha, triazophos 40 per cent EC at the rate of 25 g a.i./ha and profenofos 50 per cent EC at the rate of 500 g a.i./ha for the management of *Spodoptera litura* (Fabricius) and *Chrysodeixis acuta* (Walker) infesting soybean. Among these insecticides, chlorantraniliprole (30 g a.i./ha), methomyl (300 g a.i./ha) and spinosad (75 g a.i./ha) were found effective and statistically at par with each other in protecting the soybean crop from the infestation of both lepidopteran pests. Chlorantraniliprole provided consistent protection from defoliators to soybean crop from *Spodoptera litura* and *Chrysodeixis acuta* with highest cost benefit ratio (1:4.02) among the tested insecticides. Next effective treatments in recording higher ICBR were spinosad (1:3.15) and indoxacarb (1:3.11)

Sreekanth *et al.* (2014) evaluated the bio-efficacy and economics of certain new insecticides against pod borer, *Helicoverpa armigera* (Hubner) on pigeonpea. Experimental results showed that the number of *Helicoverpa* larvae per plant were lowest in plots treated with chlorantraniliprole 20 SC (0.43), flubendiamide 480 SC (0.59) and spinosad 45 SC (0.85) as against untreated control plot (4.17) with 89.7, 85.9 and 79.6 per cent larval reduction over control, respectively. Pod damage due to pod borer, *Helicoverpa armigera* was lowest in plots treated with flubendiamide (1.16 per cent), chlorantraniliprole (1.26 per cent) and spinosad (1.92 per cent) with 88.7, 87.7 and 81.2 per cent reduction over control, respectively. Highest grain yield was recorded in chlorantraniliprole treated plots (686.1 kg/ha) with 127.5 per cent increase over control, followed by flubendiamide (595.8 kg/ha) and spinosad (589.0 kg/ha) with 97.6 and 95.3 per cent increase over control, respectively as against the minimum yield of 301.6 kg/ha in the untreated check. The cost effectiveness of chlorantraniliprole and flubendiamide was also high and very favourable with incremental cost-benefit ratios of 1: 4.64 and 1: 4.50, respectively followed by indoxacarb (1: 3.67), emamectin benzoate (1: 3.13) and spinosad (1: 2.97).

Thodsare and Srivastava, (2014) studied toxicity of indoxacarb and emamectin benzoate was evaluated against 10 days old larvae of *Spilosoma obliqua* by residue contact bioassay method. The data revealed that indoxacarb was more toxic than emamectin benzoate at LC_{30} (0.004 and 0.001 per cent), LC_{50} (0.013 and 0.002 per cent) and LC_{90} (0.198 and 0.034per cent) levels, at 48 and 72 HAE, respectively. LC_{30}, LC_{50} and LC_{90} values of emamectin benzoate against 10 days old larvae of *S. obliqua* were 0.013, 0.031 and 0.28 at 48 HAE; and 0.004, 0.009 and 0.063 at 72 HAE, respectively. Indoxacarb was faster in action compared to emamectin benzoate. At a concentration of 0.02 per cent the LT_{30}, LT_{50} and LT_{90} values for indoxacarb were 16.36, 28.75 and 115.26 hrs, respectively while at 0.06 per cent concentration of emamectin benzoate (three times higher than indoxacarb) the values were 13.32, 23.31 and 92.30 hrs, respectively

Yogeeswarudu *et. al,* (2014). Evaluated that indoxacarb 14.5 SC @ 0.5 ml/L, profenofos 50 EC @ 2.0 ml/L, imidacloprid 17.8 SL @ 1 ml/L, novaluron 10 EC @ 1.5 ml/L, fipronil 5 SC @ 2.0 ml/L and lambda cyhalothrin 5 EC @ 1 ml/L was tested against *Helicoverpa armigera* larvae. The results revealed that indoxacarb 14.5 SC @ 0.5 ml/L was found best with minimum population of *Helicoverpa armigera* at first spray indoxacarb 14.5 SC @ 0.5 ml/L was found best among all the treatments with the minimum larval population at first spray first spray of 1.53, 0.46, 0.73 larvae/five plants being 89.45, 97.01, 95.83 percent reduction over control at 3 DAS, 5 DAS & 7 DAS, respectively.

Barad *et al.,* (2013) observed that emamectin benzoate 5 WG at the rate of 9.4 g a.i./ha was found to be most effective treatment against *Helicoverpa armigera* on red gram. The efficacy of emamectin benzoate 5 per cent WG at the rate of 9.4 g a.i./ha was reflected in lowest larval population and per cent pod damage (2.86 per cent) and in grain yield (876 kg /ha) of red gram which was highest among all treatments. The emamectin benzoate 5 per cent WG didn't had any adverse effect on the natural enemies and was safe to the natural enemies.

Ghandi *et al.* (2013) evaluated spinosad 45 SC (0.1 ml/l), cypermethrin 10 EC (0.5 ml/l), novaluron 10 EC (1 ml/lit), azadirachtin 5 per cent and *Bacillus thuringiensis* (1 ml/l) against ear head caterpillar *Helicoverpa armigera* in sorghum and found that spinosad 45 SC (0.1 ml/lit), novaluron 10 EC (1 ml/lit) and azadirachtin 5 per cent were emerged as superior by recording 72.0, 66.0 and 63.0 per cent population reduction and producing a grain loss of 43.46, 42.23 and 41.16 q/ha, respectively.

Nain *et.al* in (2013) evaluated the efficacy of some new insecticides in the management of head borer, *Helicoverpa armigera* (Hubner) on sunflower crop. The results revealed that maximum larval mortality (84.81%) and maximum yield (3294 kg/ha) were obtained with the treatment spinosad, which was at par with endosulfan (82.28% and 3255 kg/ha, respectively) and was followed by quinalphos (72.93% and 3147 kg/ha, respectively).

Priyadarshini *et al.* (2013) evaluated the comparative efficacy of six insecticides against pod borer complex *viz*., gram pod borer (*Helicoverpa armigera* Hubner), pod fly (*Melanagromyza obtusa* Malloch), flower Webber cum borer (*Maruca vitrata* Geyer), and plume moth (*Exelastis atomosa* Walsingham). Among all the chemicals, flubendiamide 480 SC at 60 g a.i./ha was found to be the most effective with a maximum reduction in lepidopteran pod borers with pod damage, grain damage and weight loss of 5.3, 3.3 and 2.9 per cent, respectively followed by lambda-cyhalothrin 5 EC at 25 g a.i./ ha (8.0, 3.4 and 2.9 per cent) and beta-cyfluthrin 25 SC at 18.8 g a.i./ha (10.3, 6.4 and 5.6 per cent), respectively. The highest net profit was obtained from the treatment flubendiamide 480 SC at 60 g a.i./ha (Rs. 12,638) followed by lambda-cyhalothrin 5 EC at 25 g a.i./ha (Rs. 7092), beta-cyfluthrin 25 SC at 18.8 g a.i./ha (Rs. 6462.4), while lambda-cyhalothrin 5 EC at 25 g a.i/ ha (1:7.5) recorded highest incremental cost benefit ratio followed by lambda-cyhalothrin 5 EC at 25 g a.i./ha (1:4.7) and quinalphos 25 EC at 250 g a.i./ha (1:4.4).

Kanwar *et al.* (2012) determined LC_{50} values of newer insecticides against 3 to 4 day old larvae of *H. armigera.* The lowest LC_{50} value was reported in flubendiamide 480 SC (0.00610 and 0.006163 per cent) followed by indoxacarb 14.5 SC (0.01818 and 0.02143 per cent), beta-cyfluthrin 2.5 SC (0.02808 and 0.02844 per cent) and lambda-cyhalothrin 5 EC (0.03616 and 0.03421 per cent) during 2008-09 and 2009-10, respectively. It was 11.64 to 11.85x relatively more toxic when compared to the standard check endosulfan 35 EC. Based on LC_{50} values and relative toxicity, the tested insecticides arranged in a decreasing order of toxicity as flubendiamide 480 SC >

indoxacarb14.5 SC > beta-cyfluthrin 2.5 SC > lambda-cyhalothrin 5 EC > endosulfan 35 EC.

Mohanraj *et al.* (2012) evaluated chlorantraniliprole 20 per cent SC at the rate of 10, 15, 20, 25 and 30 g a.i./ha against *Helicoverpa armigera, Maruca testulalis* and *Lampides* spp. The minimum survival of larval population was recorded with the treatment of chlorantraniliprole 20 per cent SC at the rate of 20, 25 and 30 g a.i./ha compared to the standard checks and control. The lowest pod damage and maximum pod yield were recorded in the above treatments.

Ameta *et al.* (2011) evaluated relative efficacy of flubendiamide 480 SC at 50, 75 and 100 ml/ha along with indoxacarb 14.5 SC at 500 ml /ha and spinosad 45 SC at 187.5 ml /ha against pigeonpea pod borer *viz., Helicoverpa armigera* (Hubner) and *Maruca testulasis* (L.) and revealed that all three insecticides were superior in reducing the infestation. However, flubendiamide 480 SC at 100 ml/ha caused significantly high reduction in larvae, recorded minimum flower and pod damage and significantly high seed yield. Insecticidal treatments did not cause adverse effects on population of natural enemies in pigeonpea.

Khan *et al.* (2011) evaluated the efficacy of chlorpyrifos, profenofos, emamectin benzoate, spinosad, indoxacarb, methoxyfenozide and lufenuron against the armyworm, *Spodoptera litura* (Fab.) and found that all the evaluated insecticides proved toxic for *S. litura* under laboratory conditions, but proved highly toxic as the exposure time was extended. After 3 days of the insecticide treatment, 100 per cent mortality was observed in emamectin benzoate at the rate of 100 and 110 ml/acre treatment, followed by chlorpyrifos at the rate of 1100 ml/acre (96.56 per cent), lufenuron at the rate of 55 ml/acre (86.67 per cent) and methomyl at the rate of 440 ml/acre (83.34 per cent). However, chlorpyrifos and emamectin benzoate, at all the three doses, lufenuron at the higher and recommended dose and thiodicarb, spinosad and methoxyfenozide, at higher doses, were ranked highly toxic-as these insecticides caused the highest mortality (>90 per cent) in *S. litura*.

Shinde *et al.* (2011) observed that imidacloprid 0.004 per cent was most effective treatment for the control of okra aphids and jassids. Whereas, spinosad 0.005 per cent followed by indoxacarb 0.01 per cent and profenophos 0.08 per cent were found to be more effective insecticides against okra fruit borer. Spinosad at the rate of 0.005 per cent achieved highest yield and highest incremental cost benefit ratio over rest of the treatments.

Ahmed and Prasad,(2010). Observed that indoxacarb at the rate of 60, 55 and 50 g a.i/ha proved to be the best among the treatments by recording higher mean per cent reduction in larval population of *Spodoptera exigua* with lowest per cent fruit damage and higher yields. Indoxacarb at the rate 60 and 55 g a.i/ha noted most effective against *Helicoverpa armigera* in recording higher per cent reduction in larval population over control. Indoxacarb at the rate 55 g a.i/ha was suggested as an optimum dose for the management of fruit borers on chillies

Ameta *et al.* (2010). The relative efficacy of flubendiamide 480 SC at the rate of 37.5, 50, 75 and 100 ml/ha, along with quinalphos 25 EC at the rate of 1000 ml, acephate 75 SP at the rate of 625 gm and endosulphan 35 EC at the rate of 1000 ml/ha was evaluated against *Helicoverpa armigera* in chickpea. Among all the treatments, flubendiamide 480 SC at the rate of 100 and 75 ml/ha were found significantly superior in reducing larval population of pod borer. Both the treatments also recorded significantly highest yield.

Deore *et al.* (2010) evaluated the bio-efficacy of newer insecticides against bollworm complex of cotton and indicated that emamectin benzoate 5 SC at the rate 6.75 g a.i/ha and spinosad 45 SC at the rate 75 g a.i/ha were most effective treatments in reducing bollworm infestation in fruiting bodies, locules, shed material and bad kapas content. The higher seed cotton yield was achieved by emamectin benzoate 5 SC at the rate 6.75 g a.i/ha (1246.31 kg/ha) and spinosad 45 SC at the rate 75 g a.i/ha (1156.91 kg/ha).

Govindan *et al.* (2010) reported emamectin benzoate 5 SG (at 11 and 15 g a.i. per ha) was highly effective in reducing the boll and locule damage when compared to other standard check, spinosad 45 SC (at the rate 75 g a.i. per ha) and endosulfan 35 EC (at the rate 350 g a.i. per ha). The lowest per cent boll and locule damage was recorded with the foliar application of emamectin benzoate 5 SG (at 11 g a.i. per ha) on par with emamectin benzoate 5 SG (at 15 g a.i. per ha) which also increased the yield of cotton.

Khalid and Prasad (2010) evaluated the efficacy of indoxacarb 15 per cent SC against *Helicoverpa armigera* and *Spodoptera exigua* on chilli and recorded that indoxacarb at the rate of 60, 55 and 50 g a.i./ha were proved to be the best among the treatments by recording higher mean per cent reduction in larval population of *Spodoptera exigua* with lowest per cent fruit damage and recorded higher yields. Indoxacarb at the rate of 60 and 55 g a.i./ha were effective against *Helicoverpa armigera* by recording higher per cent reduction in larval population over control.

Murali Baskaran *et al.* (2010) evaluated the bio-efficacy of various doses of emamectin benzoate 5 per cent SG against lepidopteran pests of cotton and indicated that emamectin benzoate 5 per cent SG at the rate 220 g per ha was effective treatment in managing the *Helicoverpa armigera* on cotton. However, emamectin benzoate at the rate 220 g per ha was on par with emamectin benzoate at the rate 190 g per ha in respect to yield, hence recommended emamectin benzoate at the rate 190 g per ha for the management of *Helicoverpa armigera.*

According to Mutkule *et al.* (2010) emamectin benzoate 5 per cent SC, thiodicarb 75 per cent WP, indoxacarb 14.5 per cent SC, quinalphos 25 per cent and endosulfan 35 per cent EC. The highest pod yield was recorded with the treatment of spinosad 45 per cent SC (2050 kg/ha) which was at par with the emamectin benzoate 5 per cent SC and indoxacarb 14.5 per cent SC.

Prasad and Rao (2010) evaluated the efficacy of chlorantraniliprole at different doses along with standard insecticides against *Helicoverpa armigera* on cotton and reported that chlorantraniliprole at the rate of 40 g a.i/ha and spinosad at the rate of 75 g a.i/ha exhibited lowest square damage inflicted by *H. armigera.* Chlorantraniliprole at the rate of 40 g a.i/ha and 30 g a.i/ha, spinosad 75 g a.i./ha and indoxacarb 75 g a.i./ha exhibited similar efficacy in reducing boll damage. The result concluded that chlorantraniliprole at the rate of 30 g a.i/ha was optimum dose for the effective control of *Helicoverpa armigera.*

Shinde and Shetgar (2010) studied the persistence and residual toxicity of six different insecticides against first and third instar nymphs of okra jassid, *Amrasca biguttula biguttula* and found that imidacloprid 0.004 per cent showed highest PT values of 431.5 and 367.3 and LT_{50} values to the tune of 2.73 and 1.67 days against first and third instar nymphs of *A. biguttula biguttula,* respectively as compared to other insecticides under investigation.

Aghav *et al.* (2009) evaluated the efficacy of spinosad 45 per cent SC @ 168 g a.i./ha was evaluated against *Helicoverpa armigera* on sunflower and reported that spinosad 45 per cent SC @ 168 g a.i./ha was most effective insecticide in suppressing larval population of *H. armigera* during both the seasons. Maximum grain yield of 980 kg/ha and 1128 kg/ha was obtained from the treatment with spinosad 45 per cent SC at the rate of168 g a.i./ha in *kharif* and *rabi* 2007, respectively.

Gaikwad *et al.* (2009) evaluated the efficacy of emamectin benzoate 5 SC at the rate of 6.75 g a.i/ha, spinosad 45 SC at the rate of 75 g a.i./ha, indoxacarb 14.5 SC at the rate of 75 g a.i/ha, acetamiprid 20 per cent SP at the rate of 20 g a.i./ha, fipronil 5 per cent SC at the rate of 100 g a.i/ha, cypermethrin 25 EC at the rate of 75 g a.i./ha and profenophos 50 EC at the rate of 375 g a.i./ha against bollworm complex of cotton. The novel molecule emamectin benzoate 5 per cent SG at the rate of 6.75 g a.i./ha and spinosad 45 SC at the rate of 75 g a.i./ha recorded most effective treatments in controlling the bollworms. The yield data proved that the plots treated with emamectin benzoate 5 per cent SG at the rate of 6.75 g a.i./ha was superior.

Hole *et.al.,* in (2009) evaluated bio-efficacy of cypermethrin, dichlorvos, endosulfan, profenophos and quinalphos against *Spodoptera litura* infesting soybean cv. DS-228 (Phule Kalyani). The soybean was sprayed twice with respective insecticides at three week intervals starting from 35 days after germination. The pooled data showed that all the insecticidal treatments were significantly superior over untreated control in reducing the larval damage. The treatment with profenofhos 0.1% gave maximum protection when recorded up to 7 days after application and reported 6.5% foliage damage. Among the different insecticidal treatments tested in field, profenophos 0.1% alone showed significantly superiority in controlling larval population and thereby, reduction in leaf damage and increasing the grain yield.

Khalid and Prasad (2009) conducted experiment to test the bio-efficacy of emamectin benzoate 5 per cent SG against thrips, *Scirtothrips dorsalis* Hood and pod borer, *Spodoptera litura* Fab. on chillies and noted that carbaryl at the rate of 750 g a.i./ha (3.88/leaf) and emamectin benzoate at the rate of 10 g a.i./ha (4.71/leaf) were superior in managing thrips incidence. Emamectin benzoate at the rate of 10 g a.i./ha (2.43 per cent) had emerged as best insecticide for controlling pod damage and found superior over other insecticides followed by emamectin benzoate at the rate of 7.5 g a.i./ha (3.67 per cent). Emamectin benzoate at the rate of 10 g a.i./ha (20.93 q/ha) and 7.5 g a.i./ha (18.4 q/ha) also registered highest chilli yields which were at par with each other.

Parmar and Borad (2009) studied efficacy and economics of ten insecticides against *Helicoverpa armigera* infesting okra. Among the tested insecticides, indoxacarb 14.5 SC (0.0075 per cent), emamectin benzoate 5 WG (0.001 per cent) and diafenthiuron 75 WP (0.05 per cent) performed better to protect the okra fruits from infestation of *Helicoverpa armigera* and gave higher yield.

Prasad *et al.* (2009) studied the residual and persistent toxicity of different insecticides against 4 to 5 days old larvae of *H. armigera* infesting pigeon pea in field cum laboratory experiment and reported that indoxacarb at the rate of 131 g a.i./ha and cypermethrin at the rate of 59 g a.i./ha showed quick knock-down effect up to 3 days after spray and were equally effective resulting into 66.67 to 77.67 per cent mortality of the larvae.

Ramanagouda and Srivastava (2009) assessed five insecticides *viz.*, indoxacarb, methomyl, fipronil, thiamethoxam and imidacloprid against seven day old larvae of *Spodoptera litura* by contact and leaf dip methods. Indoxacarb was the most toxic insecticide at 24 hrs exposure, at all the three concentrations, the values being 7.0 ppm (LC_{30}), 15 ppm (LC_{50}) and 126 ppm (LC_{90}) and imidacloprid was the least toxic with

281, 572 and 3313 ppm at respective LC levels. The order of toxicity by residue contact bioassay method at LC_{50} was: indoxacarb > methomyl > thiamethoxam > fipronil > imidacloprid. In residue contact bioassay, methomyl could cause 50 per cent mortality in a shortest span of 5.38 hrs followed by imidacloprid (10.47 hrs) and indoxacarb (12.60 hrs). Thiamethoxam and fipronil were slowest in action causing 50 per cent mortality in 33.37 and 23.93 hrs, respectively. A comparative dose mortality response expressed in terms of relative toxicity (RT) indicated that at 48 hours after exposure (HAE), the RT values for indoxacarb and methomyl were 1.0 and 1.2, respectively. Thiamethoxam, imidacloprid and fipronil were 28.54, 37.45 and 44.36 times less toxic than indoxacarb.

Raghuraman *et al.* (2008) conducted field trial to evaluate emamectin benzoate 5 SG at various doses with it's water soluble granules formulations and semi-synthetic novel insecticides spinosad against cotton bollworms and observed that EC formulations of emamectin benzoate at the dose of 11 g a.i. per ha reported effective in reducing the incidence of bollworm complex and increased the yield of seed cotton by 97.3 and 89.4 per cent over untreated control during 2004 and 2005, respectively. The WSG formulation of emamectin benzoate was also effective at the same dose (11 g a.i./ha) in protecting the crop and increased the yield of seed cotton by 89.8 and 98.1 per cent during both the years. The results suggest that the EC formulation of emamectin benzoate could be recommended as a component of sustainable management of bollworms in cotton.

Ravi *et al.* (2007) evaluated different newer insecticides and bio-pesticides for the management of two key lepidopteran pests *viz.*, *Spodoptera litura* (Fab.) and *Helicoverpa armigera* (Hub.) on sunflower and documented that indoxacarb 14.5 SC at the rate of 500 ml per ha was most effective chemical in checking the larval population of *H. armigera* and *S. litura* and was at par with spinosad 45 SC at the rate of 150 ml per ha. The highest seed yield (1520 kg/ha) was recorded in indoxacarb treated plots; however it was at par with spinosad treated plots (1480 kg/ha).

Duraimurugan *et al.* (2007) evaluated the efficacy of emamectin 5 SG against cotton bollworm *Helicoverpa armigera.* The result indicated that emamectin at the rate 11 g a.i. per ha was effective and the doses at 8 and 9.5 g a.i. per ha were equally effective when compared to standard check profenophos 50 EC at the rate of 750 g a.i per ha, lamda-cyhalothrin 5 EC at the rate of 15 g a.i per ha, indoxacarb14.5 SC at the rate of 100 g a.i per ha and spinosad 45 SC at the rate of 60 g a.i per ha in reducing larval emamectin at the rate of 9.5 g a.i. per ha and it was on par with 11 g a.i. per ha which ultimately increased the yield of cotton.

Munir *et al.* (2005) evaluated spinosad, indoxacarb, abamectin, emamectin benzoate, lufenuron, diflubenzuron, methoxyfenozide, and fipronil against 2nd instar larvae of *Spodoptera litura* and determined that emamectin was the most effective insecticide against *Spodoptera litura* followed by lufenuron, spinosad and indoxacarb in their time-oriented mortality at three concentration levels tested. However, abamectin proved to be least effective.

Swaroop *et al.* (2005) evaluated different insecticides against tomato fruit borer, *Helicoverpa armigera* on tomato and proved that acephate 75 SP at 2 kg/ha was most effective treatment in lowering fruit damage (7.44 per cent), increasing yield (756.45 q/ha) and recorded highest net return of Rs. 75645 per ha. This was at par with indoxacarb 14.5 per cent SC at 500 ml/ha reported fruit damage to the tune of 8.93 per cent and yield to the extent of 602.78 q/ha.

Aslam *et al.* (2004) tested ten insecticides under field conditions against *Earias insulana* (Boisd.) (spotted), *E. vittella* (Fab.) (spiny) and *Helicoverpa armigera* (Hub.) (American) bollworms at recommended dosages. All the insecticides were noted effective against these pests up to 7 days after treatment (DAT). For spotted bollworms, Nighaban 20 EC (fenpropathrin) followed by Talstar 10 EC (bifenthrin) was most effective up to 3 DAT, whereas Nighaban 20 EC (fenpropathrin) followed by Confidor Supra 500 EC (imidacloprid + betacyfluthrin) was most effective up to 7 DAT. Patriot 360 SC (chlorfenapyr) was least effective. For American bollworm, Patriot 360 SC (chlorfenapyr) followed by Taophos 25 EC (quinalphos) was most effective up to 3 DAT, whereas Larvin 80 DF (thiodicarb), Tracer 240 SC (spinosad) and Lorsban 40 EC (chlorpyrifos) were most effective up to 7 DAT. Vital 1.8 EC (abamectin) was least effective. So, Nighaban 20 EC (fenpropathrin) and Lorsban 40 EC (chlorpyrifos) were the most effective for spotted bollworm and American bollworm, respectively.

Srinivasan *et al.* (2004) evaluated efficacy of indoxacarb 14.5 SC and spinosad 45 SC against American bollworm on cotton and indicated that indoxacarb 14.5 SC at the rate 75 g a.i./ha was most effective treatment in controlling American bollworm followed by spinosad 45 SC at the rate 75 g a.i/ha in term of per cent damage to bolls and seed cotton yield.

Dandale and Kadam (2003) evaluated the efficacy of newer insecticide molecules *viz.*, spinosad, beta-cyfluthrin, indoxacarb, thiodicarb and decis against bollworms in comparison to check insecticide endosulfan on cotton and indicated that minimum infestation of bollworm complex in green fruiting bodies as well as in green bolls was observed in spinosad at 0.01 per cent treated plots.

Vadodaria *et al.*, (2001). In field experiment on bio-efficacy of new insecticides against cotton bollworms indicated that spinosad at 75 g a.i. per ha and beta-cyfluthrin at 18 g a.i. per ha recorded lower bollworm infestation as compared to decamethrin at 12.5 g a.i. per ha and untreated control.

Dandale *et al.* (2000) conducted field experiment to evaluate the efficacy of spinosad at the rate of 50 and 75 g a.i. per ha in comparison to two newer synthetic insecticides *viz.*, decamethrin at 10 and 12.5 g a.i. per ha and beta-cyfluthrin at 12.5 and 18 g a.i. per ha against cotton bollworms. The treatments with spinosad at 50 and 75 g a.i. per ha were found to be effective in controlling the infestation of *H. armigera* in green fruiting bodies on plants at 14 days after insecticidal application.

Bheemanna and Patil (1999) studied bio-efficacy of indoxacarb against cotton insect-pests at five dosages *viz.*, 25, 50, 75, 100 and 150 g a.i. per ha for three seasons. The results revealed that indoxacarb at 75 g a.i. per ha recorded lowest infestation of bollworm and the highest seed cotton yield which was at par with its higher dosages.

Patil *et al.* (1999) conducted an experiment to evaluate the bio-efficacy of spinosad at four dosages, *viz.*, 25, 50, 75 and 100 g a.i. per ha for two seasons against cotton bollworms and indicated that spinosad at 100 g a.i. per ha recorded minimum infestation of bollworms.

Finney, (1971) studied Three members of the δ-endotoxin group of toxins expressed by Bacillus thuringiensis subsp. israelensis, Cyt2Ba, Cry4Aa and Cry11A, were individually expressed in recombinant acrystalliferous B. thuringiensis strains for in vitro evaluation of their toxic activities against insect and mammalian cell lines. Both Cry4Aa and Cry11A toxins, activated with either trypsin or Spodoptera frugiperda gastric juice (GJ), resulted in different cleavage patterns for the activated toxins as seen by SDS-PAGE. The GJ-processed proteins were not cytotoxic to insect cell cultures. On the other hand, the combination of the trypsin-activated Cry4Aa and Cry11A toxins yielded the highest levels of cytotoxicity to all insect cells tested. The combination of activated Cyt2Ba and Cry11A also showed higher toxic activity than that of toxins activated individually. When activated Cry4Aa, Cry11A and Cyt2Ba were used simultaneously in the same assay a decrease in toxic activity was observed in all insect cells tested. No toxic effect was observed for the trypsin-activated Cry toxins in mammalian cells, but activated Cyt2Ba was toxic to human breast cancer cells (MCF-7) when tested at 20 μg/mL.

2.2 To study the population dynamics on major pest of sunflower.

Khanzada *et al.,*(2016) carried out studies on occurrence and abundance of thrips, *Thrip tabaci,* whitefly, *Bemisia tabaci* and their predator, *Geocoris* spp., on sunflower, *Helianthus annuus* L., at vegetable fields of Tandojam and Sultanaabad in Sindh. Population of thrips, whitefly and *Geocoris* spp., were recorded from January 15, 2010 up to April 16, 2011. Results showed that at Tandojam, maximum thrips population was observed at the end of March till mid of April, whitefly's population was found to be low in 2nd week of January and maximum in 2nd week of April and predator, *Geocoris* was found low initially while higher till the end of observation period. The temperature and humidity varied during different dates and significantly affected the abundance of insect population.

Horatti *et al.,* (2015) Pigeonpea was used as the main crop with intercrops of sunflower, cotton, sorghum, foxtail millet, sesamum, bajra and mesta in the ratio of 4:2 . Intercrops variety *viz.,* KBSH-1, Bt, M-35, Local seeds, Local seeds, ICTP 8203 and Local seeds. also observed maximum attack of *H.armigera* in sole pigeonpea in comparison to other poly-cropping systems tried *i.e.,* intercropping with groundnut, greengram, blackgram and finger millet.

Kumar and Bhat (2015) stated that eight sunflower lines sown on (13-9-2007) *viz.,* (EC-68415,BRS-3, MSFH-17, KBSH-1, PAC-1091, GAUSUF-15, MORDEN and TNAUSUF-7) were observed for leafhopper population on them during 25, 40 and 55 DAE revealed that all the lines except TNAUSUF-7 had progressive build up of leaf hopper population on them as they grew from seedling stage to flowering stage.

Babu *et.al.,*(2015) studied the effect of various weather parameters on the occurrence of larva and adult population of *Spodoptera litura* and their factors for outbreak of this pest in soybean in Banswara, Rajastan.

Malic *et al.,*(2015) The seasonal dynamics of *Helicoverpa armigera* and relative abundance of its larval parasitoid *Campoletis chlorideae* assessed in chickpea ecosystem.

Abdul *et al.,*in (2014)stated that three crops were sown as mustard alone, sunflower alone and under mix cropping on an area of ½ acre each. a total of 3844 specimens of 32 species were collected from mustard and sunflower mix crop mix crop. overall impact of temperature and RH indicated that the insect showed negative correlation with temperature and relative humidity on all crops, but highly significant impact whether negative or positive was recorded for few insect.

Phulse and Udikeri (2014) stated that the highest incidence of thrips, leafhoppers and whiteflies was recorded on MRC 7918 BG-II (17.3, 5.7 and 0.31/ 3 leaves respectively) followed by MRC 6918 non-Bt, RCH-2 BG-II and RCH-2 non Bt .The lowest incidence was noticed on DDhC-11. The highest seasonal mean of predatory coccinellids recorded was 2.6/plant on RCH-2 non Bt followed by RCH-2 Bt (1.6/plant). The highest *Chrysoperla zastrowisillemi* population was noticed in MRC-7918 (0.7/plant) followed by MRC-6918 non-Bt (0.6/plant), RCH-2Bt, RCH-2 non-Bt with 0.5/plant and lowest on DDhC-11 (0.3/plant).

Tukaram *et al.* (2014) conducted the bioassay of flubendiamide 39.5 per cent SC against tobacco caterpillar *Spodoptera litura* (Fab.) populations collected from different host crops like castor, ground nut, chilli, sunflower, soybean, cabbage and onion, etc. by leaf dip method and revealed that the population collected from castor recorded minimum LC_{50} value (2.66 ppm) which was followed by sunflower (2.81 ppm), groundnut (2.82 ppm), onion (2.86 ppm), cabbage (2.90 ppm) and soybean (2.94 ppm). Highest LC_{50} value of 3.29 ppm was found in population collected from chilli ecosystem indicating that these populations showed less susceptibility than the population collected from other ecosystem.

Zafar *et al.*,(2013) stated that the effect of the weather factors on incidence and development of *H.armigera* on different sunflower genotypes during 2008-2009. The *H.armigera* population was built up progressively from April 12 to April 27 in terms of egg count. The larval population started to increase continuously from April 12 to May 01 and a tremendous decrease was observed thereafter. It is evident that a maximum larval population recorded was 5.64 per 5 plants on April 24, 2009. The determination of the effects of different weather factors on egg count and larval population of *H.armigera* in sunflower is essential for effective management of this pest.

Ahmed *et al.*,(2013) investigated response of five Sunflower hybrids (FH-37, FH-331, FH-259, FH-106 and Hysun-33) to insect pests population and their bio-control agents. On the basis of two years average, sunflower hybrid FH-37 was found as comparatively resistant (1.105/leaf) to aphid (*Aphis gossypii* Glov.) whereas, FH-259 (1.922/leaf) was found to be susceptible. All genotypes showed non-significant differences regarding jassid (*Amrasca biguttula biguttula* Ishida). FH-259 proved to be susceptible (0.393/leaf) to whitefly (*Bemisia tabaci* Gen.) and did not differ significantly to Hysun-33 (0.337/leaf), FH-106 (0.154/leaf) and FH-331 (0.107). The sunflower hybrid FH-37 (0.02/plant) was found as comparatively resistant to larval population of head borer (*Helicoverpa armigera* Hub.) and did not differ significantly to FH-259 (0.04/plant), Hysun-33 (0.03/plant) and FH-331 (0.03/plant), except FH-106 (0.07/plant). while FH-106 proved as susceptible (0.05/plant). Whitefly and semi-looper exerted negative and significant effect on sunflower yield while aphid, jassid, cotton bollworm and armyworm had negative but non-significant correlation with yield.

Netam *et.al.*,(2013) observed that preying upon the sucking Insects, were two species of lady bird beetle, *Coccinella septumpunctata* and *Menochilus sexmaculata* and two species of spiders, lynx spider and an unidentified golden preying spider. The latter also a recorded preying on lepidopterous larvae. A predatory pentatomid bug, *Eocanthecona furcellata* was observed sucking the body sap of lepidopterous larvae, there existed a positive but non significant correlation between lepidopterous larvae and predators and between sucking pests and predatory fauna with 'r' values 0.545 and 0.798, respectively.

Kandakoor *et al.*,(2012) observed that the population of thrips and leafhoppers were more abundant on the crop during August and September, 2010. Results revealed that maximum activity was recorded during September and the correlation studies were made between the incidence of major sucking insect pests and select weather parameters. Thrips, leafhopper and aphids showed negative correlation with rainfall (r= -0.106, -0.056 and -0.134, respectively). Thrips showed positive correlation to both maximum(r=0.277) and minimum temperature (r=0.087). But leafhopper showed negative correlation for minimum temperature (r= -0.032) and positive correlation with maximum temperature (r=0.314).

Kumar and Durairaj.,(2012) studied population dynamics of gram pod borer, *H.armigera* using sex pheromone lures. According to them, the peak emergence of *H.armigera* adults was observed in 51^{st}(8.25 moths/trap/week) and 52^{nd} (8.00 moths/trap/week) standard meteorogical weeks followed by 1^{st} standard meteorological week (7.25 moths/trap/week). The correlation and regression analysis indicated that the emergence of *H. armigera* adults had a significant negative association with minimum temperature while, other parameters viz., maximum temperature, relative humidity, rainfall and rainy days had no influence on *H. armigera* activity.

Selvaraj and Ramesh.,(2012) conducted field trial to determine the effect of ecological factors on the incidence and development of whitefly, Bemisia tabaci at five different date of sowing on three varieties of cotton. The pest population was started from first week of March on five weeks old crop and acquired its peak in fourth week of July on thirteen weeks old crop. Maximum pest population (7.99/3 leaves) was build up at temperature ranged from 260 C to 350 C, relative humidity ranges from 84 and 67 per cent, zero rainfall, wind velocity 6.30 km/hr, total sunshine hours (9.4 hrs/week), evaporation (52.20 mm) and dewfall (0.708 mm). The highest incidence of whitefly population was recorded in SPCH 22 followed by SVPR 3 and MCU 7.

Sana *et al.*,(2011) stated that the population dynamics of different insect pests of cotton and their natural enemies, Whitefly, *Bemisia tabaci* (Gennadius); aphids, *Aphis gossypii* (Glover); leafhopper, *Amrasca biguttula biguttula* (Ishida); leaf beetle, *Cerotoma trifurcate* (Forster); red cotton bug, *Dyesdercus koenigii* (Fabricius) were the major insect pests while ladybird, beetle *Coccinella septempunctata* (Linnaeus); spider, *Dictyna sp.* (Linnaeus) and ants, *Solenopsis invicta* (Bure n) were the natural enemies recorded on cotton. Highest density of 5.78 *tabaci* leaf^{-1} was recorded on 10th August, 2.61 *gossypii* leaf^{-1} on 20th June, 6.56 *biguttula biguttula* leaf^{-1} on 10thAugust, 0.89 trifurcate leaf^{-1} on 30th August and 1.58 *koenigii* leaf^{-1} on 9th October. The highest density of 1.42 *C. septempunctata* leaf-1 on 10th August, 0.56 *Dictyna sp.* leaf^{-1} on 19th September and 1.22 *in victa* leaf^{-1} on 20th June were recorded.

Agnihotri et al., (2011) studied on seasonal incidence of Campoletis chloridae Uchida, a larval parasitoid of Helicoverpa armigera (Hubner), in chickpea crop. The parasitoid made its first appearance during 3rd standard metereological week (SMW) of the year in both the cropping seasons with parasitization of 78.57 and 80.00 per cent larval population respectively. The peak period of activity of C. chloridae in both the years (2008-09 and 2009-10) was during 6th standard week parasitizing 89.56 and 90.93 per cent larval population of H. armigera, in both the cropping season respectively

Pandha (2010) stated that during the field studies on incidence of insect pests and their natural enemies at different pheno phases of some hybrids of sunflower at Ludhiana, Mega-363 supported higher population and PSFH-67 supported lower population of major insect pests (*Helicoverpa armigera*, *Bemisia tabaci, Amrasca biguttula* and *Nysius* sp.) in spring season. Population of *A. biguttula* and *H. armigera* was significantly low in treated plots. Intervention with the insecticide did not show any considerable impact on the incidence of insect pests in sunflower crop.

Bajya *et al.*,(2010) studied the population dynamics of *H.armigera* on chickpea, pigeonpea and cotton. According to them, larval population of *H.armigera* on pigeonpea was observed from third week of August to first week of November and it was of November and it fluctuated from 0.7 to 4.8 larvae/10 plants. Its population was gradually increased and the highest population (4.8 larvae/10 plans) was recorded during third week of September.

Chatar *et al.*,(2010) reported that *H.armigera* (Hubner) appeared on chickpea from 2nd week of December to 2nd week of January. The correlation studies indicated that maximum temperature exhibited highly significant negative correlation (r=0.7514) with larval population whereas, minimum temperature (r=0.5771) and mean temperature (r=0.6836) exhibited significant negative correlation. There was significant positive correlation of larval population of *H.armigera* on chickpea with morning relative humidity (r=0.7098), evening relative humidity (r=0.7293) and mean relative humidity (r=0.8063).

Sujata *et al.*, (2010) studied natural mortality of Helicoverpa armigera (Hubner) (Lepidoptera : Noctuidae) due to different natural enemies on chickpea (Cicer arietinum L.) was recorded in six districts viz., Amritsar, Faridkot, Ferozepur, Bathinda and Hoshiarpur of Punjab state, India during the period of 1st fortnight of January to 1st fortnightly of April, 2007. H. armigera larvae were collected from insecticide-free chickpea fields at fortnightly interval. Living and dead larvae showing characteristic disease symptoms were transported aseptically to the laboratory and healthy larvae were reared on the chickpea pod and twigs. Larval mortality due to different entomopathogens (viz., bacteria, virus and fungi) and parasitoid was observed. Among different natural enemies the mortality was highest due to parasitoids (45.00%) followed by virus (16.50%), bacteria (15.86%) and fungi (7.07%). The highest parasitism was recorded during 1st fortnight of January to 1st fortnight of February due to low temperature, whereas maximum mortality due to bacterial and viral infection was observed during 1st fortnight of April when the climate is hot and dry

Selvaraj *et al.*,(2010) observed that the population of *S.litura* was build up progressively from April (1st week) and acquired its peak in the month of May (1st week) on cotton. The population of *S.litura* on cotton showed a positive correlation with relative humidity, sunshine hour and dewfall, whereas, it was negatively correlated with wind velocity.

Thilagam *et al.* (2010) evaluated the bio-efficacy of flubendiamide 480 SC against *Helicoverpa armigera* on cotton and showed marked reduction in the larval population and recorded up to 96.0 per cent reduction in damage with flubendiamide 60 g a.i. per ha. The total sugar content was significantly increased when the plants were treated with flubendiamide 60 g a.i. per ha. and there was no significant difference in amino acid, protein and phenol contents due to flubendiamide application.

Akashe *et al.*,(2009) Field experiments were conducted during the *rabi* seasons of 2004-05, 2005-06, 2006-07 and 2007-08 to correlate weather parameters with the incidence of safflower aphid. The pest was active during December to January on pre-branching stage of safflower crop, but its appearance on crop totally depends upon prevailing climatic conditions. Low temperatures and high humidity with cloudy weather are conducive for the multiplication of this pest.

Ibrahim and Adesiyun (2009) stated that onion seedlings were transplanted from November to March to study the population dynamics of onion thrips, *Thrips tabaci.* There were four transplants in 2001/2002 and five in 2002/2003 seasons. Results indicate that November transplant had a peak population of onion thrips in late February (176 thrips/plant);December (416 thrips/plant) and January (608 thrips/plant) transplants peaked in March, and February (148 thrips/plant)and March (86) transplants had peaks in April.

Pandey *et al.*, (2009) reported that *Helicoverpa armigera* (Hubner) is a serious pest of pulse crops in India and damages chickpea (*Cicer arietinum* L) on average a 30%. One of the potential natural enemies reported for its biological control is *Campoletis chlorideae* Uchida (Hymenoptera: Ichneumonidae).

Reddy *et al.*, (2009) reported that the rainfall and larval population of *H. armigera* showed positive correlation coefficient (0.03) but it was not-significant. The wind velocity and the sunshine hours showed positive non significant correlation with larval population.

Yadav and Jat (2009) studied the seasonal incidence of *Helicoverpa armigera* (Hubner) on chickpea and revealed that the infestation of *H. armigera* on chickpea started in the second fortnight of November and reached its peak in the end of February. The larval population of the pest occurred throughout the growth period of crop and was maximum at pod formation and grain developmental stage.

Bisane *et al.*, (2008) studied the parasitization of *Helicoverpa armigera* (Hubner) larvae and pupae during 2004-05 and 2005-06 from field collected life stages on pigeonpea. The other ichneumonid, *Campletis chlorideae* was observed to be active in December (16.67 per cent). Parasitism by a Braconid, *Bracon sp.*, noticed from 45th to 47th SMW and 50th SMW, was up to an extent of 7.89 per cent.

Dhaliwal *et al.*,(2008) Field studies were conducted during the crop seasons to assess the yield losses due to mustard aphid in Indian mustard [*Brassica juncea* (L.)] sown on different dates. The crop was sown on 5 October, 30 October and 25 November during 2004-05 and 2005-06 but crop was sown on 30 October and 25 November during 2003-04. Yield attributes and seed yield decreased significantly with delay in sowing under both protected and unprotected conditions. On an average maximum seed yield of 1898 kg/ha was recorded when the crop was sown on 5 October under protected conditions as compared to 1768 kg/ha in unprotected conditions. Yield losses due to mustard aphid were highest (82%) during third date of sowing in 2004-05.

Patait *et al.*,(2008) reported that the population of *S. litura* on cabbage varied from 0.6 to 3.2 and 0.2 to 1.0 larvae per quadrat during rainy and winter seasons 2006-07, respectively. The population of *S.litura* was affected positively by the action of minimum temperature and rainy days and negatively by forenoon relative humidity and rainfall.

Jagtap *et al.*, (2008) studied on the population of *Earias vittella, Helicoverpa armigera, Agrotis ypsilon [A. ipsilon]*, *Condica illecta* and *Pectinophora gossypiella* varied from 0.6 to 8.6, 0 to 3.2, 1.4 to 15.0, 7.0 to 15.8 and 0.8 to 4.0 larvae per quadrat, respectively on okra during summer 2005. Before noon relative humidity and number of rainy days had highest direct positive and negative influences on larval population of *H.armigera*.

Krishna Kant and Kanaujia (2008) reported that larval and pupal *Helicoverpa armigera* populations in chickpea sown at different crop densities and determine the effect of weather factors on the population dynamics of the pest. Larval population build up in chickpea started during 9th standard week at vegetative stage of the crop and reached its maximum during 14th and 15th standard week , there after the larval populatin declined after 19th standard week.

Singh and Tomar (2008) evaluated the bio-efficacy of different insecticides against pod borer *Helicoverpa armigera* and rekhaprported that indoxacarb 14.5 SC gave the best result in minimizing the crop damage. The treatment arranged in the descending order of efficacy were Indoxacarb 14.5 SC > cartap hydrochloride 50 SP > acephate 75 SP > endosulfan 35 EC > chlorpyriphos 20 EC > quinalphos 25 EC > cypermethrin 10 EC > control.

Sharma *et al.,* (2008) reported that the incidence of *H. armigera* larvae was first observed on chickpea in the 2nd week of December (50^{th} SW) *i.e.* at vegetative stage of crop. The larval population exhibited significant correlation with rainy days only. Two parasites *C. chlorideae* (Uchida Hymenoptera) ichnumonidae and *Carcelia sp.* (Diptera Tachnidae) were found to parasitized the *H. armigera* larvae from vegetative to pod initiation stage.

Venkateswari *et al.* (2008) evaluated LC_{50}, LD_{50}, LT_{50} values of abamectin and emamectin benzoate against the third and final instar larvae of *Spodoptera litura* (Fab.) by using leaf disc ingestion method, topical method and dip method of application of insecticides and concluded that between the two avermectins, emamectin benzoate was more toxic than abamectin.

Mishra and Ali (2007) reported that four insect pests namely leaf miner, semilooper, gram pod borer and linseed budfly were recorded in linseed varieties *viz*., Padmini, Neelum and Janki during *rabi* 2004-05 and 2005-06. Positive correlation with minimum temperature and negatively correlated with maximum temperature, RH and rainfall during both the years except budfly population was positively correlated with RF.

According to Jagtap *et al.,* (2007) the population of *S. litura* on okra varied from 1.2 to 2.8 larvae per quadrat. The highest population of *S. litura* to the extent of 2.8 larvae per quadrat was recorded on okra in 34^{th} meteorological week when the maximum temperature, minimum temperature, beforenoon relative humidity, afternoon relative humidity, rainfall and number of rainy days were 29.04°C, 22.14°C, 89.57 per cent, 84.71 per cent, 7.20 mm and 3 days, respectively during *kharif* season 2005. Their path analysis studies revealed that minimum temperature showed highest direct positive effect on incidence of *S.litura* infesting okra, while afternoon relative humidity had highest negative effect.

Kumar *et al.,*(2007) showed non-significant correlation of *S.litura* on infesting *vigna mungo* with maximum temperature, minimum temperature, relative humidity and rainfall.

Bohria and Shukla (2006) conducted a field surveys in chickpea crop to record the parasitization of *Helicoverpa armigera* larvae by *Campoletis chlorideae*. They reported the peak parasitization (19%) in the second week of January.

Jadhav *et al.*,(2006) reported that the incidence of *S.litura* on sunflower was noticed from 32nd to 38th standard meteorological weeks with its peak (16 larvae per quadrat) in 37th meteorological week when the maximum temperature, minimum temperature , before noon relative humidity, afternoon relative humidity and rainfall were 30.4°C, 19.1°C, 77.6 per cent, 55.4 per cent, and 6.1 mm, respectively, during *kharif* 2003.

Many natural enemies (Parasitoids and predators) have been recorded on *U.compositae*. In Karnataka state of India, the dipteran, *Pseudend aphis* sp. is known to cause up to 10 per cent parasitization of the aphid during first week of January (Anon, 2006).

In Karnataka state of India, the aphid first appears during November first week and reached a peak between end of December to end of January and disappeared by the end of March (Anon.,2006)

Singh and Ali (2006) studied on seasonal activity of the gram pod borer, *Helicoverpa armigera,* and its parasitoid, *Campoletis chlorideae,* on chickpea cv. K-850, using pheromone traps, during rabi 2000/01 and 2001/02. The larval activity of *H. armigera* continued throughout the crop season with two peaks in both years, first from 45 to 49 standard weeks and the second from 5th to 13th standard weeks were observed. The Maximum parasitization by *C. chlorideae* was observed in 4th standard weeks. Parasitization declined from 44th to 50th standard weeks.

Pandey and Kumar (2006) A survey conducted in the chickpea fields during 15 November to 5 December 2005 revealed that the parasitism ranged from 25.0 to 59.2%. *C. chloridae* has proved to be a potent parasitoid in chickpea ecosystem and has a great significance in biological control of *H. armigera* on chickpea.

Singh and Battu (2006) studied on 377 *Helicoverpa armigera* (Hiibner) larvae from the chickpea, Egyptian clover, sunflower and tomato crops from January 1998 to May 1999, in and around Ludhiana District (Punjab state) were analysed symptomatically (retarded growth, decreased feeding, tendency to remain at the bottom of the rearing containers and sluggishness) for detecting any incipient parasitisation during laboratory 20.9±2.9, 24.9±1.8, 20.0 and 25.9 per cent natural mortality of *H. armigera* larvae brought from chickpea, Egyptian clover, sunflower and tomato crops, respectively. .

Chandel *et al.*,(2005) recorded the population dynamics of *H.armigere* on chickpea, pigeonpea, tomato, sunflower and okra. It was observed that from October onwards, the pest infested chickpea and pigeonpea only. After the harvest of chickpea in March, the pest was found infesting sunflower and lowest population was observed on tomato in June later on the pest migrated on okra.

Mallapur *et.al*, (2005) reported that there was significantly positive correlation with relative humidity, minimum temperature and cloudy weather. Whereas, the aphid population was negatively correlated with maximum temperature, heavy rainfall and as the crop age advances.

Singh *et al.*, (2005) experiment was conducted on the incidence of *H. armigera* in chickpea (cv. GNG 469) sown in the first week of November during 1996-97, 1997-98 and 1998-99 at Sriganganagar, Rajasthan, India,. The larval population, initially observed at 15 days after sowing (0.2-0.8 larvae/m^2), increased gradually until the first week of December (3.00-3.40 larvae/m^2), then declined until the end of January. The population started to increase again from mid-February (1.0-1.8 larvae/m^2) until the second week of April (8.0-10.8 larvae/m^2), then declined abruptly. The first peak of larval population was recorded on the first week of December (3.26 larvae/m^2), whereas the second peak was registered on the second week of April (4.40 larvae/m^2).

Shah and Shahzad (2005) reported that the pest population was low during 49^{th} to 6^{th} standard weeks but increased from 7^{th} standard week onwards and declined again during 14^{th} standard week. A positive correlation existed between the eggs, larval instars and overall density of *H. armigera* and the average maximum and minimum temperatures. However, a negative correlation existed between the eggs, larval instars and overall density of *H. armigera* and the average morning relative humidity.

Pandey *et al.*, (2005) conducted an experiment on chickpea (*Cicer arietinum* cv. K-850) sowing after 20^{th} October and they observed that it reduced the grain yield as the infestation increased rapidly due to decreased parasitic activity by *Campoletis chlorideae*. Crops harvested in 3rd week of February escaped infestation caused by larva because of highest parasitic activity of *Campoletis chlorideae* (80.5%) in crop harvested in first week of April infestation increased rapidly due to sudden decrease the activity of *Campoletis chlorideae* (40.3%).

Venkateswarlu *et al.*, (2005) studied the novel insecticides tested for the management of insecticides resistance Guntur strain of *Spodoptera litura*, novaluron was found to be the best at 72 hrs after treatment with higher relative toxicity than quinalphos (x77.0) and fenvalerate (x76.9) to which the pest has developed increased levels of resistance, followed by indoxacarb which was 63.6 and 63.1 times toxic than fenvalerate and quinalphos at LD_{50} level. At LD_{90} level indoxacarb was the best to eliminate the resistant individuals which was 50.0 and 37.7 times toxic than fenvalerate and quinalphos followed by novaluron which was 27.1 and 33.0 times toxic than fenvalerate and quinalphos. Profenophos was 3rd in efficacy against resistant *Spodoptera litura*

Gupta *et al.*,(2004) evaluated the population dynamics of *H.armigera* by deploying pheromone traps in the fields of chickpea and sunflower using sex pheromone in the ratio of 97:3 ratio 25:1 of (Z)-11-hexadecenal and (Z)-9-hexadecenal as pheromonal blends. According to them, relatively higher trap catches in 97:3 ratio were recorded during the first fortnight of April.

Kaur *et al.*, (2004) studied the natural parasitism of *H. armigera* by *C. chlorideae* on chickpea cultivars at different locations in India during 2002-03. The parasitoid population varied from 0.02-1.50 cocoons per metre row length and the larval population ranged between 0.86 and 14.50 larvae per metre row length. The highest number of cocoons were recorded on PBG 5 (0.88) followed by L 550 (0.74). The *H. armigera* population was also high on PBG 5 (9.38 larvae/m row length) followed by L 550 (6.75 larvae/m row length).

Singh *et al.* (2004) recorded six newer insecticides significantly superior over untreated check in reducing population of whitefly. Among the treatments, imidacloprid 17.8 SL at the rate of 250 ml/ha was observed to provide maximum reduction of white fly (89.86 to 58.98 per cent) on chilli followed by acephate 75 SP at the rate of 1250 g/ha (87.35 to 56.95 per cent) and methyl demeton 25 EC at the rate of 1250 g/ha (82.65 to

46.00 per cent). Highest yield (36.46 g/ha) and B:C ratio (1:6.72) were obtained from imidacloprid 17.8 SL treated plots.

Devi *et al.*,(2003) observed the incidence of the pest from February and continued till May. They found 5 parasitoids were associated with *H. armigera* and among the parasitoids, *Campoletis chlorideae* was recorded as the most important natural enemy of this pest. The percentage of parasitism ranged from 0.18 to 23.81% from March to May. The maximum incidence of the parasitoids were recorded during the first and second week of April 1998-2000.

Gupta and Desh (2003) conducted experiment of *H. armigera* larvae on chickpea were parasitized by *Campoletis chlorideae* at Palampur, Himachal Pradesh, India, during two consecutive years (1997-98 and 1998-99). The extent of parasitism by *C. chlorideae* ranged from 8.33 to 28.00 per cent. The parasitoid remained active from the second week of April to the first week of May.

Kumar and Nath.,(2003) studied the population dynamics of major pests of pigeonpea on cultivar Bahar. They reported that the incidence of pod borer (*H. armigera*) was recorded on pegionpea between 23rd January to 8th April and it was at its peak on 24th March 2003.

Kumar *et al.*,(2003) conducted the field experiment on population build up and seasonal abundance of borer species on pigeonpea at the research farm of Rajendra Agricultural University, Bihar during 1998-99. They reported that larval population per plant was gradually increased from February (7th standard meteorological week) till first of April (13th standard meteorological week). The maximum mean temperature and relative humidity recorded at moning, evening and mean were found to be highly correlated with that of larval population of borer complex, while *H.armigera* remained unaffected.

Rai *et al.,* (2003) studied the extent of natural larval parasitization by *C. chlorideae* on *H. armigera* varied from 5 to 41 per cent during 1999-2000 and 3 to 40 per cent during 2000-2001 on a standard week basis. Parasitization recorded during 1999-2000 was 33, 37.3, and 9 per cent during February, March and April, respectively. During 2000- 2001 it was 36 and 5 per cent in March and April, respectively.

Swaminathan *et al.*,(2003) recorded the population of *H.armigera* under different rainfed cotton cropping systems in southern districts of Tamil Nadu. According to them, the total larval population was observed to be 276, 260 and 286 larvae per 20 plants at Aruppukottai, Thirumangalam and Kallupatty area, respectively during 12th November 1996 to 14th January 1997.

Thanki *et al.*,(2003) reported that the higher eggs and larval population as well as leaf damage caused by *S.litura* to castor plants was found in the third and fourth week of November. Whereas, the lower population and leaf damage was observed in the first and second week of October.

Rao *et al.*, (2002) reported that the influence of current and one week lag weather factors (maximum and minimum temperatures, rainfall, relative humidity and sunshine hours) on the head borer (*H. armigera*) incidence on sunflower crops. In the November-sown crop, the population increased gradually, reaching its peak of (1.7 larvae/plant) in the 1st week of January and then declined. In the December-sown crop, the population reached its peak of (1.9 larvae/plant) in the 3rd week of January and then subsequently declined. In the January-sown crop, a maximum of (1.8 larvae/plant) was recorded in the 1st week of March and then disappeared towards the end of the crop growth period. In the February-sown crop, the 6 population peaked (1.4 larvae/plant) during the 4th week of March and disappeared after the 1st week of April.

Ali and Kumar (2001) reported that *H. armigera* was found most active between 47th to 16th standard week on chickpea and attained peak density 5th to 11th standard week.

Rao *et al.*, (2001) studied on the seasonal incidence and host preference of *H. armigera* in bhendi, cotton, pigeonpea and chickpea. Larvae on each plant were counted at 7-day intervals from 1 November 1996 to 31 January 1997. The incidence of *H. armigera* on bhendi was recorded on the first week of November when the crop was 47 days old (20 larvae per 10 plants). The pest population was zero when the temperature was 25 degrees C during the last week of December through January. The peak population was observed on 128-day-old crop (25 larvae per 10 plants) during the third week of November through the second week of December. The incidence of pod borer on pigeonpea was observed at the flowering stage. Its incidence on chickpea was observed at the flowering stage 38 days after sowing (two larvae per 10 plants). The peak incidence was recorded on 87-day-old crop (20 larvae per 10 plants) in January.

Kaur *et al*., (2000) found that the larval parasitoid *Campoletis chlorideae* was the most important mortality factor for the larvae of *H. armigera* Parasitism due to *C. chlorideae* ranged from 0.98 to 68.50% throughout the crop season. The maximum parasitism was recorded during the third week of February 1999 when the minimum mean temperatures and relative humidity were 11.9 %C and 95%, respectively.

Bishnoi *et al*.,(1996) reported significant relationship of *H.armigera* population with air temperature and relative humidity

Mohasin*et.al*.,(1999) reported that population of *H.armigera* was lowest during the second fortnight of January and greatest during the first fortnight of March 1997 on red gram.

Akashe *et.al*.,(1995) the authors also found that there existed a negative correlation between these weather parameters (including rainfall) and the pest population. However, at Delhi the aphid made it appearance in February and peaked during mid March.

Goutam *et al*.,(1995) recorded that the population buildup in Solapur region of Maharashtra started at the end of October and reached a peak by January first week when maximum and minimum temperature and morning and evening relative humidity were 31.1°C, 12.9°C and 67 and 39 per cent respectively

Hallolli (1994) reported that the peak population of *Urolucon carthemi* (Theobald) (321.00/10cm area of central twig) and *C. carnea*(1.20) in crop sown on 25th November and also in second week of January. Correlation between *C.carnea* and rainfall was negatively significant (1st, 3rdand 5th sowing) because in initial rainfall was found with less population of *C.carnea* and later population increased with no rainfall.

Kharub *et al*.,(1993) reported that a peak in the larval population of *spodoptera litura* on groundnut appeared after 41st week. They also observed that maximum temperature (33.8°C and 18.6°C) and relative humidity (61%) favoured for larval development of S. litura on sunflower was observed in second week of September (Anonymous, 1999 and 2002).

Dubey *et al.,* (1993) studied the population dynamics of *Helicoverpa armigera* in Madhya Pradesh, India, over 2 years (1983-84 and 1984-85). The pest fed on various crops (chickpea, pigeonpea, pea, lentil and tomato in the cropping season). The pest 5 showed peak activity in February and March during both years. Chickpea and pigeonpea were the most preferred hosts. Environmental factors (temperature, relative humidity and rainfall) had an impact on the development of the pest population.

Prasad *et al.,* (1989) studied the population dynamics of *Heliothis armigera* (*Helicoverpa armigera*) on chickpea (*Cicer arientinum*).The larval population was fairly low during December, during this month the minimum daily temperature was a mean of 7.5 and the rate of parasitism by the ichneumonid *Campoletis chlorideae* was high (50-53.3%). The population of *H. armigera* was highest in the first week of March, when the chickpea crop was sown on 22 October, 1 or 21 November or 1 December. However, peaks of the pest also occurred on 25 January and 11 February on the crops sown on 12 October and 11 November, resp. These peaks occurred when the minimum daily temperature was between 10.4 and 14.4 degrees C, rainfall was 17, 30 and 12 mm during December, January and February, resp., and the rate of parasitism was below 20%.

Tripathi and Sharma (1985) reported that the important factors favorable for development of *H.armigera* were relative humidity below 70 per cent and low rainfall. The temperature range of 12 to 21°C was most favourable for pest development.

Raodeo *et al.*,(1983) reported positive correlation between the population of *Helicoverpa armigera* and rainfall on cotton.

Lewin *et al.*,(1973) reported the capitulum borer, *Helicoverpa armigera* (Hubner) is the regular and key pest of sunflower in many states of india. It is causing direct damage to receptacle ovaries and developing seeds and the resuting loss in seeds would spill over 50 per cent.

2.3 To study the effect of insecticides against natural enemies .

Al-Kazafy *et al.* (2014) studied the residual effect of three modern insecticides (chlorantraniliprole, thiamethoxam and spinetoram) against some natural enemies such as and *Trichogramma* wasps, *Trichogramma evanescens* and reported that all tested insecticides were less toxic to the second instar larvae of *C. carnea* larvae. The per cent mortality with the highest concentrations ranged from 40 to 43.3 per cent. Thiamethoxam and chlorantraniliprole were most toxic to the second instar larvae of *C. septempunctata*. Spinetoram was the most toxic against *T. evanescens*. The results recommended that chlorantraniliprole was the most suitable insecticides for control of pink bollworm larvae and less toxic to *C. carnea* and *T. evanescens* . So, it can be used when the population density of *C. carnea* and *T. evanescens* larvae in peak safely..

Bana *et al.* (2014) evaluated the toxicity of some of the insecticides on *Coccinella septempunctata* in cabbage ecosystem by using nine insecticides. The minimum population was recorded in imidacloprid @ 0.005 per cent (2.67/ 10 plants) which was found to be toxic insecticide than followed by malathion @ 0.05 per cent and lufenuron @ 0.006 per cent and maximum population was recorded by the NSKE @ 10 per cent (4.10/10 plants) which was found to be safer followed by Azadiractin @ 5 ml/l, B.t.k @ 2 ml/l and spinosad @ 0.01ml per cent.

Sabry *et al.,* (2014) stated toxicity of three modern insecticides like chlorantraniliprole (25, 12.5 and 6.25 ppm), thiamethoxam (25, 12.5 and 6.25 ppm) and spinetoram (30, 15 and 7.5ppm) at recommended and other two at lower dose than recommended was examined against green lacewing, *Chrysoperla carnea* in cotton ecosystem. The results showed that thiamethoxam recorded the highest per cent mortality of 2^{nd} instar grub (88.3, 71.7 and 50.0 per cent) which is said to be moderately harmful and lowest mortality was recorded in spinetoram (58.3 38.3 and 20.0) which is said to be slightly harmful to *Chrysoperla carnea.*

Thangavel *et.al,* (2014) observed that safety of EB 5 WG eggs, larval, and adults of parasitiod .The highest egg hatchability was recorded in 5 WG (93.3%) and 6.25 g a.i/ha the lowest mortality was recorded in EB 5 WG (14.2%) and 6.25 g.ai/ha in larval feeding method. In dry flim method at 48 hrs , lowest mortility of 15.0 recorded in EB 5 SG registered highest larval mortality.

Awasthi *et al.* (2013) evaluated the relative toxicity of six insecticides, *viz.*, spinosad 45 SC, indoxacarb 15.8 EC, emamectin benzoate 5 SG, acephate 75 SP, acetamiprid 20 SP and imidacloprid 17.8 SL against cotton aphid *Aphis gossypii* Glover and different stages of predatory coccinellids in the laboratory. On the basis of LC_{50} values, spinosad was the safest insecticide for the different stages of the predatory coccinellids and acetamiprid was the most toxic followed by imidacloprid, indoxacarb, emamectin benzoate and acephate.

Ghosal *et al.* (2013) concluded that the neonicotinoid (imidacloprid, thiamethoxam and acetamiprid) insecticides were quite effective against aphid population and they were relatively less toxic to natural enemies of aphid population on okra. During the investigation spinosad was found to be least effective treatment against aphids whereas, safest insecticide against natural predator population of aphid.

Govindan *et al.* (2013) evaluated the safety of new formulation emamectin benzoate 5 SG at different doses (7, 11 and 15 g a.i. per ha) in comparison with standard check, Proclaim® at 11 g a.i. per ha (emamectin benzoate 5 SG) and spinosad 45 SC at 75 g a.i. per ha) to coccinellid predators in cotton ecosystem. The results showed that emamectin benzoate 5 SG was found safer to coccinellids at all the tested concentrations. The highest population was recorded in plots treated with emamectin benzoate 5 SG at 7 g a.i. per ha followed by emamectin benzoate 5 SG at 11 g a.i. per ha.

Yogi and Kumar (2013) studied the persistent toxicity of certain insecticides against gram pod borer. The highest persistent toxicity in terms of PT values to the extent of 3456.00 was observed due to the application of chlorpyrifos 20 per cent SC followed by emamectin benzoate 5 SG (3102.72) and spinosad 45 SC (2862.72).

Govindan *et al.* (2012) evaluate the emamectin benzoate 5 SG for safety to predatory spiders in cotton ecosystem. The results showed that emamectin benzoate 5 SG was found be safer to spiders at all concentrations (Emamectin benzoate 5 SG at 7, 11 and 15 g a.i./ha) tested compared to standard endosulfan35 EC. The highest spider population was recorded in plots treated with emamectin benzoate 5 SG at 7 g a.i./ha followed by emamectin benzoate 5 SG at 11 g a.i./ha, respectively.

Parthiban *et al.*, (2012) evaluate the safety of new formulation Emamectin benzoate 5 WG at different doses (100, 125 and 150 g/ha) against the standard check, Emamectin benzoate 5 SG (135 and 170 g/ha), Lambda cyhalothrin 5 CS (300 ml/ha) and Pyridalyl 10% EC at 500 ml/ha for their safety to spider predators in okra eco-system The results showed that Emamectin benzoate 5 WG was found to be safer to spider at all concentrations tested. The highest population recorded in plots treated with Emamectin benzoate 5 WG at 100 g/ha followed by Emamectin benzoate 5 WG at 125 g/ha, respectively.

Brugger *et al* (2010) observed that chlorantraniliprole was harmless to the parasitoid wasp species tested according to IOBC classification criteria (<30% effects) and may be a useful tool in IPM programmes.

Wayal *et. al.,* (2009) reported that the treatments with lambda -cyhalothrin 5 CS at 25 g a.i./ha, lambda -cyhalothrin 5 EC at 25 g a.i./ha, thiodicarb 75 WP at 750 g a.i./ha and profenofos 50 EC at 500 g a.i./ha were also found effective against the pink bollworm. These insecticides were also safe to the natural enemies.

Yadav *et.al.,* (2008) evaluated that efficacy of spinosad 45 SC against cotton bollworm complex found lowest incidence of bollworms in fruiting bodies and spinosad was significantly superior to indoxacarb, chlorpyriphos, tracer and cypermethrin. It was observed that spinosad (Tracer) 25 g a.i./ha, Spinosad 50 g a.i./ha, dimethoate 200 g a.i./ha and spinosad @ 75 g a.i./ha were found to be more suitable to conserve natural enemies.

Shinde *et al.* (2007) revealed that spinosad at 75 g a.i. per ha was found to be safer insecticide to the predators of okra aphids. Similarly, Mane (2007) reported spinosad at 75 g a.i. per ha as a safer treatment for ladybird beetle followed by endosulfan at 262.5 g a.i. per ha. However, cypermethrin at 60 g a.i. per ha and deltamethrin at 12.5 g a.i. per ha were toxic to natural enemies of the pests of okra.

Shinde (2004) and Mallah and Korejo (2005), spinosad at 75 and 80 ml per ha were observed to be safer to beneficial insects. Prabhudesai (2005) reported that spinosad at 75 g a.i. per ha recorded higher population of potent predators followed by endosulfan 350 g a.i. per ha.

Udikeri *et. al.,* (2004) reported that e mamectin benzoate did not affect predators populations in cotton ecosystem as there was no significant difference in population of predators recorded in emamectin benzoate and untreated check. This study revealed that emamectin benzoate is a safe chemical to *C. Carnea* and *Coccinellids.*

Sechser *et al.* (2003) observed that emamectin benzoate was relatively safe to all stages of the tested predator species when applied as two applications at 13.5 g a.i. per ha to ladybird beetle and *Chrysoperla carnea* on Egyptian cotton over a period of 23 days.

Studebaker and Kring (2003) reported that abamectin and emamectin benzoate caused significant mortality in predators exposed shortely after application but survival tended to increase as residues aged on cotton crop.

Hewa-Kapuge *et al.* (2003) reported that emamectin benzoate was toxic to *Trichogramma,* egg parasitoid of *Helicoverpa* spp. on tomatoes. It caused more than 97 per cent mortality in adults 1 hour after direct application and 23 to 64 per cent mortality in residual persistence assays during the first 24 hours.

Tillman and Mulrooney (2000) evaluated toxicity of 3 insecticides viz., lambda-cyhalothrin, spinosad and S-1812 on the natural enemies of cotton pests and found that lambda-cyhalothrin residues were not very toxic to *C. marginiventris* and *H. convergens*. Spinosad didn't affect number of *G. puncitipes, H. convergens* and *C. maculana*, whereas S-1812, exhibited good to excellent selectivity to natural enemies.

Viggiani *et al.* (1998) showed that imidacloprid and acetamiprid were highly toxic to coccinellid up to 20 days under field conditions

Hendrix *et al.* (1997) reported that spinosad allowed conservation of beneficial arthropods in comparison to commonly used pyrethroids.

Materials and Methods

Chapter III

MATERIAL AND METHODS

Present investigation was carried out to study the bio-efficacy of different insecticides against major insect-pests of Sunflower at Department of Agricultural Entomology, College of Agriculture, Badnapur (Maharashtra) India during *Kharif* 2016. The details of material used and the methodology adopted during the course of investigation are described under the following heads.

3.1 Experimental site.

The experiment was conducted during the *Kharif* season of 2016-17 on the research farm of Department of Entomology, College of Agriculture, Badnapur.

3.2 Soil type

The soil of experimental plot was deep black in colour with good drainage. The topography of experimental plot was uniform and fairly leveled.

3.3 Location

Geographically, College of Agriculture Badnapur is situated at 409m above mean sea level at 19.50° Latitude and 47.53° Longitudes with an altitude of 520 meters. It is on Aurangabad – Jalna road at a distance of 40 km from Aurangabad and 20 km from Jalna. This station is at a distance of 2.50 km from Badnapur railway station on Manmad – Secundrabad rout of South Central Railway.

3.4 Climate.

Climatically, there are three seasons, *Khirif* season starts from middle of June to middle of September, *Rabi* from October to January and Summer from February to May and Badnapur has sub-tropical climate comes under Central Maharashtra Plateau Zone. The average rainfall of the Station is about 650mm received mostly during June to September. The mean minimum and maximum temperature during the last five years were 15.25 and 43.85°C and the mean relative humidity ranges from 30 to 91 per cent . Rainfall in mm this year received is 792.50 mm.

3.5 Field experiment

The field experiment with Sunflower crop using variety Morden was conducted at Research Farm of Department of Agril. Entomology, College of Agriculture, Badnapur (Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani) (MS)-India during *Kharif* 2016.

The experiment was conducted in a randomized block design with eight treatments including untreated control replicated three times.

The Sunflower crop was sown on 5th Aug 2016 in a gross plot of 4.2 x 4.5 sq. m. The row to row distance of 60 cm and plant to plant distance of 30 cm was maintained. The dose of fertilizer at the rate of 25 kg N, 50 kg P_2O_5 and 00 kg K_2O per hectare was given at the time of sowing. The crop was grown under rainfed condition. The crop was grown with all recommended package of practices recommended by V.N.M.K.V., Parbhani except insect pest management. The details of the insecticides and its schedule of application are presented in Table 1 and 2, while the plan of layout is illustrated in Fig. 1 and Plate I..

3.6 Methods of recording observations

3.6.1 To study the bio-efficacy of different insecticides against major pests of sunflower.

Five observation plants were selected randomly from the net plot of each treatment in each replication. They were labelled properly.

The observations on total number of green semilooper larvae were recorded on five randomly selected plants from each treatment at one day before treatment and 1, 3, 7,10 and 14 days after first and second application of insecticides.

The observations on total number of *Spodoptra litura* larvae were recorded on five randomly selected plants from each treatment at one day before and 1, 3, 7 ,10 and 14 days after first and second application of insecticides.

The observations on total number of capitulum borer larvae were recorded on five randomly selected plants from each treatment at one day before and 1, 3, 7,10 and 14 days after first and second application of insecticides.

The observations on total number of hairy caterpillar larvae were recorded on five randomly selected plants from each treatment at one day before and 1, 3, 7 ,10 and 14 days after first and second application of insecticides.

The yield from each net plot was recorded after harvest and computed on hectare basis for statistical interpretation. The economics of the treatment was worked out based on seed yield and cost of protection. Based on cost of protection and gross profit, the incremental cost benefit ratio (ICBR) was worked out.

3.6.2 To study the population dynamics of major pests of Sunflower.

The observation on defoliators, head borers, sucking pests, and natural enemies were recorded from randomly selected five plants at weekly interval. From seedling to harvesting stage data was generated through out the season and was correlated with the weather parameter.

3.6.3 To study the effect of insecticides on natural enemies.

The observations on total number of ladybird beetles, parasitoid (*Charops obtusks, Apantelus sp.*, Braconids, *Campoletis chlorideae*) , *C.carnea* and Spider on five randomly selected plants from net plot were also recorded at one day before and 1, 3, 7, 10 and 14 days after first and second spray in order to know the effect of different insecticides on population of natural enemies.

The data on number of green semilooper , hairy caterpillar, Spodoptra litura, capitulum borer larvae and *chrysoperla carnea*, ladybird beetle, spider , parasitoid were transformed into square root transformation before statistical analysis.

3.7 Statistical analysis

The data in respect of bio-efficacy of different insecticides against. Green semilooper S*podoptra litura* capitulum borer ,hairy caterpillar and effect on *C. carnea* , ladybird beetle, spider , parasitoid were statistically analyzed by standard 'analysis of variance'. The null hypothesis was tested by 'F' test of significance at 5 per cent level (Gomez and Gomez, 1984).

Experimental detail

Design	=	Randomized Block Design (RBD)
Replications	=	Three (3)
Treatments	=	8
Gross Plot Size	=	4.2 m × 4.5 m
Net plot size	=	3.0 x 3.9 m
Spacing	=	60cm × 30 cm
Date of Sowing	=	5th August 2016
Season	=	*Kharif*
Variety	=	Morden
Fertilizer dose	=	25 N : 50 P : 00 K kg/ha
1 st Spray	=	2nd octomber 2016
2 nd Spray	=	22 nd octomber 2016

Table no. 1 Treatment details

Treatments No.	**Treatments**	**Doses /ha**	**Doses/10 lit**
T_1	Emamectin Benzoate 5 SG	220 gm/ha	4 gm
T_2	Lambda cyhalothrin 5 EC	250 ml/ha	5 ml
T_3	Chlorantraniliprole 18.5 SC	150 ml/ha	3 ml
T_4	Indoxacarb 15.8 EC	250 ml/ha	5 ml
T_5	Spinosad 45 SC	125 ml/ha	2.5 ml
T_6	Fenvalerate 20 SC	400 ml/ha	8 ml
T_7	Profenophos 50 EC	1000 ml/ha	20 ml
T_8	Control	Water spray	-

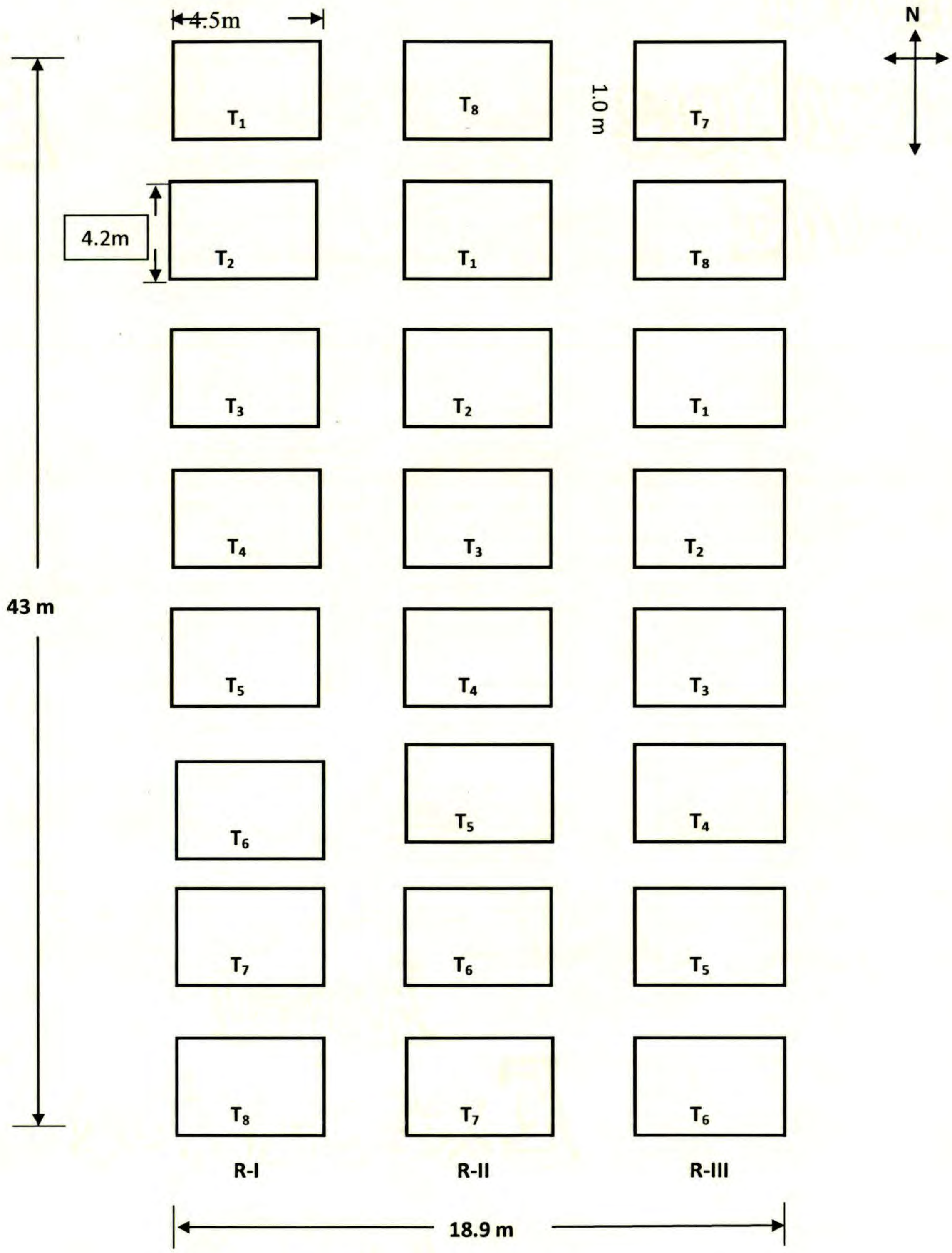


Fig 1: Plan of layout

Table 2: Details of insecticides used in the experiment

Sr. No.	Comman name with formulation	Trade name	Chemical name	Name of company
1	Emamectin benzoate 5 SG	Proclaim	Methylamino abamectin benzoate	Syngenta Professional Product, Pune,India
2	Lambda-cyhalothrin 5 EC	Karate	α-cyano-3-Phenoxybenzyl 3-(2- Chloro 3,3,3-trifluoro-prop-I-enyl)2,2-dimethlycyclo propane carboxylate	Syngenta Professional Product, Hydabad,India
3	Chlorantraniliprole 18.5 SC	Coragen	3-Bromo-N-[4-chloro-2-methyl-6-(methylcarbamoyl)phenyl]-1-(3-chloropyridin-2-yl)-1H-pyrazole-5-carboxamide	DUPONT India pvt Ltd. Gurgoan, Haryana
4	Indoxacarb 15.8 EC	Avaunt	(S) – Methyl 7 – chloro-2 {[(methoxycarbonyl)[4-trifluoromethoxy) phenyl]amino]carbonyl} 2H,3H,4aH indeno [1,2-e][1,3,4] oxadaxime-4a-carboxylate	DUPONT India pvt Ltd. Gurgoan, Haryana
5	Spinosad 45 SC	Tracer	Spinosyn A and Spinosyn B	Dow Agro Science Mumbai, Maharashtra
6	Fenvalerate 20 EC	Sumicidin	(s)-cyano(3-phenoxy phenyl)methyl (s)-4-chloro-alpha-(1-methyl ethyl)benzene acetate	Chemet chemical Pvt.Ltd Ahmadabad Gujarat
7	Profenophos 50 EC	Curacron	O-(4-bromo-2-chlorophenyl)O-ethyl S-propyl phosphorothiate	Syngenta Professional Product, Hydabad,India

Plate no. 1 experimental field view

Results and Discussion

CHAPTER-IV

RESULTS AND DISCUSSION

The present investigation was carried out on bio-efficacy of insecticides against head borer and defoliators in sunflower. The results obtained are presented under following heads.

4.1 To study the bioefficacy of different Insecticides against major pests of Sunflower.

4.2 To study the population dynamics of major pests of Sunflower.

4.3 To study the effect of insecticides on natural enemies.

4.1 Bio-efficacy of insecticide against capitulum borer

4.1.1.1 Pre-count one day before first spray .

The data in respect of capitulum borer larvae one day before first spray is presented in table 3 and depicted in fig. 2. Shows that the distribution ofcapitulum borer larvae were equally distributed and crossed ETL in all the experimental plots.

4.1.1.2 One day after first spray .

The data generated one day after first spray is presented in table 3.and graphically depicted in fig. 2.The treatment of indoxacarb 15.8 EC (0.26 larvae/plant) was proved to be significantly superior over control to suppress the population of capitulum borer, which was statistically at par with the treatments viz. spinosad 45 SC @ 2.5ml/10 lit (0.33 larvae /plant) ,emamectin benzoate 5 SG @ 4 gm/10 lit (0.40 larvae /plant) ,lambda cyhalothrin 5EC @ 5 ml/ 10 lit (0.46 larvae /plant) and chlorantraniliprole 18.5 SC@ 5ml/10 lit(0.60 larvae/plant). Whereas, the next superior treatments were fenvalerate 20 EC @ 8 ml/10 lit (0.66 larvae /plant) and profenophos 50 EC @ 20ml/10 lit (0.73 larvae /plant). Which were significantly superior over control.

4.1.1.3 Three days after first spray.

The data shown in three days after first spray is presented in table 3.and depicted in fig. 2. showed significant reduction in all the treatment , whereas the treatment of indoxacarb 15.8 EC @ 5ml/ 10 lit (0.26 larvae/plant) recorded lowest population of capitulum borer. which was statistically at par with rest of the treatments, emamectin benzoate 5 SG @ 4 gm/10 lit (0.46 larvae/plant), lambda cyhalothrin 5 EC @5ml/10 lit (0.53 larvae /plant), spinosad 45 SC @ 2.5ml/10 lit (0.53 larvae /plant) , chlorantraniliprole 18.5 SC@ 5ml/10 lit (0.66/plant) and fenvalerate 20 EC @ 8 ml/10 lit (0.73 larvae /plant). The treatment of profenophos50 EC @ 20ml/10 lit was the least effective treatment (0.86 larvae/plant). Whereas,maximum number of larvae 1.06/plant were recorded in a control.

4.1.1.4 Seven days after first spray .

The data generated seven days after first spray is presented in table 3.and depicted in fig. 2. Indicated that the maximum reduction in the incidence of capitulum borer (0.40 larvae/plant) was registered over control with the treatment of indoxacarb 15.8 EC @ 5ml/ 10 lit which was statistically at par with rest of the treatments , emamectin benzoate 5 SG @ 4 gm/10 lit (0.53 larvae/plant), lambda cyhalothrin 5 EC @5ml/10 lit (0.60 larvae /plant), chlorantraniliprole 18.5 SC@ 5ml/10 lit (0.73 larvae /plant), spinosad 45 SC @ 2.5ml/10 lit (0.73 larvae /plant) ,fenvalerate 20 EC @ 8 ml/10 lit (0.93 larva/plant). Profenophos 50 EC @ 20ml/10 lit was least effective treatment (0.86 larvae/plant).Whereas, maximum number of larvae (1.20/plant) were recorded in a control.

4.1.1.5 Ten days after first spray .

The data recorded ten days after first spray is presented in table 3.and depicted in fig. 2. showed that significant reduction in all the treatment, though the treatment of indoxacarb 15.8 EC @ 5ml/ 10 lit lit exhibited higher reduction in capitulum borer abundance (0.46 larvae/plant) which was statistically at par with the treatments , emamectin benzoate 5 SG @ 4 gm/10 lit (0.66/plant), lambda cyhalothrin 5 EC@5ml/10 lit (0.66 larvae /plant), spinosad 45 SC @ 2.5ml/10 lit (0.80 larvae /plant) and chlorantraniliprole 18.5 SC@ 5ml/10 lit (0.86/plant). Fenvalerate 20 EC @ 8 ml/10 lit (0.93 larva/plant) and profenophos 50 EC @ 20ml/10 lit (0.93 larvae/plant) exhibited poor performance and stand at par with control(1.40 larvae/plant) .

4.1.1.6 Fourteen days after first spray .

The population built up observed at fourteen days after spray presented in table 3.and depicted in fig. 2. Minimum larvae (0.80/plant) were recorded in the treatment of indoxacarb 15.8 EC@ 5ml/ 10 lit, which was significantly superior over control and at par with treatment of lambda cyhalothrin 5 EC @5ml/10 lit (0.93 larvae /plant), emamectin benzoate 5 SG @ 4 gm/10 lit (1.00 larvae/plant), chlorantraniliprole 18.5 SC@ 5ml/ 10 lit (1.00 larvae/plant) ,spinosad 45 SC @ 2.5ml/10 lit (1.00 larvae /plant) , fenvalerate 20 EC @ 8 ml/10 lit (1.13 larva/plant) and profenophos 50 EC @ 20ml/10 lit (1.20 larvae/plant). whereas maximum larvae (1.60/plant) were recorded in a control.

Table 3. Efficacy of different insecticides against Capitulum borer larvae after first spray .

Sr. No	Treatment	Dose ml/ 10 lit.	Av. Capitulum borer larvae/ plant					
			1 DBS	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS
1.	Emamectin Benzoate 5 SG	4 gm	1.26 **(1.32)**	0.40 **(0.94)**	0.46 **(0.97)**	0.53 **(0.99)**	0.66 **(1.06)**	1.00 **(1.21)**
2.	Lambda cyhalothrin 5 EC	5 ml	1.40 **(1.37)**	0.46 **(0.97)**	0.53 **(1.00)**	0.60 **(1.04)**	0.66 **(1.06)**	0.93 **(1.19)**
3.	Chlorantraniliprole 18.5 SC	3 ml	1.13 **(1.27)**	0.60 **(1.04)**	0.66 **(1.07)**	0.73 **(1.10)**	0.86 **(1.15)**	1.00 **(1.23)**
4.	Indoxacarb 15.8 EC	5 ml	1.06 **(1.25)**	0.26 **(0.86)**	0.33 **(0.90)**	0.40 **(0.94)**	0.46 **(0.97)**	0.80 **(1.13)**
5.	Spinosad 45 SC	2.5 ml	0.80 **(1.13)**	0.33 **(0.90)**	0.53 **(1.00)**	0.73 **(1.10)**	0.80 **(1.13)**	1.00 **(1.22)**
6.	Fenvalerate 20 EC	8 ml	1.06 **(1.25)**	0.66 **(1.07)**	0.73 **(1.10)**	0.93 **(1.13)**	0.93 **(1.19)**	1.13 **(1.26)**
7.	Profenophos 50 EC	20 ml	1.46 **(1.39)**	0.73 **(1.11)**	0.86 **(1.16)**	0.86 **(1.17)**	0.93 **(1.19)**	1.20 **(1.31)**
8.	Control		1.86 **(1.53)**	0.86 **(1.16)**	1.06 **(1.25)**	1.20 **(1.30)**	1.40 **(1.37)**	1.60 **(1.44)**
	SE(m) ±		**0.09**	**0.05**	**0.07**	**0.06**	**0.07**	**0.09**
	CD at 5 %		**NS**	**0.18**	**0.23**	**0.19**	**0.21**	**0.28**
	CV (%)		**(12.31)**	**(10.27)**	**(12.53)**	**(10.26)**	**(10.69)**	**(13.27)**

DBS- Days before spray .

DAS- Days after spray .

Figure in parenthesis are $\sqrt{x + 0.5}$ transformed values.

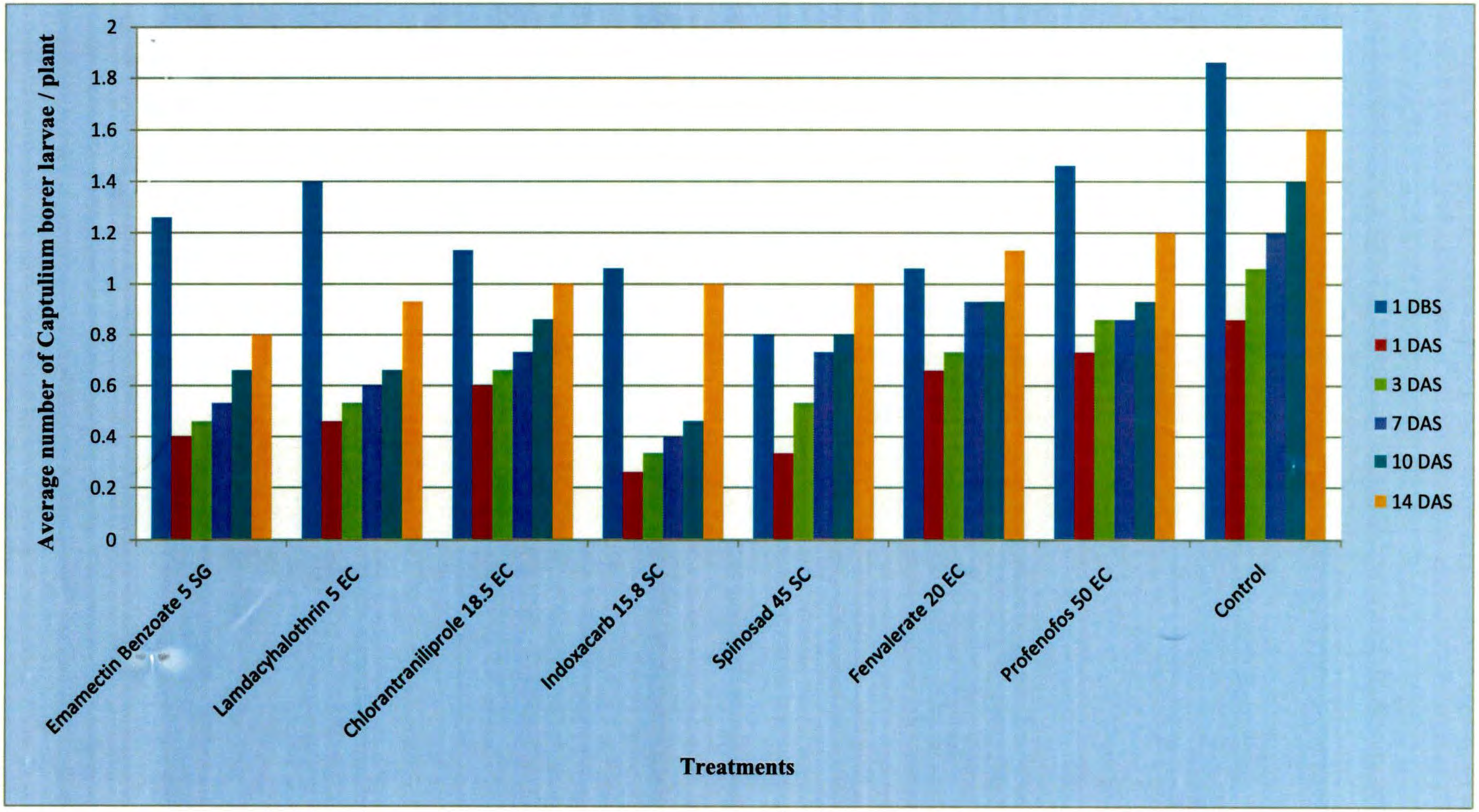


Fig.2. Population of Captulium borer larvae per plant before and after first spray

4.1.1.1 Pre-count one day before second spray

The data in respect of capitulum borer presented in table 4.and depicted in fig. 3 Shows that the distribution of capitulum borer larvae were equally distributed and crossed ETL in all the experimental plots.

4.1.1.2 One day after second spray

The data generated one day after spray in table 4. and graphically presented in fig. 3 shows that significant reduction in all the treatment , whereas the treatment of indoxacarb 15.8 EC (0.26 larvae/plant) was proved to be significantly superior over control to suppress the population of capitulum borer, which was statistically at par with treatment of emamectin benzoate 5 SG @ 4 gm/10 lit (0.33/plant). Spinosad 45 SC @ 2.5ml/10 lit (0.40 larvae /plant), lambda cyhalothrin 5 EC@5 ml/10 lit (0.46 larvae/plant), chlorantraniliprole 18.5 SC@ 5ml/10 lit (0.46 larvae/plant). Profenophos 50 EC @ 20ml/10 lit andfenvalerate 20 EC @ 8 ml/10 lit (0.73 larva/plant) stands second best treatment. However maximum number of larvae 1.46/plant were recorded in a control.

4.1.1.3 Three days after second spray .

The data tabulated in three days after spray in table 4.and graphically presented in fig. 3 shows that significant reduction in all the treatment. whereas the treatment of indoxacarb 15.8 EC @ 5ml/ 10 lit (0.26 larvae/plant) was proved superior treatment and which was statistically at par with rest of all the treatment , emamectin benzoate 5 SG @ 4 gm/10 lit (0.40/plant), spinosad 45 SC @ 2.5ml/10 lit (i,e 0.46 larvae /plant) ,chlorantraniliprole 18.5 SC@ 5ml/10 lit (0.53 larvae/plant), fenvalerate 20 EC @ 8 ml/10 lit (0.73 larva/plant), lambda cyhalothrin 5 EC @ 5 ml/10 lit (0.80larvae/plant) and profenophos 50 EC @ 20ml/10 lit (0.80 larvae/plant). whereas maximum number of larvae 1.73/plant were recorded in a control.

4.1.1.4 Seven days after second spray .

The data generated seven days after spray in table 4. and presented in fig. 3 indicates that the maximum reduction in the incidence of capitulum borer (0.46 larvae/plant) was registered over control with the treatment of indoxacarb 15.8 EC @ 5ml/ 10 lit which was statistically at par with rest of all the treatment , emametin benzoate 5 SG @ 4 gm/10 lit (0.53 larvae/plant), chlorantraniliprole 18.5 SC@ 5ml/10 lit (0.53 larvae/plant) ,spinosad 45 SC @ 2.5ml/10 lit (0.53 larvae /plant), fenvalerate 20 EC @ 8 ml/10 lit (0.80 larva/plant), except lambda cyhalothrin 5 EC @ 5 ml/10 lit (0.93larvae/plant) and profenophos 50 EC @ 20ml/10 lit (0.80 larvae/plant) were stand second best treatments but significantly superior over control

4.1.1.5 Ten days after second spray.

The data recorded ten days after spray in table 4. and graphically presented in fig. 3 shows that significant reduction in all the treatment , though the treatment of indoxacarb 15.8 EC @ 5ml/ 10 lit and chlorantraniliprole 18.5 SC@ 5ml/ 10 lit (0.60 larvae/plant) was exhibited higher reduction in capitulum borer which was statistically at par with rest of all the treatment followed by spinosad 45 SC @ 2.5ml/10 lit (0.73 larvae /plant),emamectin benzoate 5 SG @ 4 gm/10 lit (0.80 larvae/plant),fenvalerate 20 EC @ 8 ml/10 lit (0.86 larva/plant), lambda cyhalothrin 5 EC @ 5 ml/10 lit (1.00 larvae/plant) and profenophos 50 EC @ 20ml/10 lit (1.06 larvae/plant).Whereas maximum number of larvae (1.80/plant) were recorded in a control.

4.1.1.6 Fourteen days after second spray .

The population built up was observed in fourteen days after Spray however minimum larvae (0.66/plant) was recorded by the treatment of indoxacarb 15.8 EC @ 5ml/ 10 lit, which was significantly superior over control and at par with treatment of chlorantraniliprole 18.5 SC@ 5ml/ 10 lit (1.00 larvae/plant), lamdacyhalothrin 5 EC @5ml/10 lit (0.80 larvae /plant), spinosad 45 SC @ 2.5ml/10 lit (0.80 larvae /plant),emamectin benzoate 5 SG @ 4 gm/10 lit (1.00 larvae/plant), profenophos 50 EC @ 20ml/10 lit (1.13 larvae/plant) and lambda cyhalothrin 5 EC @ 5 ml/10 lit (1.26 larvae/plant). Which are significantly superior over control.

The above results are in agreement with the findings of Srinivivasan *et .al,*(2004), who evaluated efficacy of indoxacarb 15.8 EC against *Helicoverpa armigera* and indicated that indoxacarb 15.8 EC was effective treatment in controlling *Helicoverpa armigera* in cotton.

The similar results were also reported by Ravi *et .al,*(2007) that indoxacarb was superior chemical in checking larval population of *Helicoverpa armigera* in sunflower.

The similar result were recorded byYogeeswarudu *et. al,* (2014) , who determined the efficacy of seven insecticides. Treatment included two doses each of indoxacarb, profenofos, imidacloprid, novaluron, fipronil and lambda cyhalothrin results revealed that indoxacarb14.5

SC @ 0.5 ml/l was found best with minimum population of *Helicoverpaarmigera.*at first spray .

Bheemanna and Patil (1999) reported similar results which revealed that bio-efficacy of indoxacarb was highest with minimum population of *Helicoverpa armigera.*

Table 4.Efficacy of different insecticides against Capitulum borer larvae after second spray .

Sr. No	Treatment	Dose ml/10 lit.	Av. Capitulum borer larvae/ plant					
			1 DBS	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS
1.	Emamectin Benzoate 5 SG	4 gm	1.40 **(1.37)**	0.33 **(0.90)**	0.40 **(0.93)**	0.53 **(1.00)**	0.80 **(1.13)**	1.00 **(1.21)**
2.	Lambda cyhalothrin 5 EC	5 ml	1.20 **(1.29)**	0.46 **(0.96)**	0.80 **(1.12)**	0.93 **(1.19)**	1.00 **(1.21)**	1.26 **(1.32)**
3.	Chlorantraniliprole 18.5 SC	3 ml	1.06 **(1.25)**	0.46 **(0.97)**	0.53 **(1.00)**	0.53 **(1.01)**	0.60 **(1.03)**	0.80 **(1.13)**
4.	Indoxacarb 15.8 EC	5 ml	1.20 **(1.34)**	0.26 **(0.79)**	0.26 **(0.86)**	0.46 **(0.97)**	0.60 **(1.03)**	0.66 **(1.06)**
5.	Spinosad 45 SC	2.5 ml	1.40 **(1.37)**	0.40 **(0.93)**	0.46 **(0.97)**	0.53 **(1.01)**	0.73 **(1.10)**	0.80 **(1.13)**
6.	Fenvalerate 20 EC	8 ml	1.53 **(1.42)**	0.73 **(1.10)**	0.73 **(1.11)**	0.80 **(1.13)**	0.86 **(1.17)**	1.20 **(1.29)**
7.	Profenophos 50 EC	20 ml	1.66 **(1.46)**	0.73 **(1.10)**	0.80 **(1.13)**	0.93 **(1.19)**	1.06 **(1.25)**	1.13 **(1.27)**
8.	Control		2.20 **(1.65)**	1.46 **(1.39)**	1.73 **(1.49)**	1.53 **(1.42)**	1.80 **(1.51)**	1.80 **(1.52)**
	SE(m) ±		**0.08**	**0.08**	**0.09**	**0.07**	**0.08**	**0.09**
	CD at 5 %		**NS**	**0.12**	**0.27**	**0.21**	**0.226**	**0.29**
	CV (%)		**10.22**	**14.97**	**14.73**	**11.24**	**13.12**	**13.96**

Figure in parenthesis are $\sqrt{x + 0.5}$ transformed values.

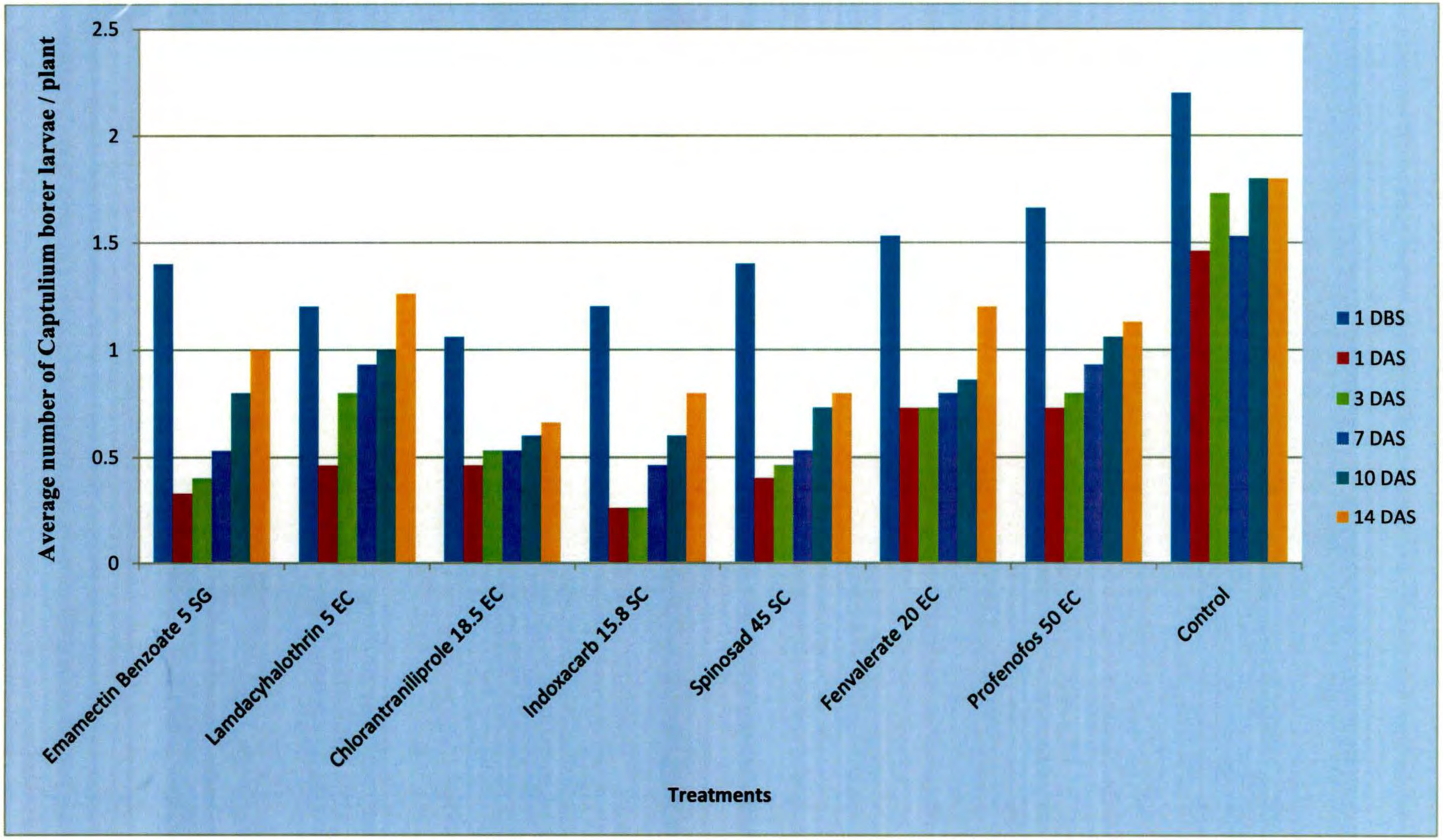


Fig. 3. Population of Captulium borer larvae per plant before and after second spray

4.1.3.1 Bioefficacy of different Insecticides against Green semilooper larvae.

Pre-count one day before first spray .

The data on semilooper larvae population one day before first spray is presented in table 5.and depicted in fig. 4. Shows that the distribution of Green semilooper larvae were equally distributed and crossed ETL in all the experimental plots.

4.1.3.2 One day after first spray .

The data recorded one day after Spray is presented in table 5.and depicted in fig. 4. revealed that significant reduction of Green semilooper in all the treatment , whereas the treatment of chlorantraniliprole 18.5 SC@ 5ml/10 lit (0.26 larvae/plant) was recorded lowest population of Green semilooper larvae, which are statistically at par with rest of all the treatments viz, fenvalerate 20 EC @ 8 ml/ 10 lit (0.33 larvae/plant), Lambda cyhalothrin 5 EC @5ml/10 lit (0.40 larvae/plant), spinosad 45 SC @ 2.5 ml/10 lit (0.40 larvae/plant), indoxacarb 15.8 EC @ 5 ml/10 lit(0.40 larvae/plant), profenophos 50 EC @ 20m/10 lit (0.46 larvae/plant) and emamectin benzoate 5 SG @ 4gm/10 lit (0.46 larvae/plant) . However maximum number of larvae 1.00/plant was recorded in a control.

4.1.3.3 Three days after first spray .

The similar results was also observed three days after in table 5.and graphically presented in fig. 4. as the least no. of larvae (0.40/plant) was recorded with the treatment of chlorantraniliprole 18.5 SC@ 5ml/10 lit . which was statistically at par with rest of all the treatments viz, emamectin benzoate 5 SG @ 4 gm/10 lit (0.46/plant), Lambda cyhalothrin 5 EC @5ml/10 lit (0.53 larvae /plant), fenvalerate 20 EC @ 8 ml/10 lit (0.53 larva/plant) , spinosad 45 SC @ 2.5 ml/10 lit (0.53 larva/plant), Lambda cyhalothrin 5 EC @5ml/10 lit (0.53 larva/plant) and profenophos 50 EC @ 20m/10 lit (0.66 larva/plant) . whereas maximum number of larvae 1.06/plant was recorded in a control.

4.1.3.4 Seven days after first spray.

The data generated seven days after spray is presented in table 5.and depicted in fig. 4. indicates that the maximum reduction in the incidence of semilooper (0.46 larvae/plant) was registered over control with the treatment of chlorantraniliprole 18.5 SC@ 5ml/10 lit which was statistically at par with rest of all the treatments , emamectin benzoate 5 SG @ 4 gm/10 lit (0.53/plant), Lambda cyhalothrin 5 EC @5ml/10 lit (0.60 larvae /plant), fenvalerate 20 EC @ 8 ml/10 lit (0.60 larva/plant) , spinosad 45 SC @ 2.5 ml/10 lit (0.60 larva/plant) , indoxacarb 15.8 EC @ 5 ml/10 lit (0.66 larvae/plant) and profenophos 50 EC @ 20m/10 lit

(0.66 larva/plant) . whereas maximum number of larvae (1.26/plant) was recorded in a control.

4.1.3.5 Ten days after first spray.

The data recorded ten days after spray is presented in table 5.and graphically presented in fig. 4. shows that significant reduction in all the treatment , though the treatment of chlorantraniliprole 18.5 SC@ 5ml/10 lit was proved to be significantly superior over control to suppress the population of Green semilooper (0.53 larvae/plant) which was statistically at par with rest of all the treatments followed by emamectin benzoate 5 SG @ 4 gm/10 lit (0.60/plant), lambda cyhalothrin 5 EC @5ml/10 lit (0.66 larvae /plant), indoxacarb 15.8 EC @ 5 ml/10 lit (0.66 larvae/plant) ,fenvalerate 20 EC @ 8 ml/10 lit (0.66 larvae/plant), spinosad 45 SC @ 2.5 ml/10 lit (0.73 larva/plant) and profenophos 50 EC @ 20m/10 lit (0.80 larva/plant). However maximum number of larvae (1.73/plant) was recorded in a control.

4.1.3.6 Fourteen days after first spray.

The population built up was observed in fourteen days after spray. However minimum larvae (0.60/plant) was recorded by the treatment of chlorantraniliprole 18.5 SC@ 5ml/10 lit, which was significantly superior over control and at par with treatments of lambda cyhalothrin 5 EC @5ml/10 lit (0.80 larvae /plant), spinosad 45 SC @ 2.5ml/10 lit (0.80 larvae /plant) , emamectin benzoate 5 SG @ 4 gm/10 lit (0.86/plant) , fenvalerate 20 EC @ 8 ml/10 lit (0.86 larvae/plant) , indoxacarb 15.8 EC @ 5 ml/10 lit (0.86 larvae/plant) and profenophos 50 EC @ 20m/10 lit (0.86 larva/plant). Whereas maximum larvae (2.10/plant) was recorded in a control.

Table 5.Efficacy of different insecticides against Green semilooper larvae after first spray .

Sr. No	Treatment	Dose ml/10 lit.	Av. Green semilooper larvae/ plant					
			1 DBS	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS
1.	Emamectin Benzoate 5 SG	4 gm	2.00 **(1.57)**	0.46 **(0.97)**	0.46 **(0.97)**	0.53 **(1.01)**	0.60 **(1.04)**	0.86 **(1.14)**
2.	Lambda cyhalothrin 5 EC	5 ml	1.46 **(1.39)**	0.40 **(0.94)**	0.53 **(0.99)**	0.60 **(1.04)**	0.66 **(1.07)**	0.80 **(1.12)**
3.	Chlorantraniliprole 18.5 SC	3 ml	2.40 **(1.70)**	0.26 **(0.87)**	0.40 **(0.94)**	0.46 **(0.97)**	0.53 **(1.01)**	0.60 **(1.04)**
4.	Indoxacarb 15.8 EC	5 ml	2.20 **(1.64)**	0.40 **(0.94)**	0.60 **(1.04)**	0.66 **(1.07)**	0.66 **(1.07)**	0.86 **(1.15)**
5.	Spinosad 45 SC	2.5 ml	1.80 **(1.51)**	0.40 **(0.94)**	0.53 **(1.01)**	0.60 **(1.04)**	0.73 **(1.11)**	0.80 **(1.13)**
6.	Fenvalerate 20 EC	8 ml	1.20 **(1.31)**	0.33 **(0.90)**	0.53 **(1.00)**	0.60 **(1.04)**	0.66 **(1.07)**	0.86 **(1.15)**
7.	Profenofos 50 EC	20 ml	1.93 **(1.55)**	0.46 **(0.97)**	0.66 **(1.07)**	0.66 **(1.07)**	0.80 **(1.13)**	0.93 **(1.19)**
8.	Control		2.20 **(1.63)**	1.00 **(1.22)**	1.06 **(1.25)**	0.26 **(1.32)**	1.73 **(1.48)**	2.10 **(1.62)**
	SE(m) ±		**0.10**	**0.05**	**0.07**	**0.06**	**0.06**	**0.09**
	CD at 5 %		**NS**	**0.17**	**0.22**	**0.20**	**0.19**	**0.28**
	CV (%)		**11.29**	**10.60**	**12.37**	**10.77**	**10.16**	**14.78**

Figure in parenthesis are $\sqrt{x + 0.5}$ transformed values.

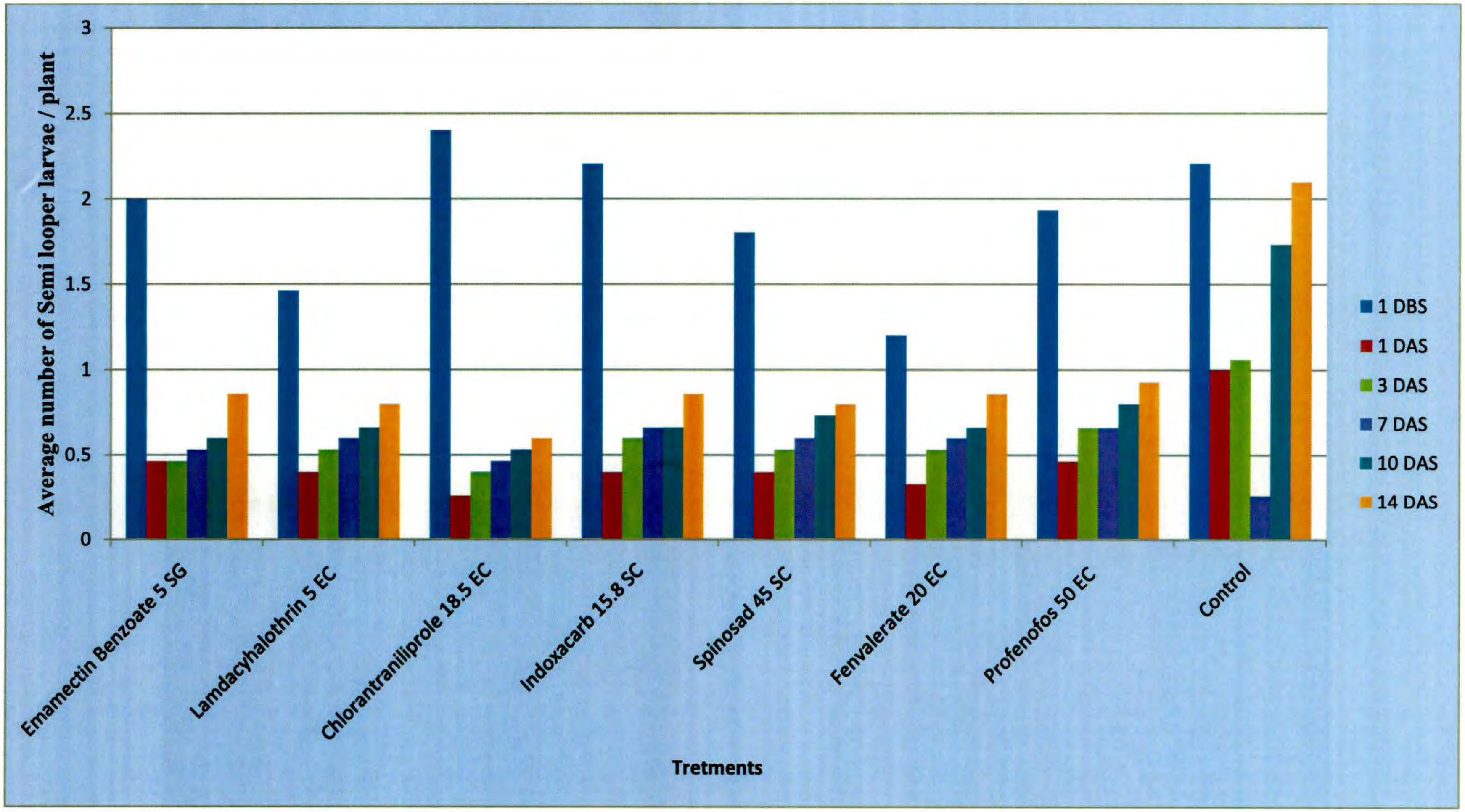


Fig. 4. Population of Green semilooper larvae per plant before and after first spray

4.1.4.1 Pre-count one day before second spray

The data on Green semilooper larvae population one day before second spray is presented in table 6.and depicted in fig. 5.Shows that the distribution of Green semilooper larvae were distributed and crossed ETL uniformly in all the experimental plots.

4.1.4.2 One day after second spray .

The data recorded one day after second spray in table 6. and depicted in fig. 5 revealed that significant reduction of Green semilooper in all the treatment, whereas the treatment of chlorantraniliprole 18.5 SC@ 5ml/10 lit (0.33 larvae/plant) was recorded lowest population of Green semilooper larvae, which is statistically at par with rest of all the treatments emamectin benzoate 5 SG @ 4gm/10 lit (0.40 larvae/plant) , spinosad 45 SC @ 2.5 ml/10 lit (0.60 larvae/plant), fenvalerate 20 EC @ 8 ml/ 10 lit (0.80 larvae/plant), Lambda cyhalothrin 5 EC @5ml/10 lit (0.80 larvae/plant), indoxacarb 15.8 EC @ 5 ml/10 lit(1.00 larvae/plant) and profenophos 50 EC @ 20m/10 lit (1.44 larvae/plant) . However maximum number of larvae 2.06/plant was recorded in a control.

4.1.4.3 Three days after second spray .

The similar results was also observed three days after second spray in table 6. and presented in fig. 5 as the least no. of larvae (0.40/plant) were recorded with the treatment of chlorantraniliprole 18.5 SC@ 5ml/10 lit and emamectin benzoate 5 SG @ 4 gm/10 lit. which is statistically at par with rest of all the treatments viz. spinosad 45 SC @2.5ml/10 lit (0.60 larvae /plant), fenvalerate 20 EC @ 8 ml/10 lit (0.80 larva/plant), lambda cyhalothrin 5 EC @ 5 ml/10 lit(0.80 larvae/plant) , indoxacarb 15.8 EC @ 5 ml/10 lit(1.00 larvae/plant) and profenophos 50 EC @ 20m/10 lit (1.44 larvae/plant). Whereas maximum number of larvae 1.06/plant was recorded in a control.

4.1.4.4 Seven days after second spray.

The data generated seven days after second spray in table 6. and depicted in fig. 5 indicates that the maximum reduction in the incidence of Green semilooper (0.46 larvae/plant) was registered over control with the treatment of chlorantraniliprole 18.5 SC@ 5ml/10 lit which is statistically at par with rest of all the treatments viz, emamectin benzoate 5 SG @ 4 gm/10 lit (0.53/plant), spinosad 45 SC @ 2.5ml/10 lit (0.60 larvae /plant), except fenvalerate 20 EC @ 8 ml/10 lit (1.20 larva/plant), lambda cyhalothrin 5 EC @ 5 ml/10 lit(1.20 larvae/plant) and profenophos 50 EC @ 20ml/10 lit(1.73 larvae/ plant) stands second best treatment but significantly superior over control. Whereas maximum number of larvae (1.53/plant) were recorded in a control.

4.1.4.5 Ten days after second spray .

The data recorded ten days after second spray in table 6. and graphically presented fig. 5 shows that significant reduction in all the treatment , though the treatment of chlorantraniliprole 18.5 SC@ 5ml/10 lit was proved superior treatment in Green semilooper (0.46 larvae/plant) which was statistically at par with treatment of emamectin benzoate 5 SG @ 4 gm/10 lit (0.60/plant), whereas indoxacarb 15.8 EC @ 5 ml/ 10 lit (1.13 larvae /plant),spinosad 45 SC @ 2.5ml/10 lit (1.13 larvae /plant),fenvalerate 20 EC @ 8 ml/10 lit (1.20 larvae/plant), lambda cyhalothrin 5 EC @5ml/10 lit (1.26 larvae /plant) stands second best treatment. However maximum number of larvae (1.73/plant) was recorded in a control.

4.1.4.6 Fourteen days after second spray .

The population built up was observed in fourteen days after second spray however minimum larvae (0.73/plant) was recorded by the treatment of chlorantraniliprole 18.5 SC@ 5ml/10 lit, which is significantly superior over control and at par with treatment of spinosad 45 SC @ 2.5ml/10 lit (1.13 larvae /plant),indoxacarb 15.8 EC @ 5 ml/ 10 lit (1.26 larvae /plant). But lambda cyhalothrin 5 EC @ 5ml/10 lit (1.60 larvae /plant), profenophos 50 EC @ 20ml/10 lit(1.73 larvae/ plant), emamectin benzoate 5 SG @ 4 gm/10 lit (1.80/plant) fenvalerate 20 EC @ 8 ml/10lit stands second best treatments, whereas maximum larvae (2.10/plant) was recorded in a control.

Findings of Mutkule*et.al*, (2010) are in agreement with the present findings regarding green semilooper control.

The similar result were obtained from Mutkule*et.al*, (2010) amongst various treatments, spinosad was found to be significantly superior treatment against defoliators larvae. Which was followed by emamectinbenzoate ,indoxacarb , endosulfan.

Table 6.Effect of different insecticides against Green semilooper larvae after second spray .

Sr. No	Treatment	Dose ml/10 lit.	Av. Green semilooper larvae/ plant					
			1 DBS	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS
1.	Emamectin Benzoate 5 SG	4 gm	2.06 **(1.60)**	0.33 **(0.90)**	0.40 **(0.94)**	0.53 **(1.01)**	0.86 **(1.17)**	1.80 **(1.51)**
2.	Lambda cyhalothrin 5 EC	5 ml	1.06 **(1.24)**	0.80 **(1.13)**	0.80 **(1.13)**	1.20 **(1.30)**	1.26 **(1.32)**	1.60 **(1.44)**
3.	Chlorantraniliprole 18.5 SC	3 ml	1.20 **(1.29)**	0.40 **(0.94)**	0.40 **(0.94)**	0.46 **(0.97)**	0.46 **(0.97)**	0.73 **(1.10)**
4.	Indoxacarb 15.8 EC	5 ml	1.53 **(1.42)**	1.00 **(1.22)**	1.00 **(1.22)**	1.00 **(1.22)**	1.13 **(1.27)**	1.26 **(1.32)**
5.	Spinosad 45 SC	2.5 ml	1.53 **(1.42)**	0.60 **(1.04)**	0.60 **(1.04)**	0.73 **(1.11)**	1.13 **(1.27)**	1.13 **(1.27)**
6.	Fenvalerate 20 EC	8 ml	1.53 **(1.42)**	0.80 **(1.13)**	0.80 **(1.13)**	1.13 **(1.28)**	1.20 **(1.30)**	1.93 **(1.55)**
7.	Profenophos 50 EC	20 ml	1.66 **(1.46)**	1.44 **(1.39)**	1.46 **(1.39)**	1.73 **(1.48)**	1.73 **(1.49)**	1.60 **(1.44)**
8.	Control		0.86 **(1.16)**	2.06 **(1.60)**	2.06 **(1.60)**	1.53 **(1.40)**	1.73 **(1.49)**	2.10 **(1.62)**
	SE(m) ±		**0.08**	**0.06**	**0.06**	**0.09**	**0.07**	**0.08**
	CD at 5 %		**NS**	**0.20**	**0.20**	**0.28**	**0.23**	**0.25**
	CV (%)		**10.48**	**10.09**	**10.09**	**13.66**	**10.83**	**10.26**

Figure in parenthesis are $\sqrt{x + 0.5}$ transformed values.

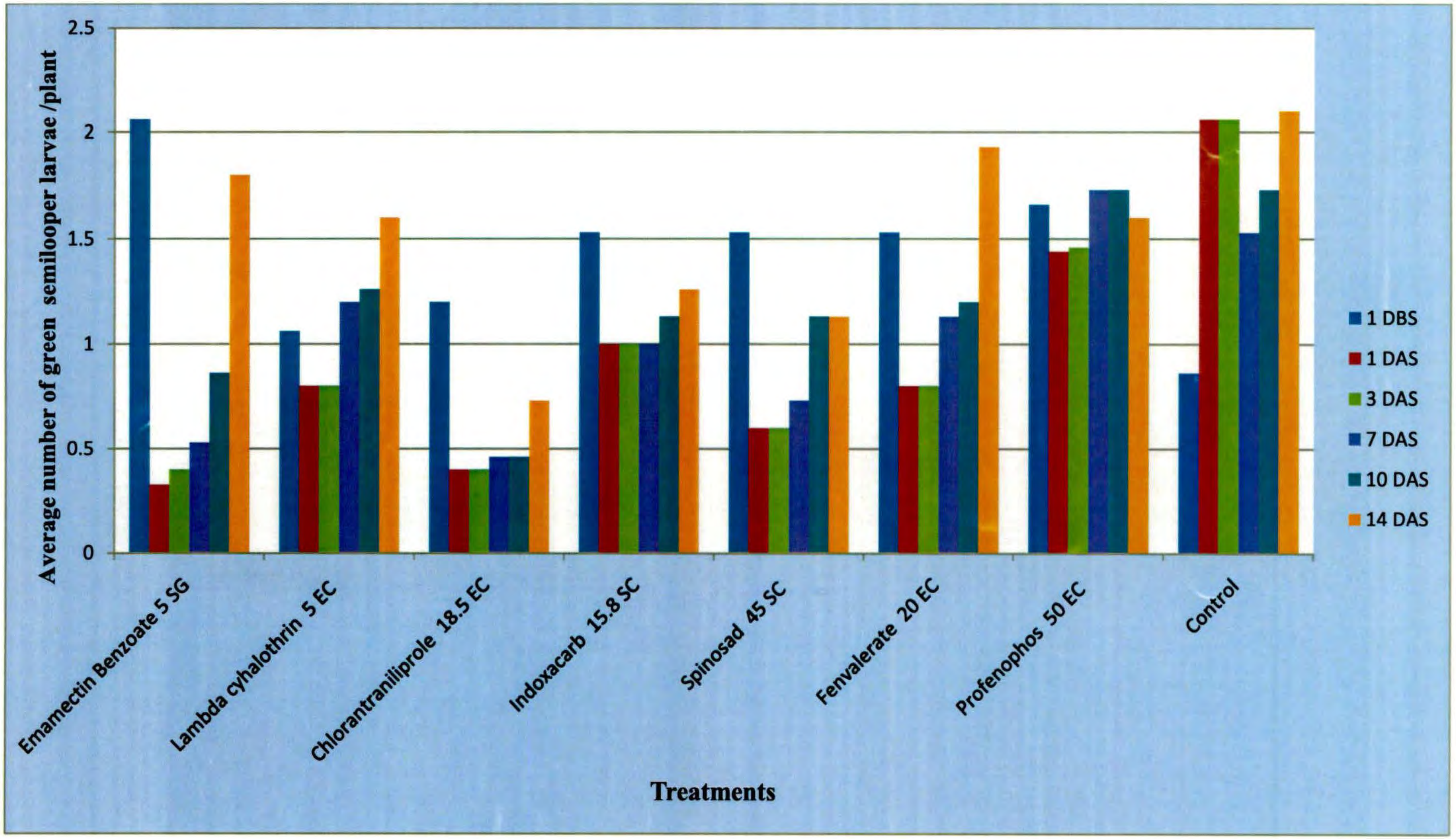


Fig. 5. Population of Green semilooper larvae per plant before and after second spray

4.1.5 Bio-efficacy of the insecticides against Hairy caterpillar larvae.

4.1.5.1 Pre-count one day before first spray

The data on hairy caterpillar population one day before first spray is presented in table 7.and depicted in fig. 6. Shows that the distribution of hairy caterpillar larvae were equally distributed and crossed ETL in all the experimental plots.

4.1.5.2 One day after first spray .

The data recorded one day after first Spray is presented in table 7.and graphically presented in fig. 6 revealed that significant reduction in all the treatments. Though the treatment of chlorantraniliprole 18.5 SC@ 5ml/10 lit (0.33 larvae/plant) was recorded lowest populatin of hairy catterpillar larvae, which is statistically at par with rest of all the treatments and significantly superior over control. Whereas the at par treatment are lambda cyhalothrin 5EC @ 5 ml/ 10 lit (0.46/plant), spinosad 45 SC @ 2.5ml/10 lit (0.53 larvae /plant) ,emamectin benzoate 5 SG @ 4 gm/10 lit (0.40/plant) , profenophos 50 EC @ 20ml/10 lit (0.60 larvae /plant),indoxacarb 15.8 EC @ 5ml/ 10 lit (0.66 larvae/plant) and , emamectin benzoate 5 SG @ 4 gm/10 lit (0.73/plant). However maximum number of larvae 1.40 /plant was recorded in a control.

4.1.5.3 Three days after first spray .

The similar results were also observed three days after first spray is presented in table 7 and depicted in fig. 6. as the least no. of larvae (0.46/plant) was recorded with the treatment of chlorantraniliprole 18.5 SC@ 5ml/10 lit. which is statistically at par with the treatments of Lambda cyhalothrin 5 EC @ 5 ml/10 lit(0.66 larvae/plant) ,indoxacarb 15.8 EC @ 5 ml/ 10 lit (66 larvae /plant), fenvalerate 20 EC @ 8 ml/10 lit (0.73 larva/plant), spinosad 45 SC @ 2.5ml/10 lit (0.73 larvae /plant), emamectin benzoate 5 SG @ 4 gm/10 lit (0.73/plant) and profenophos 50 EC @ 20ml/10 lit (0.80 larvae /plant). Whereas maximum number of larvae 1.26/plant was recorded in a control.

4.1.5.4 Seven days after first spray .

The data generated seven days after first spray is presented in table 7. and depicted in fig. 6 indicates. that the maximum reduction in the incidence of hairy caterpillar (0.53 larvae/plant) was registered over control with the treatment of chlorantraniliprole 18.5 SC@ 5ml/10 lit which is statistically at par with rest of all the treatments , indoxacarb 15.8 EC @ 5 ml/ 10 lit (0.73 larvae /plant), fenvalerate 20 EC @ 8 ml/10 lit (0.73 larva/plant), Lambda cyhalothrin 5 EC @ 5 ml/10 lit(0.73 larvae/plant), spinosad 45 SC @ 2.5ml/10 lit (0.86 larvae /plant) ,profenophos 50 EC @ 20ml/10 lit (0.86 larvae /plant) and emamectin benzoate 5 SG @ 4 gm/10 lit (0.93/plant). However maximum number of larvae (1.40/plant) was recorded in a control.

4.1.5.5 Ten days after first spray .

The data recorded ten days after first spray is presented in table 7 and depicted in fig. 6 shows that significant reduction in all the treatment. Though the treatment of chlorantraniliprole 18.5 SC@ 5ml/10 lit was proved to be significantly superior over control to suppress the population of hairy caterpillar (0.73 larvae/plant) which was statistically at par with treatment of Lambda cyhalothrin 5 EC @5ml/10 lit (0.80 larvae /plant), indoxacarb 15.8 EC @ 5 ml/ 10 lit (0.86 larvae /plant) spinosad 45 SC @ 2.5ml/10 lit (0.93 larvae /plant), profenophos 50 EC @ 20ml/10 lit (1.06 larvae /plant), fenvalerate 20 EC @ 8 ml/10 lit (1.13 larva/plant), emamectin benzoate 5 SG @ 4 gm/10 lit (1.20/plant). Whereas maximum number of larvae (1.46/plant) were recorded in a control.

4.1.5.6 Fourteen days after first spray .

The population built up was observed in fourteen days after first spray however minimum larvae (0.86/plant) was recorded by the treatment of chlorantraniliprole 18.5 SC@ 5ml/10 lit, which is significantly superior over control and at par with treatment of emamectin benzoate 5 SG @ 4 gm/10 lit (1.40/plant) , lambda cyhalothrin 5 EC @5ml/10 lit (1.40 larvae /plant), spinosad 45 SC @ 2.5ml/10 lit (1.40 larvae /plant), profenophos 50 EC @ 20ml/10 lit (1.40 larvae /plant), indoxacarb 15.8 EC @ 5 ml/ 10 lit (1.46 larvae /plant) and fenvalerate 20 EC @ 8 ml/10 lit (1.46 larva/plant). Whereas maximum larvae (1.80 larvae/plant) was recorded in a control.

Table 7. Efficacy of different insecticides against hairy caterpillar larvae after first spray .

Sr. No	Treatment	Dose ml/10 lit.	Av. hairy caterpillar larvae / plant					
			1 DBS	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS
1.	Emamectin Benzoate 5 SG	4 gm	1.26 **(1.32)**	0.73 **(1.10)**	0.73 **(1.11)**	0.93 **(1.19)**	1.20 **(1.29)**	1.40 **(1.36)**
2.	Lambda cyhalothrin 5 EC	5 ml	1.26 **(1.32)**	0.46 **(0.97)**	0.66 **(1.07)**	0.73 **(1.10)**	0.80 **(1.13)**	1.40 **(1.37)**
3.	Chlorantraniliprole 18.5 SC	3 ml	1.06 **(1.24)**	0.33 **(0.90)**	0.46 **(0.97)**	0.53 **(0.99)**	**0.73** **(1.10)**	0.86 **(1.17)**
4.	Indoxacarb 15.8 EC	5 ml	1.33 **(1.34)**	0.66 **(1.07)**	0.66 **(1.07)**	0.73 **(1.09)**	0.86 **(1.16)**	1.46 **(1.39)**
5.	Spinosad 45 SC	2.5 ml	1.06 **(1.24)**	0.53 **(1.01)**	0.73 **(1.11)**	0.86 **(1.15)**	0.93 **(1.18)**	1.40 **(1.37)**
6.	Fenvalerate 20 EC	8 ml	0.93 **(1.19)**	0.73 **(1.10)**	0.73 **(1.10)**	0.73 **(1.11)**	1.13 **(1.27)**	1.46 **(1.41)**
7.	Profenophos 50 EC	20ml	1.20 **(1.30)**	0.60 **(1.04)**	0.80 **(1.13)**	0.86 **(1.17)**	1.06 **(1.25)**	1.40 **(1.37)**
8.	Control		1.13 **(1.27)**	1.40 **(1.36)**	1.26 **(1.32)**	1.40 **(1.37)**	1.46 **(1.39)**	1.80 **(1.51)**
	SE(m)±		**0.06**	**0.07**	**0.06**	**0.09**	**0.08**	**0.08**
	CD at 5 %		**NS**	**0.23**	**0.20**	**0.28**	**0.25**	**0.24**
	CV (%)		**(9.27)**	**(12.62)**	**(10.76)**	**(14.11)**	**(12.02)**	**(10.50)**

Figure in parenthesis are $\sqrt{x + 0.5}$ transformed values.

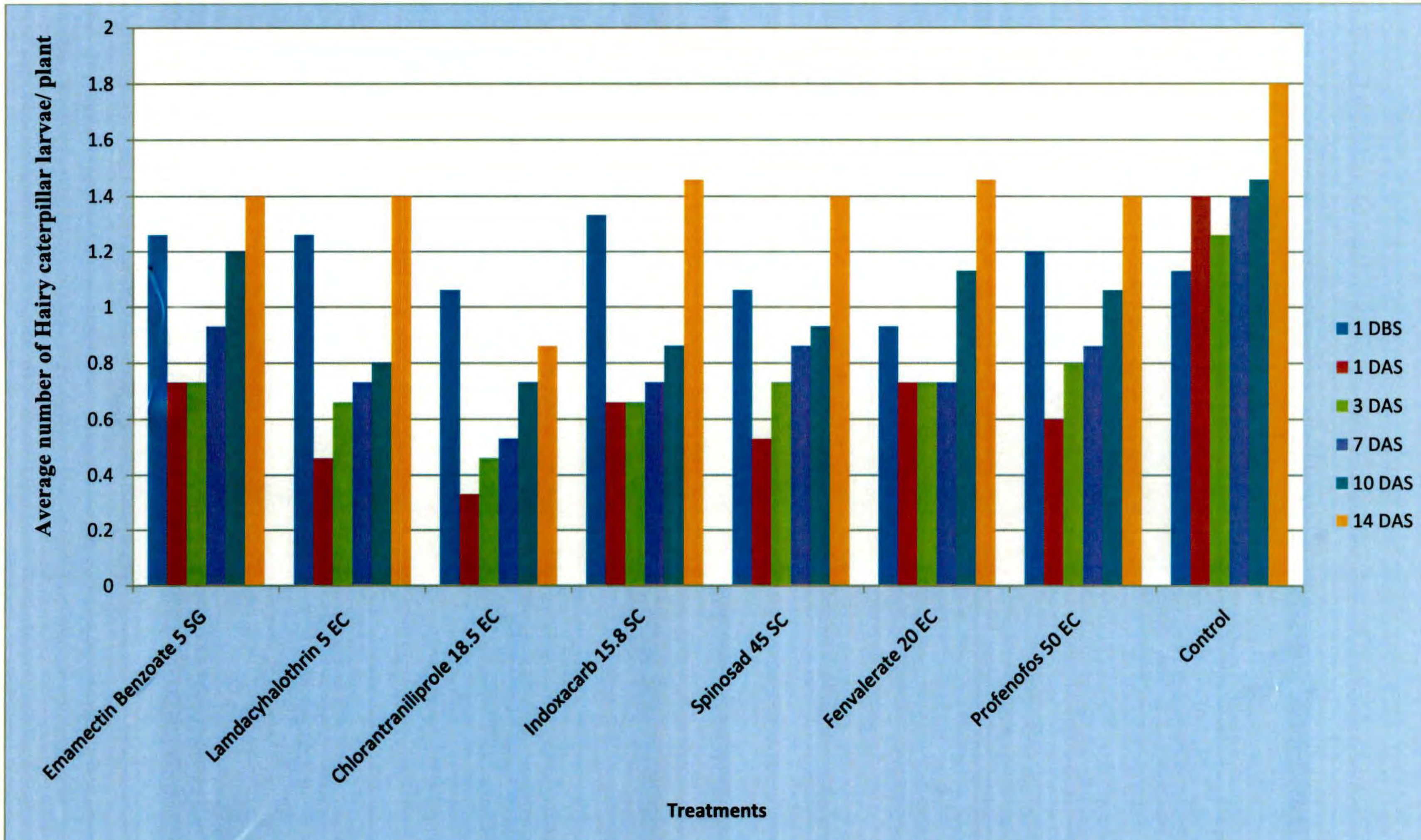


Fig. 6. Population of hairy caterpillar larvae per plant before and after first spray

4.1.6.1 Pre-count one day before second spray .

The data on hairy caterpillar population one day before first spray is presented in table 8.and depicted in fig. 7. Shows that the distribution of hairy caterpillar larvae were equally distributed and crossed ETL in all the experimental plots.

4.1.6.2 One day after second spray .

The data recorded one day after second spray is presented in table 8. and depicted in fig. 7 revealed that significant reduction in all the treatment, whereas the treatment of chlorantraniliprole 18.5 SC@ 5ml/10 lit (0.20 larvae/plant) was exhibited as higher reduction of hairy caterpillar larvae, which is statistically at par with rest of all the treatments viz, lambda cyhalothrin 5 EC @ 5ml/10 lit (0.40 larvae/plant), profenophos 50 EC @ 20ml/10 lit (0.40 larvae/plant), spinosad 45 SC@ 8ml/ 10 lit (0.53 larvae/plant),indoxacarb 15.8 EC @ 5ml/10 lit (0.60 larvae/plant),emamectin benzoate 5 SG@ 4gm/ 10 lit (0.66 larvae/plant), and fenvalerate 20 EC @ 8m/10 lit (0.66 larvae/plant). However maximum number of larvae (1.40 /plant) was recorded in a control.

4.1.6.3 Three days after second spray .

The data recorded three days after second spray is presented in table 8.and graphically presented in fig. 7. as the least no. of larvae (0.40/plant) was recorded with the treatment of chlorantraniliprole 18.5 SC@ 5ml/10 lit. which is statistically at par with the treatments of emamectin benzoate 5 SG @ 4 gm/10 lit (0.53/plant), indoxacarb 15.8 EC @ 5 ml/ 10 lit (60 larvae /plant) ,profenophos 50 EC @ 20ml/10 lit (0.60 larvae/plant) and spinosad 45 SC @2.5ml/10 lit (0.66 larvae /plant).whereas lambda cyhalothrin 5 EC @ 5 ml/10 lit(0.86 larvae/plant) and fenvalerate 20 EC @ 8 ml/10 lit (0.93 larva/plant) stands second best treatment but significantly superior over control .Though maximum number of larvae 1.53/plant was recorded in a control.

4.1.6.4 Seven days after second spray .

The data generated seven days after second spray is presented in table 8. and depicted in fig. 7 indicates that the maximum reduction in the incidence of hairy caterpillar (0.40 larvae/plant) was registered over control with the treatments of chlorantraniliprole 18.5 SC@ 5ml/10 lit which is statistically at par with the treatments viz. indoxacarb 15.8 EC @ 5 ml/ 10 lit (0.66 larvae /plant) and emamectin benzoate 5 SG @ 4 gm/10 lit (0.73/plant). whereas spinosad 45 SC @ 2.5ml/10 lit (0.93 larvae /plant) profenophos 50 EC @ 20ml/10 lit(1.00

larvae/ plant), lambda cyhalothrin 5 EC @ 5 ml/10 lit(1.06 larvae/plant) andfenvalerate 20 EC @ 8 ml/10 lit (1.46 larva/plant) stands second best treatment but significantly superior over control. Whereas maximum number of larvae (1.73/plant) was recorded in a control.

4.1.6.5 Ten days after second spray.

The similar results were also observed ten days after second spray in table 8. and graphically presented in fig. 7 shows that significant reduction in all the treatment , Though the treatment of chlorantraniliprole 18.5 SC@ 5ml/10 lit was proved superior treatment in hairy caterpillar (0.53 larvae/plant) which is statistically at par with treatments of indoxacarb 15.8 EC @ 5 ml/ 10 lit (0.80 larvae /plant) and emamectin benzoate 5 SG @ 4 gm/10 lit (0.86/plant), except spinosad 45 SC @ 2.5ml/10 lit (1.06 larvae /plant), lambda cyhalothrin 5 EC @5ml/10 lit (1.13 larvae /plant), profenophos 50 EC @ 20ml/10 lit(1.13 larvae/ plant) and fenvalerate 20 EC @ 8 ml/10 lit (1.60 larva/plant) . Though maximum number of larvae (1.93/plant) was recorded in a control.

4.1.6.6 Fourteen days after second spray .

The population built up was observed in fourteen days after second spray is presented in table 8. and depicted in fig. 7 however minimum larvae (0.73/plant) was recorded in the treatment of chlorantraniliprole 18.5 SC@ 5ml/10 lit, which is significantly superior over control and at par with treatments of emamectin benzoate 5 SG @ 4 gm/10 lit (1.06/plant), indoxacarb 15.8 EC @ 5 ml/ 10 lit (1.33 larvae /plant), spinosad 45 SC @ 2.5ml/10 lit (1.33 larvae /plant), lambda cyhalothrin 5 EC @5ml/10 lit (1.46 larvae /plant), profenophos 50 EC @ 20ml/10 lit(1.46 larvae/ plant) and fenvalerate 20 EC @ 8 ml/10 lit (1.60 larva/plant). whereas maximum larvae (2.26 /plant) was recorded in a control.

Selvaraj *et.al,* (2015) reported that chlorantraniliprole 18.5 SC is useful chemical in checking the population of hairy caterpillar.

The similar results were also reported by Selvaraj*et.al,*(2015) that chlorantraniliprole 18.5 SC was effective chemical in checking the larval population of hairy caterpillar.

Table 8.Efficacy of different insecticides against hairy caterpillar larvae after second spray .

Sr. No	Treatment	Dose ml/lit.	Av. hairy caterpillar larvae/ plant					
			1 DBS	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS
1.	Emamectin Benzoate 5 SG	4 gm	1.33 **(1.34)**	0.66 **(1.07)**	0.53 **(1.00)**	0.73 **(1.11)**	0.86 **(1.16)**	1.06 **(1.24)**
2.	Lambda cyhalothrin 5 EC	5 ml	1.66 **(1.46)**	0.40 **(0.93)**	0.86 **(1.17)**	1.06 **(1.24)**	1.13 **(1.27)**	1.46 **(1.36)**
3.	Chlorantraniliprole 18.5 SC	3 ml	0.93 **(1.19)**	0.20 **(0.83)**	0.40 **(0.94)**	0.40 **(0.94)**	0.53 **(1.01)**	1.00 **(1.22)**
4.	Indoxacarb 15.8 EC	5 ml	1.46 **(1.39)**	0.60 **(1.04)**	0.60 **(1.04)**	0.66 **(1.06)**	0.80 **(1.13)**	1.33 **(1.34)**
5.	Spinosad 45 SC	2.5 ml	1.60 **(1.44)**	0.53 **(1.00)**	0.66 **(1.08)**	0.93 **(1.19)**	1.06 **(1.24)**	1.33 **(1.34)**
6.	Fenvalerate 20 EC	8 ml	1.60 **(1.43)**	0.66 **(1.07)**	0.93 **(1.19)**	1.46 **(1.39)**	1.60 **(1.43)**	1.60 **(1.44)**
7.	Profenophos 50 EC	20 ml	1.46 **(1.39)**	0.40 **(0.93)**	0.60 **(1.04)**	1.00 **(1.22)**	1.13 **(1.27)**	1.46 **(1.39)**
8.	Control		1.93 **(1.55)**	1.40 **(1.37)**	1.53 **(1.42)**	1.73 **(1.49)**	1.93 **(1.55)**	2.26 **(1.67)**
	SE(m) ±		**0.07**	**0.08**	**0.07**	**0.07**	**0.07**	**0.07**
	CD at 5 %		**NS**	**0.26**	**0.22**	**0.22**	**0.22**	**0.22**
	CV (%)		**(9.8)**	**(14.64)**	**(11.51)**	**(10.58)**	**(10.10)**	**(9.81)**

Figure in parenthesis are $\sqrt{x + 0.5}$ transformed values.

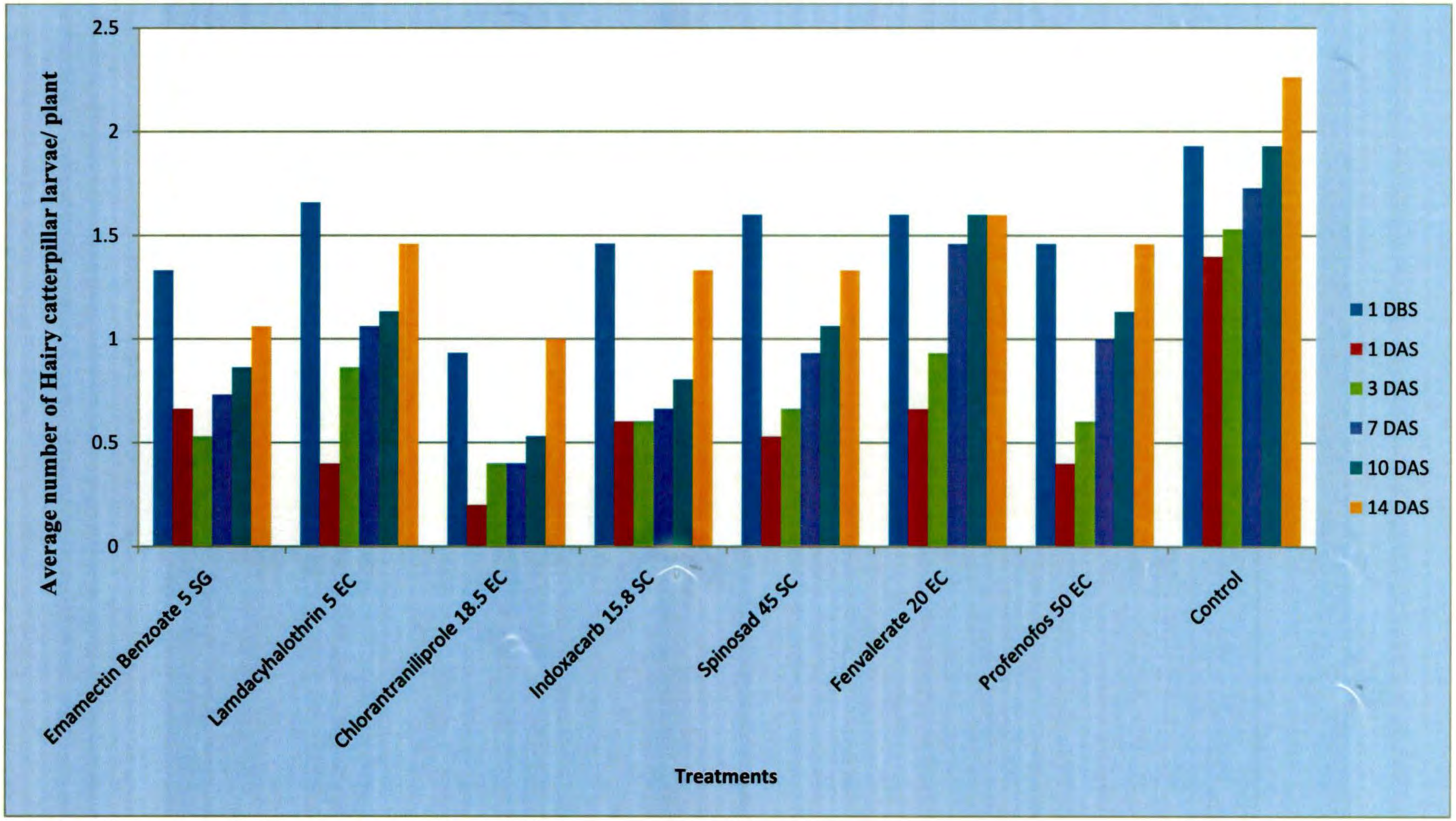


Fig. 7. Population of hairy caterpillar larvae per plant before and after second spray

4.1.7 Bio-efficacy of the insecticides against *Spodoptera litura* larvae.

4.1.7.1Pre-count one day before first spray

The data in respect of *S. litura* larvae presented in table 9.and depicted in fig. 8. Shows that the distribution of *S. litura* larvae were equally distributed and crossed ETL in all the experimental plots.

4.1.7.2 One day after first spray .

The data generated one day after spray is presented in table 9.and depicted in fig. 8. shows that spinosad 45 SC @ 2.5ml/10 lit (0.20 larvae /plant) and emamectin benzoate 5 SG @ 4 gm/10 lit (0.20 larvae/plant) has significant reduction in all the treatments and were exhibited as higher reduction in *S.litura*, which is statistically at par with treatments of lambda cyhalothrin 5 EC @5ml/10 lit (0.40 larvae /plant), chlorantraniliprole 18.5 SC@ 5ml/ 10 lit (0.46 larvae/plant) and indoxacarb 15.8 (0.53 larvae/plant) , whereas profenophos 50 EC @ 20ml/10 lit (0.80 larvae/plant) and fenvalerate 20 EC @ 8 ml/10 lit (0.53 larvae/plant) stands second best treatment. Whereas maximum number of larvae 1.80 larvae/plant was recorded in a control.

4.1.7.3 Three days after first spray .

The data shown in three days after spray as shows that significant reduction in all the treatment , whereas the treatment of that spinosad 45 SC @ 2.5ml/10 lit (0.26 larvae /plant) was recorded lowest populatin of *S.litura*. which is statistically at par with rest of all the treatment followed by emamectin benzoate 5 SG @ 4 gm/10 lit (0.33/plant), lambda cyhalothrin 5 EC @5ml/10 lit (0.46 larvae /plant), chlorantraniliprole 18.5 SC@ 5ml/ 10 lit (0.53 larvae/plant), indoxacarb 15.8 EC (0.60 larvae/plant) and fenvalerate 20 EC @ 8 ml/10 lit (0.66 larvae/plant). exceptprofenophos 50 EC @ 20ml/10 lit (0.86 larvae/plant) stands second best treatment. Whereas maximum number of larvae 2.00/plant was recorded in a control.

4.1.7.4 Seven days after first spray .

The data generated seven days after spray is presented in table 9.and depicted in fig. 8. indicates that the maximum reduction in the incidence of *S. litura*(0.40 larvae/plant) was registered over control with the treatment of spinosad 45 SC @ 2.5ml/10 lit (0.33 larvae /plant) which is statistically at par with rest of all the treatments , emamectin benzoate 5 SG @ 4 gm/10 lit (0.40/plant), lambda cyhalothrin 5 EC @5ml/10 lit (0.53 larvae /plant), chlorantraniliprole 18.5 SC@ 5ml/ 10 lit (0.60 larvae/plant), indoxacarb 15.8 EC @2.5 ml/10 lit (0.66 larvae/plant) and fenvalerate 20 EC @ 8 ml/10 lit (0.53 larvae/plant). But profenophos 50 EC @ 20ml/10 lit stands second best treatment (1.00 larvae/plant).

4.1.7.5 Ten days after first spray

The data recorded ten days after spray is presented in table 9.and graphically presented in fig. 8. shows that significant reduction in all the treatment , though the treatment shows that spinosad 45 SC @ 2.5ml/10 lit (0.53 larvae /plant) and emamectin benzoate 5 SG @ 4 gm/10 lit (0.53 larvae/plant) were exhibited higher reduction in *S. litura*which is statistically at par with rest of all the treatments viz, lambda cyhalothrin 5 EC @5ml/10 lit (0.60 larvae /plant), chlorantraniliprole 18.5 SC@ 5ml/ 10 lit (0.66 larvae/plant) , indoxacarb 15.8 EC @2.5 ml/10 lit (0.73 larvae/plant), fenvalerate 20 EC @ 8 ml/10 lit (0.80 larvae/plant) and profenophos 50 EC @ 20ml/10 lit (0.93 larvae/plant). Whereas maximum number of larvae (1.40/plant) was recorded in a control.

4.1.7.6 Fourteen days after first spray

The population built up was observed in fourteen days after spray is presented in table 9 and depicted in fig. 8. However minimum larvae (0.73/plant) was recorded by the treatment spinosad 45 SC @ 2.5ml/10 lit) which is significantly superior over control and at par with treatments of indoxacarb 15.8 (0.80 larvae/plant) , fenvalerate 20 EC @ 8 ml/10 lit (0.86 larvae/plant), emamectin benzoate 5 SG @ 4 gm/10 lit (0.93 larvae/plant) , Lambda cyhalothrin 5 EC @5ml/10 lit (1.06 larvae /plant), chlorantraniliprole 18.5 SC@ 5ml/ 10 lit (1.13 larvae/plant) and profenophos 50 EC @ 20ml/10 lit (1.40 larvae/plant) whereas maximum larvae (1.66/plant) was recorded in a control.

Munir*et al*., (2005) reported that SC formulation of emamectin benzoate was effective in reducing the incidence of *S. litura.* The results suggest that EC formulation of emamectin benzoate could be recommended to control *Spodopteralitura.*

The similar result were observed by Gadhia*et. al,* (2014) , who determined the efficacy of nine insecticides.which included emamectin benzoate, thiodicarb, indoxacarb, spinosad, novaluron, lufenuron, flubendiamide, chlorantraniliprole, metaflumizone against *Spodopteralitura.*Among nine insecticide results revealed that emamectin benzoate was found best with minimum population of *spodopteralitura.*

Table 9. Efficacy of different insecticides against *S. litura* larvae after first spray .

Sr. No	Treatment	Dose ml/ 10 lit.	Av. *S. litura*larvae/ plant					
			1 DBS	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS
1.	Emamectin Benzoate 5 SG	4 gm	1.33 **(1.34)**	0.20 **(0.83)**	0.33 **(0.90)**	0.40 **(0.94)**	0.53 **(1.00)**	0.73 **(1.10)**
2.	Lambda cyhalothrin 5 EC	5 ml	1.46 **(1.39)**	0.40 **(0.94)**	0.46 **(0.97)**	0.53 **(1.00)**	0.60 **(1.04)**	1.00 **(1.23)**
3.	Chlorantraniliprole 18.5 SC	3 ml	1.53 **(1.41)**	0.46 **(0.97)**	0.53 **(1.00)**	0.60 **(1.03)**	0.66 **(1.07)**	1.13 **(1.27)**
4.	Indoxacarb 15.8 EC	5 ml	1.60 **(1.44)**	0.53 **(1.01)**	0.60 **(1.04)**	0.66 **(1.06)**	0.73 **(1.09)**	0.80 **(1.13)**
5.	Spinosad 45 SC	2.5 ml	1.46 **(1.39)**	0.20 **(0.83)**	0.26 **(0.87)**	0.33 **(0.90)**	0.53 **(1.00)**	0.93 **(1.19)**
6.	Fenvalerate 20 EC	8 ml	1.53 **(1.41)**	0.53 **(1.01)**	0.66 **(1.07)**	0.73 **(1.11)**	0.80 **(1.13)**	0.86 **(1.17)**
7.	Profenophos 50 EC	20 ml	1.20 **(1.29)**	0.80 **(1.14)**	0.86 **(1.17)**	1.00 **(1.22)**	0.93 **(1.19)**	1.40 **(1.35)**
8.	Control		2.13 **(1.61)**	1.86 **(1.52)**	2.00 **(1.58)**	1.73 **(1.49)**	1.93 **(1.55)**	1.66 **(1.46)**
	SE(m) ±		**0.10**	**0.06**	**0.07**	**0.08**	**0.09**	**0.10**
	CD at 5 %		**NS**	**0.20**	**0.22**	**0.24**	**0.28**	**0.31**
	CV (%)		**12.54**	**11.56**	**12.25**	**13.04**	**14.21**	**14.59**

Figure in parenthesis are $\sqrt{x + 0.5}$ transformed values

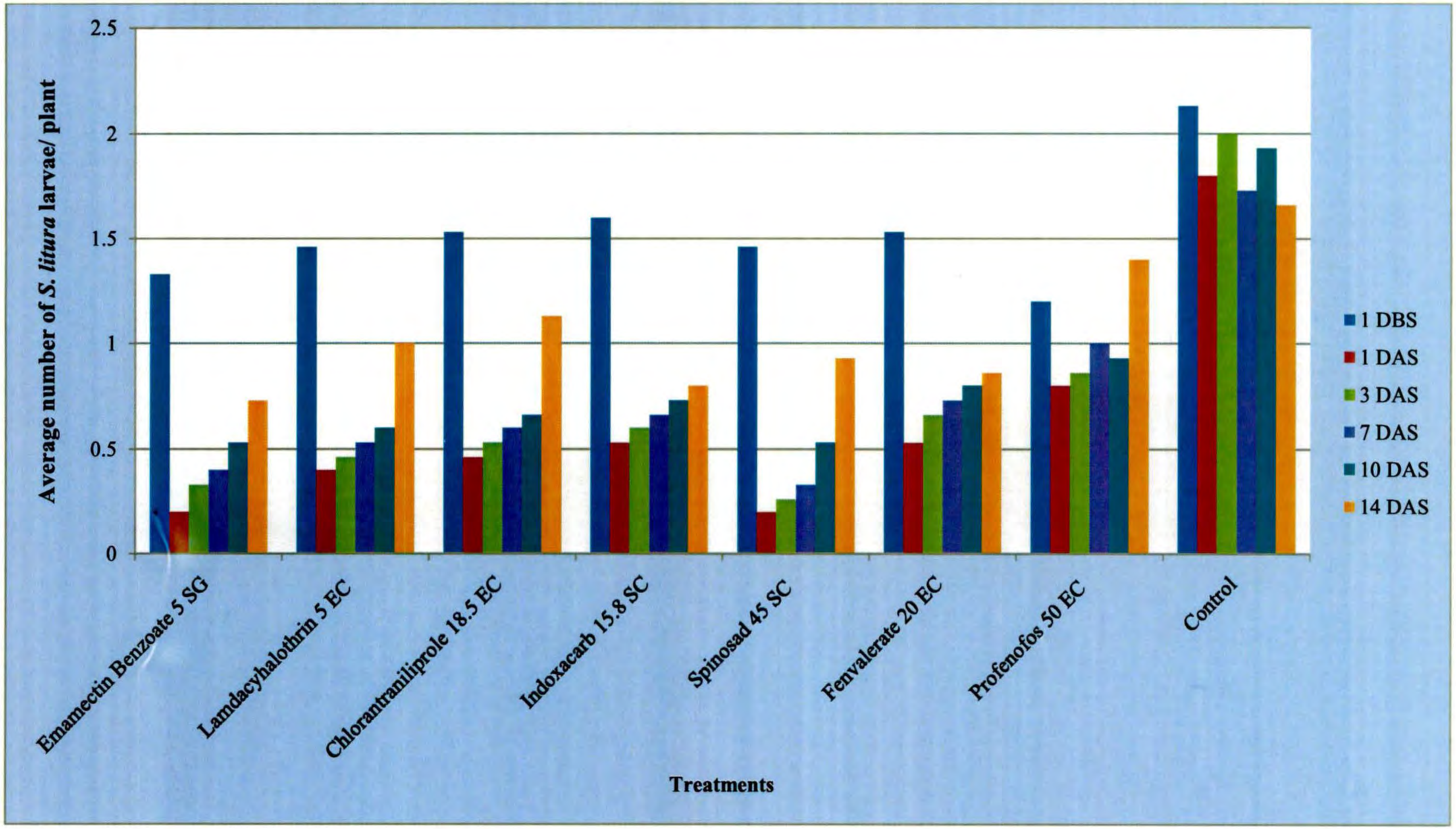


Fig. 8. Population of *S.litura* larvae per plant before and after fisrt spray

4.1.8.1 Pre-count one day before second spray

The data generated of *S. litura* presented in table 10.and depicted in fig. 9. Shows that the distribution of *S. litura* larvae were equally distributed and crossed ETL in all the experimental plots.

4.1.8.2 One day after second spray

The data generated one day after second spray is presented in table 10.and graphically presented in fig. 9. shows that spinosad 45 SC @ 2.5ml/10 lit (0.26 larvae /plant) and emamectin benzoate 5 SG @ 4 gm/10 lit (0.26 larvae/plant) has significant reduction in all the treatments and was recorded lowest population of *S.litura*, which is statistically at par with rest of all the treatments , indoxacarb 15.8 (0.33 larvae/plant) Lambda cyhalothrin 5 EC @5ml/10 lit (0.46 larvae /plant), chlorantraniliprole 18.5 SC@ 5ml/ 10 lit (0.46 larvae/plant), fenvalerate 20 EC @ 8 ml/10 lit (0.60/plant) and profenophos 50 EC @ 20ml/10 lit (0.73 larvae /plant) . Whereas maximum number of larvae 1.80 larvae/plant was recorded in a control.

4.1.8.3 Three days after second spray

The data shown in three days after second spray is presented in table 10. and graphically presented in fig. 9 shows that reduction in all the treatment , whereas the treatment of that spinosad 45 SC @ 2.5ml/10 lit (0.33 larvae /plant) was proved to be significantly superior over control to suppress the population of *S.litura*. which is statistically at par with rest of all the treatments viz, emamectin benzoate 5 SG @ 4 gm/10 lit (0.46 larvae/plant), indoxacarb 15.8 EC (0.46 larvae/plant), Lambda cyhalothrin 5 EC @5ml/10 lit (0.73 larvae /plant), chlorantraniliprole 18.5 SC@ 5ml/ 10 lit (0.73 larvae/plant) and fenvalerate 20 EC @ 8 ml/10 lit (0.73/plant). Profenophos 50 EC @ 20ml/10 lit (0.80 larvae/plant) stands second best treatment. whereas maximum number of larvae 1.86/plant was recorded in a control.

4.1.8.4 Seven days after second spray

The data generated seven days after second spray is presented in table 10.and depicted in fig. 9. indicates that the maximum reduction in the incidence of *S. litura*(0.53 larvae/plant) was registered over control with the treatment of spinosad 45 SC @ 2.5ml/10 lit (0.33 larvae /plant) which is statistically at par with rest of all the treatments , emamectin benzoate 5 SG @ 4 gm/10 lit (0.60/plant), chlorantraniliprole 18.5 SC@ 5ml/ 10 lit (0.60 larvae/plant), indoxacarb 15.8 EC (0.66 larvae/plant), fenvalerate 20 EC @ 8 ml/10 lit

(0.73/plant) , lambda cyhalothrin 5 EC @ 5ml/10 lit (0.80 larvae /plant) and profenophos 50 EC @ 20ml/10 lit (0.93 larvae /plant) . Whereas maximum number of larvae (2.13/plant) was recorded in a control.

4.1.8.5 Ten days after second spray

The data recorded ten days after second Spray is presented in table 10.and depicted in fig. 9. shows that significant reduction in all the treatment , though the treatment Spray shows that spinosad 45 SC @ 2.5ml/10 lit (0.60 larvae /plant) was *S. litura*which is statistically at par with rest of all the treatments viz, emamectin benzoate 5 SG @ 4 gm/10 lit (0.66/plant), chlorantraniliprole 18.5 SC@ 5ml/ 10 lit (0.73 larvae/plant), indoxacarb 15.8 EC (0.80 larvae/plant), lambda cyhalothrin 5 EC @5ml/10 lit (0.93 larvae /plant), fenvalerate 20 EC @ 8 ml/10 lit (1.00 larvae/plant) and profenophos 50 EC @ 20ml/10 lit (1.00 larvae /plant).

4.1.8.6 Fourteen days after second spray

The population built up were observed in fourteen days after second spray is presented in table 10 and depicted in fig. 9.However minimum larvae (0.80/plant) was recorded by the treatment spinosad 45 SC @ 2.5ml/10 lit (0.80 larvae /plant) and emamectin benzoate 5 SG @ 4 gm/10 lit (0.80 /plant) which is significantly superior over control and at par with treatments of indoxacarb 15.8 EC (0.93 larvae/plant), lambda cyhalothrin 5 EC @5ml/10 lit (1.00 larvae/plant), chlorantraniliprole 18.5 SC@ 5ml/ 10 lit (1.06 larvae/plant), fenvalerate 20 EC @ 8 ml/10 lit (1.20 larvae/plant) and profenophos 50 EC @ 20ml/10 lit (1.20 larvae /plant). whereas maximum larvae (2.20/plant) was recorded in a control.

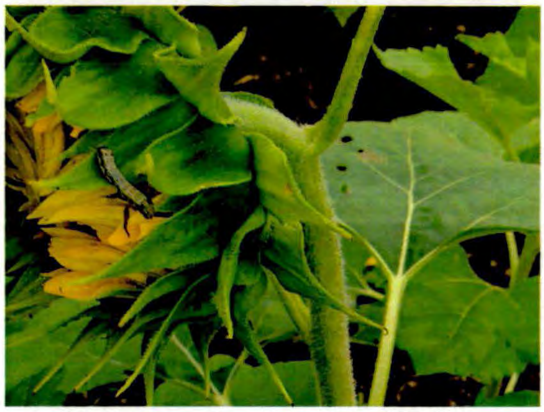
The above results are in agreement with the findings of Patil *et.al,* (2014) for management of *S. litura*.Among various insecticides tested they formed spinosad was effective in protecting the crop.

Table 10. Efficacy of different insecticides against *S. litura* larvae after second spray .

Sr. No	Treatment	Dose ml/lit.	Av. *S. litura* larvae/ plant					
			1 DBS	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS
1.	Emamectin Benzoate 5 SG	4 gm	1.20 **1.30)**	0.26 **(0.85)**	0.46 **(0.97)**	0.60 **(1.04)**	0.66 **(1.07)**	0.80 **(1.13)**
2.	Lambda cyhalothrin 5 EC	5 ml	1.20 **(1.28)**	0.46 **(0.97)**	0.73 **(1.09)**	0.80 **(1.13)**	0.93 **(1.19)**	1.00 **(1.21)**
3.	Chlorantraniliprole 18.5 SC	3 ml	1.06 **(1.25)**	0.46 **(0.9s6)**	0.73 **(1.00)**	0.60 **(1.04)**	0.73 **(1.10)**	1.06 **(1.23)**
4.	Indoxacarb 15.8 EC	5 ml	0.86 **(1.17)**	0.33 **(0.90)**	0.46 **(0.97)**	0.66 **(1.07)**	0.80 **(1.13)**	0.93 **(1.19)**
5.	Spinosad 45 SC	2.5 ml	1.40 **(1.37)**	0.26 **(0.86)**	0.33 **(0.90)**	0.53 **(1.01)**	0.60 **(1.04)**	0.80 **(1.13)**
6.	Fenvalerate 20 EC	8 ml	1.46 **(1.39)**	0.60 **(1.04)**	0.73 **(1.10)**	0.73 **(1.10)**	1.00 **(1.22)**	1.20 **(1.28)**
7.	Profenophos 50 EC	20 ml	1.06 **(1.26)**	0.73 **(1.11)**	0.80 **(1.13)**	0.93 **(1.19)**	1.00 **(1.21)**	1.20 **(1.30)**
8.	Control		1.53 **(1.40)**	1.46 **(1.39)**	1.86 **(1.51)**	2.13 **(1.60)**	2.20 **(1.64)**	2.20 **(1.64)**
	SE(m) ±		**0.11**	**0.08**	**0.07**	**0.08**	**0.09**	**0.08**
	CD at 5 %		**NS**	**0.25**	**0.22**	**0.25**	**0.30**	**0.25**
	CV (%)		**14.66**	**14.70**	**12.04**	**12.83**	**14.14**	**11.62**

Figure in parenthesis are $\sqrt{x + 0.5}$ transformed values.

Helicoverpa armigera



Spodoptera litura

Spodoptera litura

Green Semilooper

Jassid

Plate no .2 Actual incidence of defoliators in experimental plots

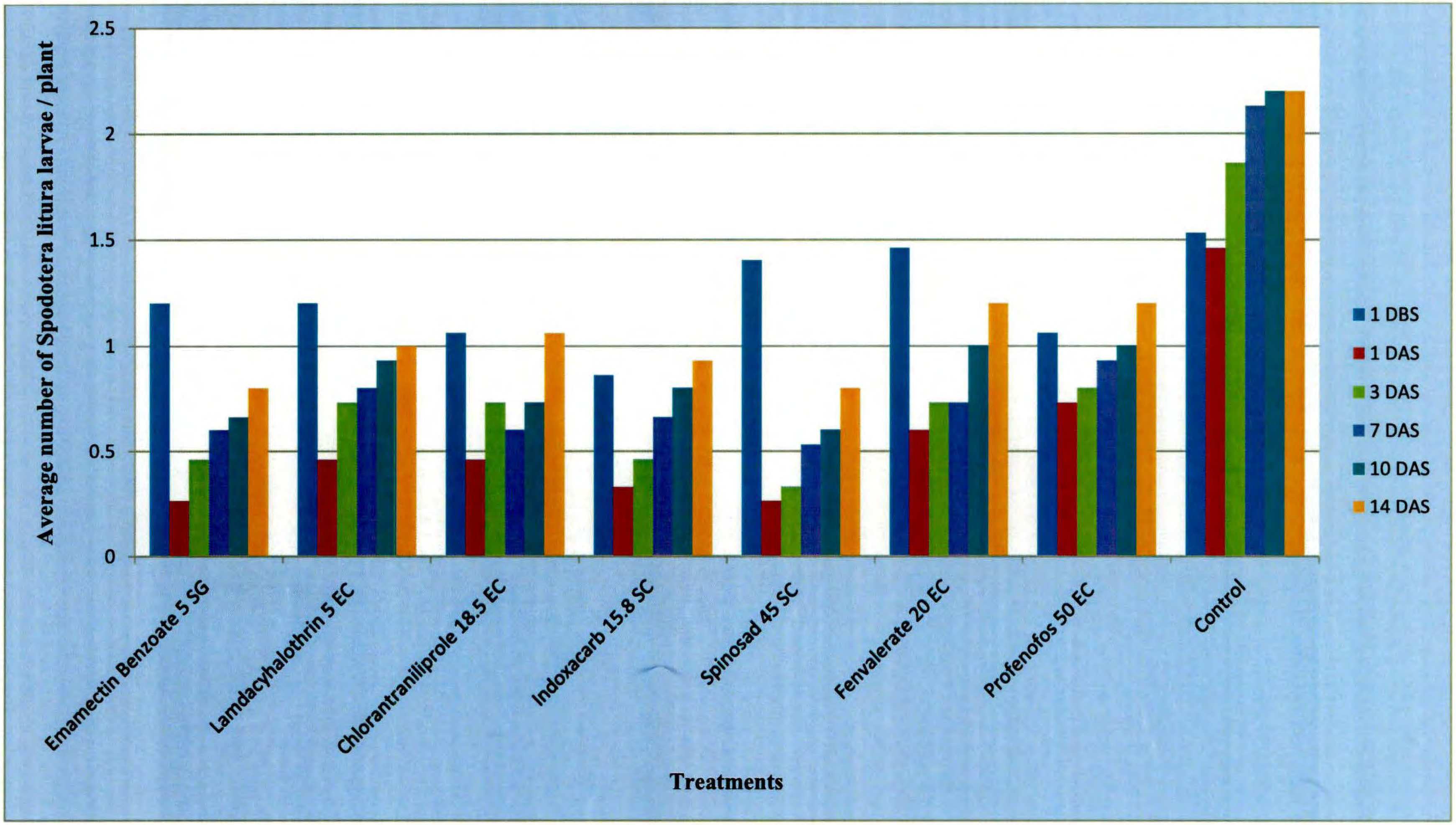


Fig. 9.Population of *S.litura* larvae per plant before and after second spray.

4.2.1 To study the population dynamics of major pest of sunflower.

The correlation of sucking pests, natural enemies and defoliators of sunflower such as thrips, jassids, whitefly, aphids ,capitulum borer, *Spodoptera litura*, green semilooper , hairy caterpillar infesting sunflower was studied during *kharif* season 2016-17.

The population of sunflower sucking pests i.e thrips, jassids, whitefly and aphids,/ leaf was recorded and defoliators capitulum borer, *Spodoptera litura* , green semilooper and hairy caterpillar along with the natural enemies such as *C.carnea*, ladybird bettle, spider & parasitiod (*Charops obtusus, Apantelus spp*, Braconids, *Campoletis chlorideae*) per plant was recorded. The incidence was recorded on 5 randomly selected plants from 33rd to 43th meterological week.

Table 11. Seasonal incidence of defoliators and head borers in sunflower.

Duration	MW	*Spodopter litura* (larvae/plant)	Green semilooper (larvae/plant)	Capitulum borer (Larvae/plant)	Hairy caterpillar (larvae/plant)
07-14 Aug.	33	0.6	1.0	0.0	0.0
15-21 Aug.	34	1.0	2.0	0.0	0.6
22-28 Aug.	35	1.0	2.0	0.6	0.6
29-04 Sep	36	1.4	1.4	0.6	0.4
05-11 Sep.	37	1.8	1.8	1.0	1.8
12-18 Sep	38	1.2	1.2	0.6	0.8
19-25 Sep.	39	1.2	1.2	0.6	1.0
26-02 Oct	40	1.6	1.6	1.0	0.8
03-09 Oct	41	1.8	1.8	1.0	0.6
10-16 Oct	42	0.8	0.8	1.0	1.0
17-23 Oct.	43	0	0.0	0.2	0.0

Spodoptera litura

The *Spodoptera litura* larval population ranged between 0.60 to 1.80 larvae /plant as shown in the table 11 the incidence of *Spodoptera litura* started from 33rd MW 0.60/plant.The peak activity of spodoptera was observed during 37th MW 1.80 larvae/plant . Thereafter the population declined and reached up to 0.8 larvae/ plant in the 42nd MW.

Jadhav *et.al,*(2004) recorded the *spodoptera litura* population during 32 to 38 week after emergence of crops had progressive build up in sunflower and Kharub *et al.*,(1993) reported a peak activities of *spodoptera litura* larval population were in 41st week.

The similar results were also reported by Jagtap *et.al,*(2007) regarding the peak of *spodoptera litura* population . He recorded highest population of *S. litura* to the extent of 2.8 larvae per quadrat was recorded on okra in 34th meteorological week

Green semilooper

The data on population of green semilooper infesting sunflower was studied in different meterological weeks as shown in table 11 the population ranged between 0.80 to 2.00 larvae/plant. The peak was observed during 34th to 35th MW, The population was not observed from 43rd week

Capitulum borer

The data represented in table 11 on population of Capitulum borer larvae ranged between 0.20 to 1.00. The occurance of helicoverpa armigera started from 35th MW 0.60 larvae /plant and the peak activity of helicoverpa armigera was 1.00 larvae /plant in 37th MW, Thereafter the population of helicoverpa decreased with flactuation upto 44th week

The similar results were also recorded by Chandel *et.al,*(2005) he recorded the population dynamics of *H.armigere* on chickpea, pigeonpea, tomato, sunflower and okra. It was observed that from October onwards.

Hairy caterpillar

The hairy caterpillar population ranged between 0.40 to 1.8 as shown in the table 11 the incidence of hairy caterpillar larvae started from 34th MW 0.60 larvae/plant went on rising. The peak activity of hairy caterpillar was observed during 37th MW 1.80 larvae/plant. Thereafter the

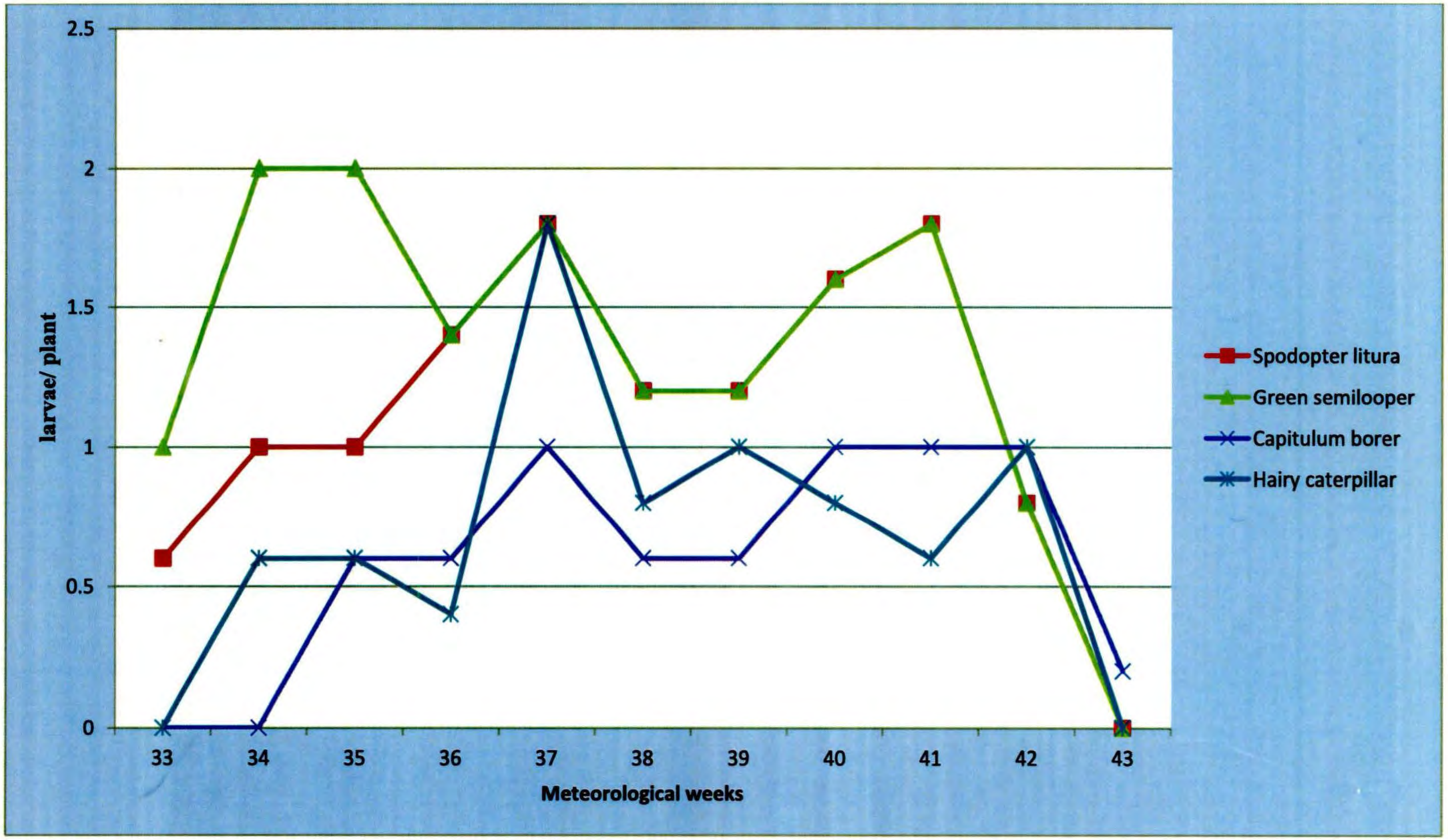


Fig. 10 Seasonal incidence of defoliators and head borers in sunflower.

population went on increasing, there was fluctuation in rise and fall in number of Hairy caterpillar.

Table 12. Seasonal incidence of natural enemies in sunflower.

Duration	MW	LBB (adult/plant)	Chrysopa (grub/plant)	Predatory Spider (adult/plant0	Parasitoid (pupae/plant)
07-14 Aug.	33	0.0	0.0	0	0.0
15-21 Aug.	34	0.8	0.6	0	0.6
22-28 Aug.	35	0.6	1.0	1.0	0.6
29-04 Sep	36	0.8	0.6	0.4	0.6
05-11 Sep.	37	0.8	0.8	0.8	0.6
12-18 Sep	38	1.0	1.4	1.2	0.8
19-25 Sep.	39	1.2	1.2	0.8	0.6
26-02 Oct	40	1.6	1.0	0.6	1.0
03-09 Oct	41	0.6	0.6	0.4	0.4
10-16 Oct	42	0.4	0.4	0	0.6
17-23 Oct.	43	0.0	0.0	0.0	0.0

Ladybird beetle

Occurance of ladybird beetle started from 34th MW 0.80 adult/plant. The peak was observed during 40th MW 1.60 adult/plant. Thereafter the population declined upto 0.40 adult/plant on 42nd MW.

Chrysoperla carnea

The data of population of *C.carnea* during *kharif* (2016-17) from table 12 revealed that *C.carnea* population ranged between 0.40 to 1.40 grub /plant. Peak population was observed in 38th MW 1.40 grub /plant, Thereafter it was declined with fluctuation upto 0.40 grub/plant till 42nd MW.

The findings of Hallolli *et.al* (1994) was justifies the present results regarding natural enemies. He reported that the peak population *C. carnea*(1.20) in crop sown on 25th November and also in second week of January.

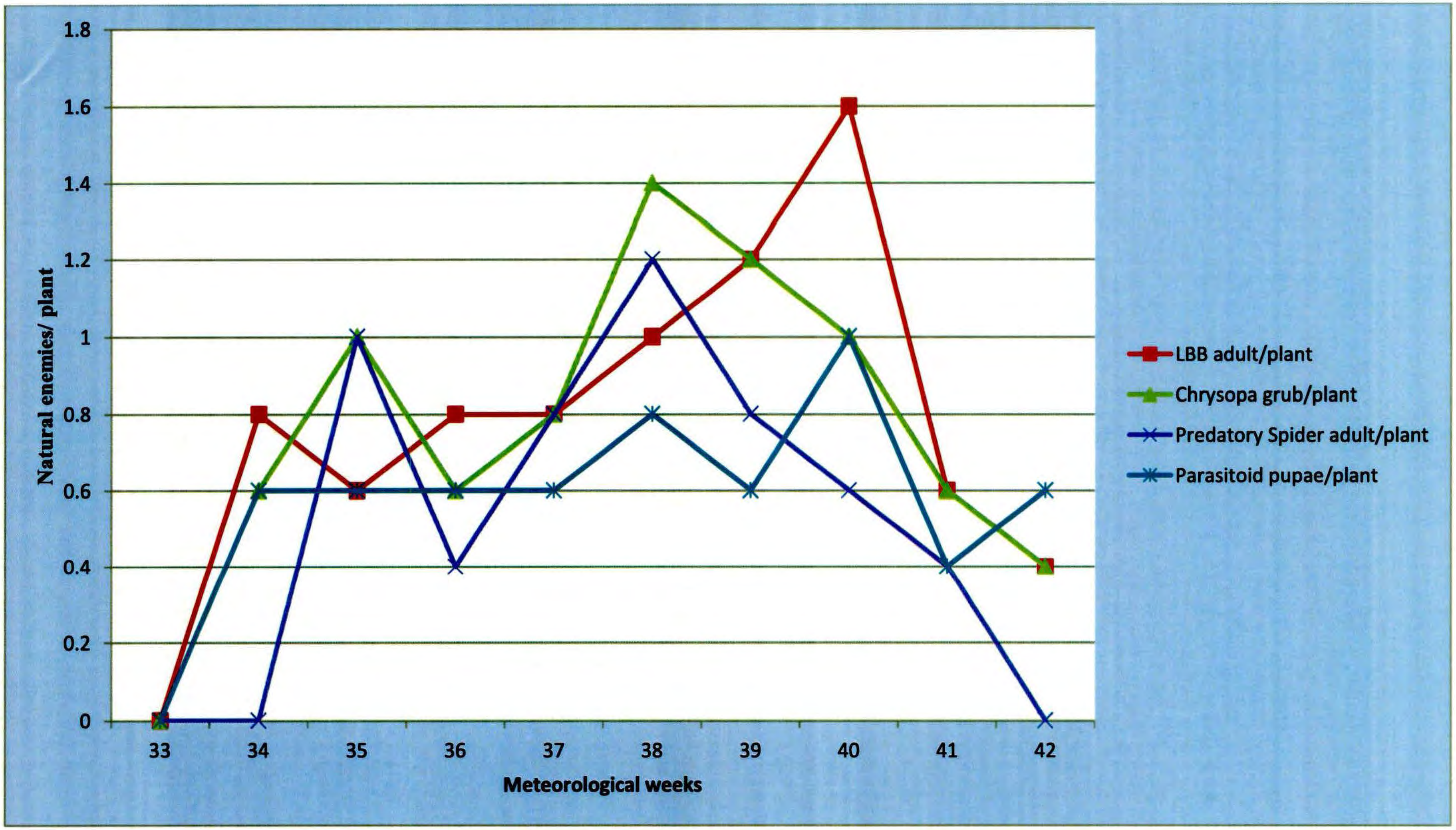


Fig. 11 Seasonal incidence of natural enemies in sunflower.

Predatory spider

Occurance of predator spider started from 35th MW 1.00 adult/plant. The peak was observed during 38th MW 1.20 adult/plant. Thereafter population was declined upto 0.40 adult /plant on 42th MW.

Parasitoids

The population of parasitoids (*Charops obtusus, Apantelus sp., Campoletis chlorideae*) ranged between 0.4 to1.0 pupae/plant. Occurrence of parasitoids started from 34th MW 0.6 pupae/plant. Peak was recorded in 40th MW 1.0 pupae/plant. Thereafter the population declined up to 0.6 pupae/plant till 42nd MW.

Kaur *et.al,* (2000) and Devi *et.al,* (2003) had similar observations which falls in line with present findings. He reported parasitoid larval population ranged between 0.86 and 14.50 larvae per metre row length.

Agnihotri *et.al,*(2011) also reported the similar results regarding parasitiods. The peak period of activity of C. chloridae was during 6th standard week .

Table 13. Seasonal incidence of sucking pests in sunflower.

Duration	MW	Thrips / 3 leaves	Leaf hopper / 3 leaves	Whitefly /3 leaves	Aphids \3 leaves
07-14 Aug.	33	0	0	0	0
15-21 Aug.	34	3.0	1.0	2.0	2.0
22-28 Aug.	35	3.0	2.0	3.0	4.0
29-04 Sep	36	5.0	1.6	5.0	3.6
05-11 Sep.	37	6.2	1.2	7.0	4.0
12-18 Sep	38	3.2	1.6	5.4	5.0
19-25 Sep.	39	2.4	1.6	2.6	3.2
26-02 Oct	40	2.2	2.0	2.4	4.4
03-09 Oct	41	2.6	1.2	1.6	2.8
10-16 Oct	42	1.2	0.4	1.2	1.4
17-23 Oct.	43	0.6	0.2	0.6	0.6
24-31 Oct.	44	0.4	0.0	0.2	0.0

Thrips

The thrips population ranged between 0.40 to 6.2 as shown in the table 13 the incidence of thrips started from 34th MW 3.00/3 leaves and went on fluctuation, the peak activity of thrips was observed during 37th MW i.e 6.20 /3 leaves. Thereafter the population went on decreasing with fluctuation upto 0.40 /3 leaves till 43rd MW.

The present results are in agreement with Kandakoor *et.al,*(2012) who recorded same population of thrips. The population of thrips was more abundant on the crop during August and September, 2010. Results revealed that maximum activity was recorded during September

Leaf hopper

The data presented on table 13 on population of leaf hopper ranged between 0.20 to 2.00. The occurance of leaf hopper started from 34th 1.00 /3 leaves and peak activity of leaf hopper was 2.00 in 35th MW thereafter the population of leaf hopper went on fluctuating upto 44th MW, it was 0.20 /3 leaves.

Sana *et al.*,(2011) reported highest density of leaf hopper on 30th August which justify the present findings. The population dynamics of leaf hopper in cotton was 6.56 *biguttula biguttula* leaf^{-1} on 10 thAugust.

Whitefly

Incidence of whitefly started from 34th MW 2.00 /3 leaves. The peak was observed during 37th MW 7.00 /3 leaves, Thereafter the population was upto 0.20 /3 leaves on 44th MW.

The similar results were also reported by Phulse and Udikeri (2014), regarding the whitefy incidence. The highest incidence of whiteflies was recorded on (MRC 7918 BG-II) variety in cotton

Aphids

The aphids population ranged between 0.60 to 5.00 as shown in the table 13, the incidence of aphids started from 34th MW 2.00 /3 leaves went on rising, The peak activity of aphids was observed during 38th MW 5.00 /3 leaves. Thereafter the population went on fluctuating in rise and fall in number of aphids.

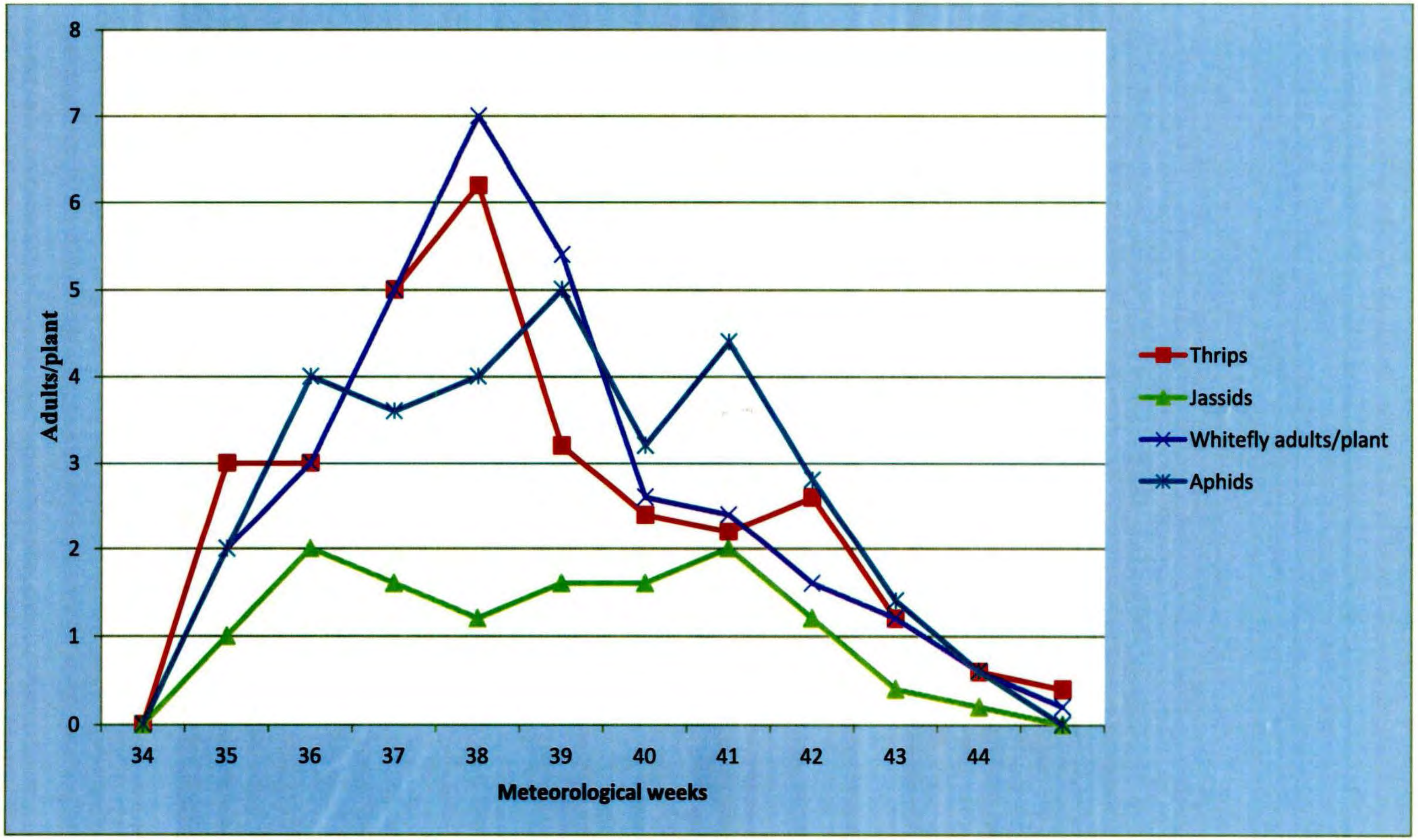


Fig. 12 Seasonal incidence of sucking pests in sunflower.

Table 14. Correlation coefficient between thrips and weather parameters during *Kharif* 2016-17.

Weather parameters	Thrips 'r' value
Minimum temperature (°C)	0.315
Maximum temperature (°C)	- 0.519
Minimum humidity (%)	0.557*
Maximum humidity (%)	0.496
Rainfall (mm)	0.278
Wind velocity (km/hr)	- 0.235

* Significant at 5 % (r = 0.532) at n-2*n = 12

** Significant at 1 % (r= 0.661) at n-2

The data on correlation coefficient between thrips and weather parameter depicted in table 14 showed that minimum temperature (r = 0.315), maximum humidity (r = 0.496) and rainfall (r = 0.278) had positive effect on population but was statistically non- significant, but minimum humidity (r = 0.557*) had positive effect with significant correlation. Whereas maximum temperature (r= -0.519) and wind velocity (r = -0.235) had negative effect with non-significant correlation .

Table 15. Correlation coefficient between leaf hopper and weather parameters during *Kharif* 2016-17.

Weather parameters	leaf hopper 'r' value
Minimum temperature (°C)	0.269
Maximum temperature (°C)	0.446
Minimum humidity (%)	-0.620*
Maximum humidity (%)	0.547*
Rainfall (mm)	-0.547*
Wind velocity (km/hr)	-0.103

* Significant at 5 % (r = 0.532)

** Significant at 1 % (r= 0.661)

As shown in Table 15 the data on correlation coefficient between leaf hopper and weather parameter revealed that minimum temperature (r = 0.269), maximum temperature (r = 0.446), maximum humidity and rainfall(r = -0.547*) had negative effect on leaf hopper population but non-significant correlation but rainfall (r = 0.547) had positive effect with significant correlation; whereas minimum humidity (r = -0.620*) had significant value and wind velocity (r = -0.103) had non-significant value, with negative effect.

Khandakoor *et al.*,2012, reported that the jassids showed negative correlation with rainfall and had positive correlation to both maximum and minimum temperature.

Table 16. Correlation coefficient between whitefly and weather parameters during *Kharif* 2016-17.

Weather parameters	Whitefly 'r' value
Minimum temperature (°C)	0.245
Maximum temperature (°C)	-0.565*
Minimum humidity (%)	0.610*
Maximum humidity (%)	0.569*
Rainfall (mm)	0.355
Wind velocity (km/hr)	-0.202

* Significant at 5 % (r = 0.532)

** Significant at 1 % (r= 0.661)

The data presented in Table 16 regarding correlation coefficient between whitefly and weather parameter has revealed that the minimum temperature (r = 0.245) and rainfall (r = 0.355) had positive effect on population though statistically non–significant correlation but minimum humidity (r = 0.610*) and maximum humidity (r = 0.569*) has positive effect on population with significant correlation whereas, negative and significant correlation registered with maximum temperature (r = -0.565*) and negative and non–significant correlation with wind velocity (r = -0.202) .

Table 17. Correlation coefficient between aphids and weather parameters during *Kharif* 2016-17.

Weather parameters	Aphids 'r' value
Minimum temperature (°C)	0.313
Maximum temperature (°C)	-0.739**
Minimum humidity (%)	0.397
Maximum humidity (%)	0.360
Rainfall (mm)	0.523
Wind velocity (km/hr)	-0.192

* Significant at 5 % (r = 0.532)

** Significant at 1 % (r= 0.661)

The data presented in Table 17 regarding correlation coefficient between aphid and weather parameter presented similar correlation as that of Table 14. The maximum temperature (r = -0.739**) negative highly significant and wind velocity (r = -0.192) negative non – significant and all other remain positive effect on multiplication population of aphids i.e minimum temperature (r = 0.313),minimum humidity (r = 0.397) ,maximum humidity (r = 0.360) and rainfall (r = 0.523) but the influence was non–significant.

Mallapur *et.al*, (2005) reported that there was significantly positive correlation with relative humidity, minimum temperature and cloudy weather. Whereas, the aphid population was negatively correlated with maximum temperature, and as the crop age advances.

Table 18. Correlation coefficient between capitulum borer larvae and weather parameters during *Kharif* 2016-17.

Weather parameters	capitulum borer 'r' value
Minimum temperature (°C)	0.077
Maximum temperature (°C)	-0.265
Minimum humidity (%)	-0.145
Maximum humidity (%)	-0.285
Rainfall (mm)	0.171
Wind velocity (km/hr)	-0.088

* Significant at 5 % (r = 0.532)

** Significant at 1 % (r= 0.661)

The correlation coefficient was worked out between population of captulium borer and weather parameter the data showed that minimum temperature (r = 0.077) and rainfall (r = 0.171) positive effect but non – significant correlation and other remain negative effect with non - significant correlation maximum temperature (r = -0.265) ,minimum humidity (r = -0.285) and wind velocity(r = -0.088).

Reddy *et al.*, (2009) reported that the rainfall and larval population of *H. armigera* showed positive correlation coefficient (0.03) but it was not-significant.

Yadav and lal (1998) reported that the larval population of *H. armigera* on chickpea was negatively correlated with relative humidity.

Table 19. Correlation coefficient between *Spodoptera litura* larvaeand weather parameter during *Kharif* 2016-17.

Weather parameters	***Spodoptera litura* 'r' value**
Minimum temperature (°C)	0.549*
Maximum temperature (°C)	-0.726**
Minimum humidity (%)	0.277
Maximum humidity (%)	0.163
Rainfall (mm)	0.152
Wind velocity (km/hr)	-0.389

* Significant at 5 % (r = 0.532)

** Significant at 1 % (r= 0.661)

The data on correlation coefficient between spodoptera litura larval population and weather parameter decipted in Table 19 revealed that maximum temperature (r = -0.726**) has negative effect on population with highly significant correlation and wind velocity had negative effect with non-significant correlation whereas, all other remain positive effect with non-significant correlation minimum humidity (r = 0.277) ,maximum humidity (r = 0.163) ,rainfall (r = 0.152) except minimum temperature has positive effect with significant correlation (r = 0.549*).

The present findings are more or less in agreement with those of earlier research workers Thanki *et.al,*(2003) reported that the higher eggs and larval population as well as leaf damage caused by *S.litura* to castor plants was found in the third and fourth week of November

Table 20. Correlation coefficient between Green semilooper larvae and weather parameters during *Kharif* 2016-17.

Weather parameters	Green semilooper 'r' value
Minimum temperature (°C)	0.490
Maximum temperature (°C)	-0.520
Minimum humidity (%)	0.434
Maximum humidity (%)	0.237
Rainfall (mm)	0.309
Wind velocity (km/hr)	0.136

* Significant at 5 % (r = 0.532)

** Significant at 1 % (r= 0.661)

The data on correlation coefficient between green semilooper larvae and weather parameters depicted in table 20 revealed that maximum temperature (r = -0.520) had negative effect with non- significant coefficient whereas, all other parameters had positive effect with non-significant correlation minimum temperature (r = 0.490), minimum humidity (r = 0.490), maximum humidity (r = 0.237), rainfall (r = 0.309) and wind velocity (r =0.136).

The similar results are also reported by Mishra and ali (2007) that green semilooper was recorded in linseed varieties *viz*., Padmini, Neelum and Janki during *rabi* 2004-05 and 2005-06. Positive correlation with minimum temperature and negatively correlated with maximum temperature was observed.

Table no. 21 Correlation coefficient between hairy caterpillar larvae and weather parameters during *Kharif* 2016-17.

Weather parameters	hairy caterpillar 'r' value
Minimum temperature (°C)	0.251
Maximum temperature (°C)	-0.446
Minimum humidity (%)	0.296
Maximum humidity (%)	0.138
Rainfall (mm)	0.199
Wind velocity (km/hr)	-0.005

* Significant at 5 % (r = 0.532)

** Significant at 1 % (r= 0.661)

The data showed in table 21 of correlation coefficient between hairy caterpillar and weather parameters revealed that maximum temperature (r = -0.446) and wind velocity (r = -0.005) had negative effect with non–significant correlation, but all other parameter had positive correlation with non–significant manner minimum temperature (r = 0.251), minimum humidity (r = 0.296) correlative in maximum humidity (r = 0.138) and rainfall (r = 0.199).

Table 22. Correlation coefficient between Ladybird bettle and weather parameters during *Kharif* 2016-17.

Weather parameters	Ladybird beetle 'r' value
Minimum temperature (°C)	0.289
Maximum temperature (°C)	-0.703**
Minimum humidity (%)	0.195
Maximum humidity (%)	0.124
Rainfall (mm)	0.171
Wind velocity (km/hr)	-0.125

* Significant at 5 % (r = 0.532)

** Significant at 1 % (r= 0.661)

The data presented in Table 22 regarding correlation coefficient between Ladybird beetle and weather parameters present the similar correlation as that of Table no: 2. The maximum temperature (r= -0.703**) negative highly significant and wind velocity (r= -0.125) negative non – significant and rest of the parameter had positive effect on multiplication population of Ladybird beetle i.e minimum temperature (r = 0.289), minimum humidity (r = 0.195), maximum humidity (r = 0.124) and rainfall (r = 0.171) but the influence was statistically non–significant.

Table 23. Correlation coefficient between *C. carnea* and weather parameters during *Kharif* 2016-17.

Weather parameters	*C. carnea* 'r' value
Minimum temperature (°C)	0.341
Maximum temperature (°C)	-0.769**
Minimum humidity (%)	0.411
Maximum humidity (%)	0.369
Rainfall (mm)	0.497
Wind velocity (km/hr)	-0.168

* Significant at 5 % (r = 0.532)

** Significant at 1 % (r= 0.661)

The data presented in Table 23 regarding correlation between *C. carnea* and weather parameters represented the similar correlation as that of table no :4. Maximum temperature had negative effect and high significant correlation (r= 0.769**) and wind velocity had negative effect and non-significant correlation (r = - 0.168) whereas, all the weather parameter had favrourable influence over *C. carnea* population minimum temperature (r = 0.341) minimum humidity (r = 0.411) maximum humidity (r = 0.369) and rainfall (r = 0.497).

Table 24. Correlation coefficient between Predatory Spider and weather parameters during *Kharif* 2016-17.

Weather parameters	Predatory Spider 'r' value
Minimum temperature (°C)	-0.138
Maximum temperature (°C)	-0.611*
Minimum humidity (%)	0.390
Maximum humidity (%)	0.465
Rainfall (mm)	0.664**
Wind velocity (km/hr)	-0.265

* Significant at 5 % (r = 0.532)

** Significant at 1 % (r= 0.661)

As shown in Table 24 the data on correlation coefficient between Predatory spider and weather parameters had minimum temperature (r = -0.138) wind velocity (r = -0.265) had non-significant correlation and maximum temperature (r = -0.611*) has significant value had negative value whereas, minimum humidity (r= 0.390), maximum humidity (r = 0.465) had non-significant value and rainfall (r = 0.664**) had positive effect on Predatory population with significant correlation had positive effect.

The similar results were also reported by Netam *et.al,* (2013) regarding positive correlation of Minimum humidity, Maximum humidity, Rainfall.

Table 25. Correlation coefficient between Parasitoids and weather parameters during *Kharif* 2016-17.

Weather parameters	Parasitoids 'r' value
Minimum temperature (°C)	0.279
Maximum temperature (°C)	-0.674**
Minimum humidity (%)	0.277
Maximum humidity (%)	0.154
Rainfall (mm)	0.336
Wind velocity (km/hr)	0.147

* Significant at 5 % (r = 0.532)

** Significant at 1 % (r= 0.661)

The data presented in Table 25 regarding correlation between Parasitoids (*Charops obtusks, Apantelus sp.*, braconids, *Campoletis chlorideae*) and weather parameter represented maximum temperature had negative effect and high significant correlation (r= -0.674**) whereas, all the weather parameters had favourable influence over Parasitoids population minimum temperature (r = 0.279), minimum humidity (r = 0.277), maximum humidity (r = 0.154) and rainfall (r = 0.336) with positive effect with non–significant correlation .

4.3.1 Effect of different insecticide on *Chrysoperla carnea* adult.

After first spray

4.3.1.1 Pre-count one day before first spray.

The data on *C. carnea* population on one day before first spray is presented in Table 26. and graphically represented in Fig. 13.The results were statistically non-significant indicating uniform distribution of population. The average number of *C. carnea* ranged from 0.54 to 1.15/plant in all the experimental plots.

4.3.1.2 One day after first spray.

The data recorded one day after spray is presented in Table 26. and depicted in Fig. 13. All the treatments recorded lower population of *C.carnea* than untreated control but stastically non-significant. Population of *C. carnea* in emamectin benzoate 5 SG @ 4 gm/10 lit was higher (0.40 /plant), spinosad 45 SC @ 2.5 ml/10 lit (0.40 /plant), profenophos 50 EC @ 20 ml/10 lit (0.20/plant), chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.20 /plant) recorded similar trend. The highest population of C.*carnea* (0. 73 / plant) was observed in untreated control.

4.3.1.3 Three days after first spray.

The data generated three day after spray is presented in Table 26. and depicted in Fig. 13. All the treatments were recorded low population of *C.carnea* compared to untreated control. But it was non-significant population of *C.carnea* in emamectin benzoate 5 SG @ 4 gm/10 lit was higher (0.40 /plant) and in fenvalerate 20 EC @ 8 ml/ 10 lit (0.40 /plant) spinosad 45 SC @ 2.5 ml/10 lit (0.33 /plant), chlorantraniliprole 18.5 EC @ 5 ml/10 lit (0.33 /plant) , lamda cyhalothin 5 EC @ 5 ml/10 lit (0.20 /plant) showed maximum reduction. The maximum population of *C.carnea* (0.60 / plant) was observed in untreated control.

4.3.1.4 Seven days after first spray.

The data is presented in seven day after spray presented in Table 26. and depicted in Fig. 13. Though the treatments recorded lower population of *C. carnea* than untreated control but were statistically non-significant. Population of *C. carnea* in emamectin benzoate 5 SG @ 4 gm/10 lit (0.26 /plant) and was followed by spinosad 45 SC @ 2.5 ml/10 lit (0.20 /plant) , lamda cyhalothin 5 EC @ 5 ml/10 lit (0.26/plant) were recorded the similar trend. The highest population of *C.carnea* (0.66 / plant) was observed in untreated control.

4.3.1.5 Ten days after first spray.

The data presented in Table 26. and depicted in Fig. 13 revealed that Population of *C. carnea* in emamectin benzoate 5 SG @ 4 gm/10 lit (0.40 /plant) treated plot was higher followed by spinosad 45 SC @ 2.5 ml/10 lit (0.46 /plant), indoxacarb 15.8 SC @ 5 ml/10 lit , fenvalerate 20 EC @ 8 ml/10 lit (0.46 /plant) recorded maximum reduction. The maximum population of *C. carnea* (0.60 / plant) was observed in untreated control.

4.3.1.6 Fourteen days after first spray.

The data pertaining *C.carnea* fourteen day after spray are presented in Table 26. and depicted in Fig. 13. All the treatments recorded lower population of *C.carnea* than untreated control. Population of *C.carnea* in emamectin benzoate 5 SG @ 4 gm/10 lit (0.53/plant) was higher and treatments of fenvalerate 20 EC @ 8 ml/10 lit (0.46 /plant),spinosad 45 SC @ 2.5 ml/10 lit (0.46/plant),lamda cyhalothin 5 EC @ 5 ml/10 lit (0.40/plant) showed maximum reduction .The highest population of *C.carnea* (0.66 / plant) was observed in untreated control.

Table 26. Effect of different insecticides on *C.carnea* larvae adult/plant after first spray.

Sr. No	Treatment	Dose ml/10 lit.	Av. *C. carnea* adult / plant					
			1 DBS	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS
1.	Emamectin Benzoate 5 SG	4 gm	0.46 **(0.97)**	0.40 **(0.94)**	0.40 **(0.94)**	0.26 **(0.87)**	0.40 **(0.94)**	0.53 **(1.01)**
2.	Lambda cyhalothrin 5 EC	5 ml	0.40 **(0.94)**	0.33 **(0.90)**	0.20 **(0.83)**	0.20 **(0.83)**	0.33 **(0.90)**	0.40 **(0.94)**
3.	Chlorantraniliprole 18.5 SC	3 ml	0.33 **(0.90)**	0.20 **(0.83)**	0.33 **(0.90)**	0.33 **(0.90)**	0.40 **(0.94)**	0.40 **(0.94)**
4.	Indoxacarb 15.8 EC	5 ml	0.40 **(0.94)**	0.20 **(0.83)**	0.26 **(0.87)**	0.06 **(0.75)**	0.46 **(0.97)**	0.46 **(0.97)**
5.	Spinosad 45 SC	2.5ml	0.33 **(0.90)**	0.06 **(0.75)**	0.13 **(0.79)**	0.26 **(0.87)**	0.20 **(0.83)**	0.46 **(0.97)**
6.	Fenvalerate 20 EC	8 ml	0.20 **(0.83)**	0.13 **(0.79)**	0.40 **(0.94)**	0.33 **(0.90)**	0.46 **(0.97)**	0.46 **(0.97)**
7.	Profenophos 50 EC	20ml	0.33 **(0.90)**	0.26 **(0.87)**	0.13 **(0.79)**	0.20 **(0.83)**	0.33 **(0.90)**	0.40 **(0.94)**
8.	Control		0.73 **(1.11)**	0.60 **(1.04)**	0.60 **(1.03)**	0.66 **(1.07)**	0.60 **(1.04)**	0.66 **(1.08)**
	SE(m) ±		**0.06**	**0.07**	**0.06**	**0.06**	**0.06**	**0.07**
	CD at 5 %		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
	CV (%)		**11.65**	**14.82**	**11.79**	**13.03**	**12.31**	**14.17**

Figure in parenthesis are $\sqrt{x + 0.5}$ transformed values.

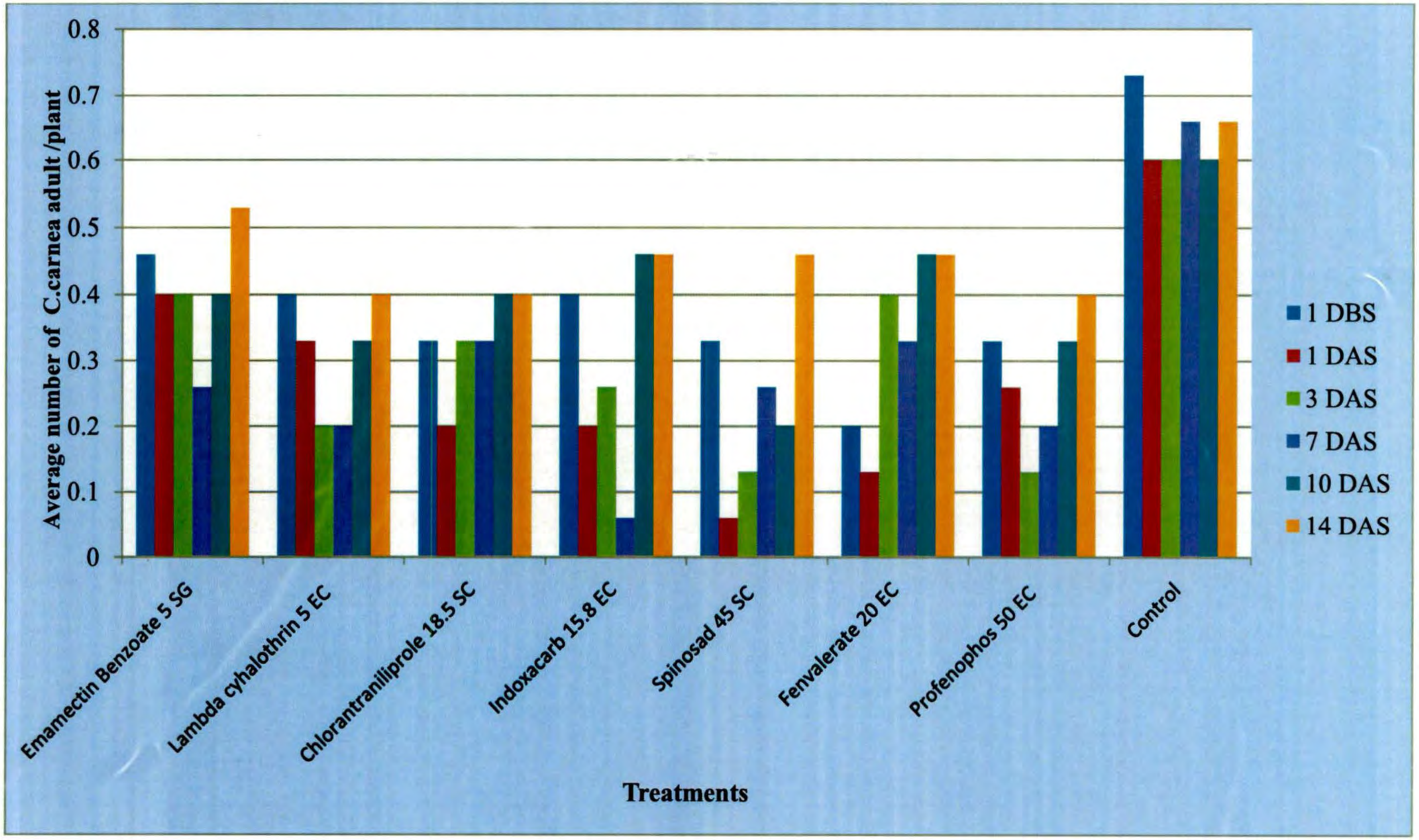


Fig.13. Population of *C.carnea* adult per plant before and after first spray

4.3.2 After second spray

4.3.2.1 Pre-count one day before second spray

The data on *Chrysoperla carnea* population on one day before second spray is presented in Table 27 and graphically represented in Fig. 14.The results were statistically non-significant indicating uniform distribution of predators population. The average number of *C. carnea* ranged from 0.54 to 1.15/plant in different insecticidal treatments.

4.3.2.2 One day after second spray.

The data generated one day after spray is presented in Table 27. and depicted in Fig. 14. All the treatments recorded lower population of *C.carnea* than untreated control. Population of *C.carnea* in emamectin benzoate 5 SG @ 4 gm/10 lit was higher (0.46 /plant) lambda cyhalothrin 5 EC @ 5 ml/10 lit (0.40 /plant), spinosad 45 SC @ 2.5 ml/10 lit (0.40 /plant), lambda cyhalothrin 5EC @ 5ml/10 lit showed maximum reduction whereas, the highest population of *C.carnea* (0.60 / plant) was observed in untreated control.

4.3.2.3 Three days after second spray.

The data shown three days after spray is presented in Table 27. and depicted in Fig. 14. All the treatments recorded non-significantly lower population of *C. carnea* compared to untreated control. Population of *C. carnea* in emamectin benzoate 5 SG @ 4 gm/10 lit was higher (0.46 /plant) was non-significant spinosad 45 SC @ 2.5 ml/10 lit (0.40 /plant), lambda cyhalothin 5 EC @ 5 ml/10 lit (0.33 /plant), chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.20 /plant), recorded similar trend. The maximum population of *C.carnea* (0.66/ plant) was observed in untreated control.

4.3.2.4 Seven days after second spray.

The data recorded seven days after spray is presented in Table 27. and depicted in Fig. 14. Population of *C. carnea* in emamectin benzoate 5 SG @ 4 gm/10 lit (0.53/plant) was higher. whereas chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.40 /plant),lambda cyhalothin 5 EC @ 5 ml/10 lit (0.40/plant),indoxacarb 15.8 SC @ 5 ml/10 lit (0.33/plant) were noticed with maximum reduction. The highest population of *C.carnea* (0.66 / plant) was observed in untreated control.

4.3.2.5 Ten days after second spray.

The data is about effect of various insecticidal treatment on natural enemies ten day after spray in Table 27. and depicted in Fig. 14. revealed that all the treatments recorded lower population of *C. carnea* than untreated control. Population of *C.carnea* in emamectin benzoate 5 SG @ 4 gm/10 lit (0.66/plant) was highest spinosad 45 SC @ 2.5 ml/10 lit (0.46 /plant), indoxacarb 15.8 SC @ 5 ml/10 lit, fenvalerate 20 EC @ 8 ml/10 lit (0.40 /plant) showed higher reduction. The highest population of *C. carnea* (0.73 / plant) was observed in untreated control.

4.3.2.6 Fourteen days after second spray.

The data generated in Table 27. and depicted in Fig. 14. Revealed that all the treatments recorded lower population of *C. carnea* compare to untreated control. Population of *C. carnea* in emamectin benzoate 5 SG @ 4 gm/10 lit (0.53/plant) was higher. chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.53/plant), lambda cyhalothin 5 EC @ 5 ml/10 lit (0.40/plant), indoxacarb 15.8 SC @ 5 ml/10 lit (0.26/plant) were recorded the similar trend.The maximum population of *C. carnea* (0.86/ plant) was observed in untreated control.

The findings of Al-Kazafy *et* al.,(2014) recommended that chlorantraniliprole was most suitable insecticide to conserve the natural enemies is in line with present findings . He studied the residual effect of three modern insecticides (chlorantraniliprole, thiamethoxam and spinetoram) against some natural enemies such as green lacewing, *Chrysoperla carnea*, seven-spotted ladybug, *,Trichogramma* wasps, *Trichogramma evanescens* and reported that all tested insecticides were less toxic to the second instar larvae of *C. carnea* larvae.

Udikeri *et.al* (2004) reported that emamectin benzoate 5 SG did not affect pred ators population as there was no significant difference in population of predators recorded in emamectin benzoate 5 SG and untreated check. This study revealed that emamectin benzoate is safe chemical for *C. carnea.*

Sechser *et. al* , (2003) evaluated toxicity of 3 insecticide viz., emamectin benzoate 5 SG, fenvalerate 20 EC and spinosad 45 SC, on natural enemies and founded that emamectin benzoate 5 SG residues were not very toxic to *C.carnea* , The emamectin benzoate 5 SG exhibited good to excellent selectivity to natural enemies. Which supports present findings.

Table 27 Effect of different insecticides on *C. carnea* adult after second spray

Sr. No	Treatment	Dose ml/10 lit.	Av.*C. carnea* adult / plant					
			1 DBS	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS
1.	Emamectin Benzoate 5 SG	4 gm	0.46 **(0.97)**	0.40 **(0.94)**	0.46 **(0.97)**	0.53 **(1.01)**	0.66 **(1.07)**	0.53 **(1.01)**
2.	Lambda cyhalothrin 5 EC	5 ml	0.46 **(0.97)**	0.33 **(0.90)**	0.20 **(0.83)**	0.40 **(0.93)**	0.20 **(0.83)**	0.40 **(0.94)**
3.	Chlorantraniliprole 18.5 SC	3 ml	0.40 **(0.94)**	0.20 **(0.83)**	0.53 **(1.01)**	0.40 **(0.94)**	0.20 **(0.83)**	0.53 **(1.01)**
4.	Indoxacarb 15.8 EC	5 ml	0.40 **(0.94)**	0.20 **(0.83)**	0.46 **(0.97)**	0.33 **(0.90)**	0.46 **(0.97)**	0.26 **(0.87)**
5.	Spinosad 45 SC	2.5 ml	0.46 **(0.97)**	0.40 **(0.94)**	0.20 **(0.83)**	0.20 **(0.83)**	0.46 **(0.97)**	0.46 **(0.97)**
6.	Fenvalerate 20 EC	8 ml/	0.40 **(0.94)**	0.26 **(0.86)**	0.20 **(0.83)**	0.20 **(0.83)**	0.40 **(0.94)**	0.26 **(0.86)**
7.	Profenophos 50 EC	20 ml	0.26 **(0.86)**	0.20 **(0.83)**	0.20 **(0.83)**	0.26 **(0.86)**	0.20 **(0.83)**	0.40 (0.94)
8.	Control		0.66 **(1.06)**	0.60 **(1.04)**	0.60 **(1.04)**	0.73 **(1.07)**	0.73 **(1.10)**	0.80 **(1.13)**
	SE(m)+		**0.07**	**0.06**	**0.05**	**0.07**	**0.07**	**0.07**
	CD at 5 %		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
	CV (%)		**14.21**	**12.81**	**10.60**	**13.47**	**12.97**	**13.47**

Figure in parenthesis are $\sqrt{x + 0.5}$ transformed values.

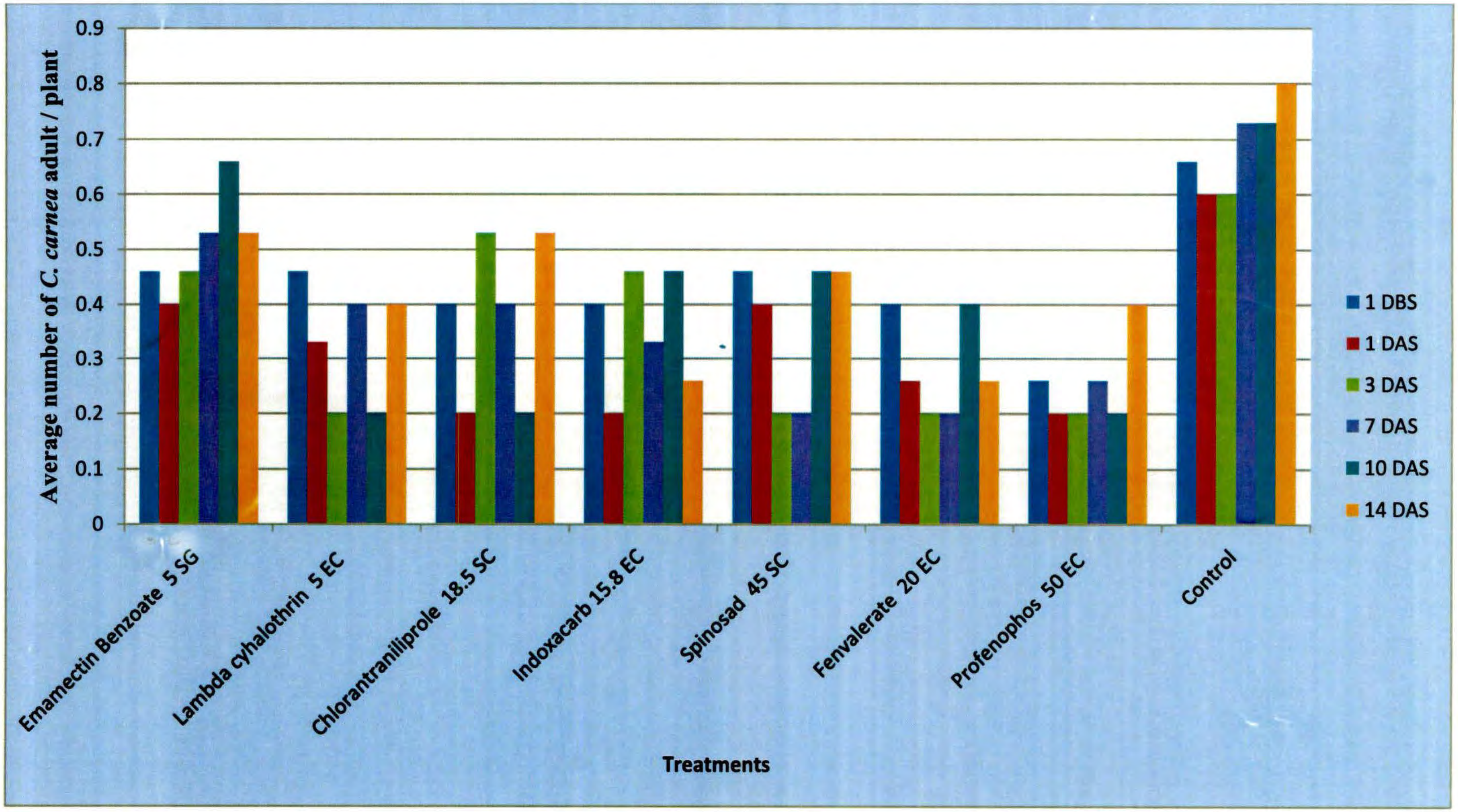


Fig.14. Population of *C. carnea* adult per plant before and after second spray

4.3.3 Effect of different insecticide against Ladybird beetle

After first spray

4.3.3.1 Pre-count one day before first spray.

The data on Ladybird beetle population on one day before first spray is presented in Table 28. and graphically represented in Fig. 15.The results were statistically non-significant indicating uniform distribution of population. The average number of Ladybird beetle ranged from 0.13 to 0.60/plant in different insecticidal treatments.

4.3.3.2 One day after first spray.

The data are presented in Table 28. and depicted in Fig. 15. Population of Ladybird beetle in emamectin benzoate 5 SG @ 4 gm/10 lit was higher (0.33/plant) was non-significant. indoxacarb 15.8 SC @ 5 ml/10 lit (0.40/plant), fenvalerate 20 EC @ 8ml/10 lit (0.33/plant) were noticed with maximum reduction.whereas the maximum population of Ladybird beetle (0.60/ plant) was observed in untreated control.

4.3.3.3 Three days after first spray.

The data are generated in Table 28. and depicted in Fig. 15. Though all the treatments were recorded lower population of Ladybird beetle compare to untreated control. Population of Ladybird beetle in emamectin benzoate 5 SG @ 4 gm/10 lit (0.40/plant) was higher. chlorantraniliprole 18.5 SC @ 5 ml/10 lit(0.40/plant) , indoxacarb 15.8 SC @ 5 ml/10 lit (0.33/plant), fenvalerate 20 EC @ 8ml/10 lit (0.26/plant) shows the similar trend. The highest population of ladybird beetle (0.73/ plant) was observed in untreated control.

4.3.3.4 Seven days after first spray.

The data pertaining to Ladybird beetle on seven day after spray are presented in Table 11. and depicted in Fig. 11. All the treatments were recorded lower population of Ladybird beetle than untreated control. Population of Ladybird beetle in emamectin benzoate 5 SG @ 4 gm/10 lit (0.40/plant) were maximum and chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.33/plant),profenophos 50 EC @ 5 ml/10 lit (0.33/plant),spinosad 45 SC @ 2.5 ml/10 lit (0.26/plant)were recorded maximum reduction. The maximum population of Ladybird beetle (0.66/ plant) was observed in untreated control but it was non-significant.

4.3.3.5 Ten days after first spray.

The data recorded ten days after spraying are presented in Table 28. and depicted in Fig. 15. This table reveals that treatments were recorded lower population of Ladybird beetle compare to untreated control. Population of Ladybird beetle in emamectin benzoate 5 SG @ 4 gm/10 lit (0.33/plant) and chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.33/plant) was higher and fenvalerate 20 EC @ 8 ml/10 lit (0.20/plant), profenophos 50 EC @ 20 ml/10 lit (0.20/plant) has highest reduction. The highest population of Ladybird beetle (0.66/ plant) was observed in untreated control.

4.3.3.6 Fourteen days after first spray.

The data is generated ten days after spraying in Table 28. and depicted in Fig. 15. Though all the treatments were recorded lower population of Ladybird beetle than untreated control. Population of Ladybird beetle in emamectin benzoate 5 SG @ 4 gm/10 lit (0.46/plant) was maximum. Whereas profenophos 50 EC @ 20 ml/10 lit (0.40/plant), chlroantraniliprole 18.5 EC @ 5 ml/10 lit (0.33/plant), lamda cyhalothin 5 EC @ 5 ml/10 lit (0.26/plant), shows maximum reduction.The maximum population of Ladybird beetle (0.73/plant) was recorded in untreated control.

Table 28. Effect of different insecticides on Ladybird beetle adult after first spray.

Sr. No	Treatment	Dose ml/10 lit.	Av.Ladybird beetle adult / plant					
			1 DBS	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS
1.	Emamectin Benzoate 5 SG	4 gm	0.46 **(0.97)**	0.33 **(0.90)**	0.40 **(0.94)**	0.40 **(0.94)**	0.33 **(0.90)**	0.46 **(0.97)**
2.	Lambda cyhalothrin 5 EC	5 ml	0.33 **(0.90)**	0.26 **(0.87)**	0.33 **(0.90)**	0.13 **(0.79)**	0.13 **(0.79)**	0.26 **(0.87)**
3.	Chlorantraniliprole 18.5 SC	3 ml	0.40 **(0.94)**	0.13 **(0.79)**	0.40 **(0.93)**	0.33 **(0.90)**	0.33 **(0.90)**	0.33 **(0.90)**
4.	Indoxacarb 15.8 EC	5 ml	0.26 **(0.87)**	0.20 **(0.83)**	0.26 **(0.87)**	0.26 **(0.86)**	0.20 **(0.83)**	0.20 **(0.82)**
5.	Spinosad 45 SC	2.5 ml	0.46 **(0.97)**	0.20 **(0.83)**	0.20 **(0.83)**	0.13 **(0.79)**	0.26 **(0.87)**	0.46 **(0.97)**
6.	Fenvalerate 20 EC	8 ml	0.40 **(0.94)**	0.33 **(0.90)**	0.26 **(0.86)**	0.26 **(0.86)**	0.20 **(0.82)**	0.40 **(0.93)**
7.	Profenophos 50 EC	20 ml	0.33 **(0.90)**	0.26 **(0.87)**	0.33 **(0.90)**	0.33 **(0.90)**	0.20 **(0.83)**	0.40 **(0.94)**
8.	Control		0.73 **(1.10)**	0.60 **(1.04)**	0.73 **(1.11)**	0.66 **(1.07)**	0.66 **(1.07)**	0.73 **(1.11)**
	SE(m) ±		**0.06**	**0.05**	**0.06**	**0.05**	**0.05**	**0.05**
	CD at 5 %		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
	CV (%)		**12.82**	**11.21**	**11.91**	**10.16**	**10.24**	**10.83**

Figure in parenthesis are $\sqrt{x + 0.5}$ transformed values.

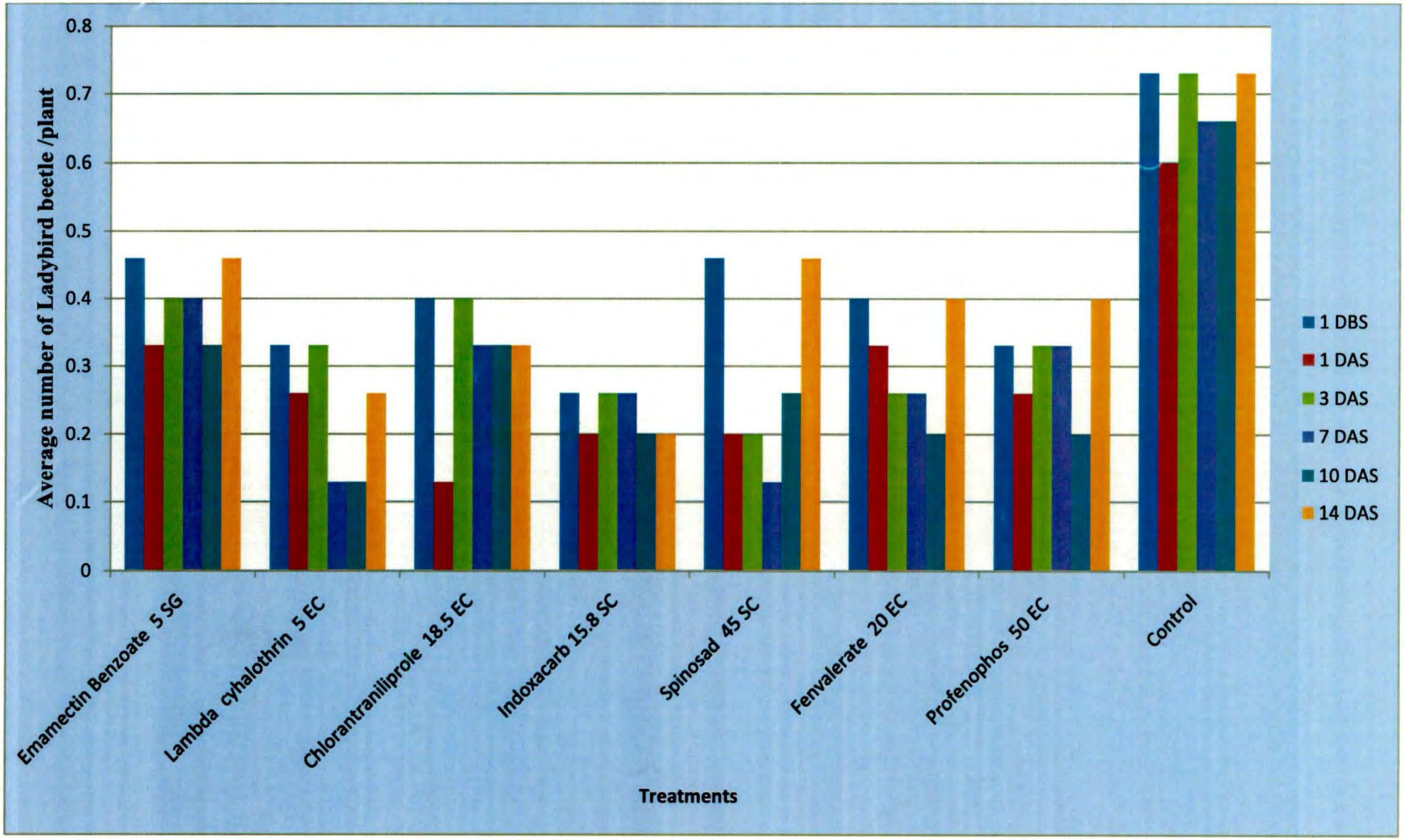


Fig. 15. Population of Ladybird beetle per plant before and after first spray

4.3.4 After second spray

4.3.4.1 Pre-count one day before second spray.

The data on Ladybird beetle population on one day before second spray is presented in Table 29. and graphically represented in Fig. 16.The results were statistically non-significant indicating uniform distribution of population. The average number of Ladybird beetle ranged from 0.13 to 0.66/plant in different insecticidal treatments.

4.3.4.2 One day after second spray.

The data recorded presented one day after spray shown in Table 29. and depicted in Fig. 16. Though all the treatments were recorded lower population of ladybird beetle compare to untreated control. Population of Ladybird beetle in emamectin benzoate 5 SG @ 4 gm/10 lit (0.53/plant) was higher. While chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.33/plant), spinosad 45 SC @ 2.5 ml/10 lit (0.46/plant) ,profenophos 50 EC@ 15.8 SC @ 5 ml/10 lit (0.26/plant) shows maximum reduction .whereas the maximum population of Ladybird beetle (0.66/ plant) was observed in untreated control.

4.3.4.3 Three days after second spray.

The data generated three day after spray is presented in Table 29. and depicted in Fig. 16. Population of Ladybird beetle in emamectin benzoate 5 SG @ 4 gm/10 lit (0.53/plant) was higher and chlorantraniliprole 18.5 SC @ 5 ml/10 lit(0.46/plant), indoxacarb 15.8 SC @ 5 ml/10 lit (0.40/plant) were recorded as maximum reduction. The highest population of Ladybird beetle (0.66/ plant) was observed in untreated control.

4.3.4.4 Seven days after second spray.

The data are presented in Table 29. and depicted in Fig. 16. Though all the treatments were recorded lower population of Ladybird beetle compare to untreated control. Population of Ladybird beetle in emamectin benzoate 5 SG @ 4 gm/10 lit (0.40/plant) were higher whereas spinosad 45 SC @ 2.5 ml/10 lit (0.40/plant), chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.20 /plant),lambda cyhalothin 5 EC @ 5 ml/10 lit (0.40/plant) were recorded the similar trend. The maximum population of *Ladybird beetle* (0.53/ plant) was observed in untreated control.

4.3.4.5 Ten days after second spray.

The data pertaining to the population of Ladybird beetle is presented in Table 29. and depicted in Fig. 16 .Population of Ladybird beetle in emamectin benzoate 5 SG @ 4 gm/10 lit (0.53/plant) was highest chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.33/plant), profenophos 50 EC @ 20 ml/10 lit (0.33/plant) were recorded as maximum reduction . The highest population of Ladybird beetle (0.60/ plant) was observed in untreated control.

4.3.4.5 Fourteen days after second spray.

The data generated fourteen day after spray is shown in Table 29. and depicted in Fig. 16. Population of Ladybird beetle in emamectin benzoate 5 SG @ 4 gm/10 lit (0.40/plant) was higher whereas chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.40/plant), lambda cyhalothin 5 EC @ 5 ml/10 lit (0.20/plant) has maximum reduction .The maximum population of Ladybird beetle (0.60/plant) was observed in untreated control.

The similar results were recorded by Wayal *et.al,*(2009) and revealed that lambda cyhalothrin 5 EC was safe to the natural enemies.

Govindan *et. al* , (2013) evaluated the safety of emamectin benzoate 5 SG to ladybird beetle . The results showed that emamectin benzoate was found safer to ladybird beetle at all the tested concentration. The highest population was recorded in plots treated with emamectin benzoate 5 SG.

Table 29. Effect of different insecticides on Ladybird beetle adult after second spray.

Sr. No	Treatment	Dose ml/10 lit.	Av. Ladybird beetle adult / plant					
			1 DBS	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS
1.	Emamectin Benzoate 5 SG	4 gm	0.60 **(1.04)**	0.53 **(1.01)**	0.53 **(1.01)**	0.40 **(0.94)**	0.53 **(1.01)**	0.53 **(1.01)**
2.	Lambda cyhalothrin 5 EC	5 ml	0.40 **(0.94)**	0.20 **(0.83)**	0.20 **(0.83)**	0.06 **(0.75)**	0.13 **(0.79)**	0.20 **(0.82)**
3.	Chlorantraniliprole 18.5 SC	3 ml	0.46 **(0.97)**	0.33 **(0.90)**	0.46 **(0.97)**	0.20 **(0.83)**	0.33 **(0.90)**	0.40 **(0.94)**
4.	Indoxacarb 15.8 EC	5 ml	0.40 **(0.94)**	0.20 **(0.83)**	0.40 **(0.94)**	0.06 **(0.75)**	0.20 **(0.83)**	0.46 **(0.97)**
5.	Spinosad 45 SC	2.5 ml	0.53 **(1.01)**	0.40 **(0.97)**	0.46 **(0.97)**	0.40 **(0.94)**	0.13 **(0.79)**	0.33 **(0.90)**
6.	Fenvalerate 20 EC	8 ml	0.26 **(0.86)**	0.13 **(0.79)**	0.40 **(0.94)**	0.06 **(0.75)**	0.13 **(0.79)**	0.26 **(0.86)**
7.	Profenophos 50 EC	20 ml	0.40 **(0.93)**	0.26 **(0.86)**	0.20 **(0.83)**	0.06 **(0.75)**	0.33 **(0.90)**	0.33 **(0.90)**
8.	Control		0.66 **(1.06)**	0.66 **(1.06)**	0.66 **(1.07)**	0.53 **(1.01)**	0.60 **(1.03)**	0.60 **(1.04)**
	SE(m)+		**0.08**	**0.06**	**0.05**	**0.06**	**0.06**	**0.07**
	CD at 5 %		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
	CV (%)		**14.76**	**12.69**	**10.54**	**14.45**	**13.17**	**13.77**

Figure in parenthesis are $\sqrt{x + 0.5}$ transformed values.

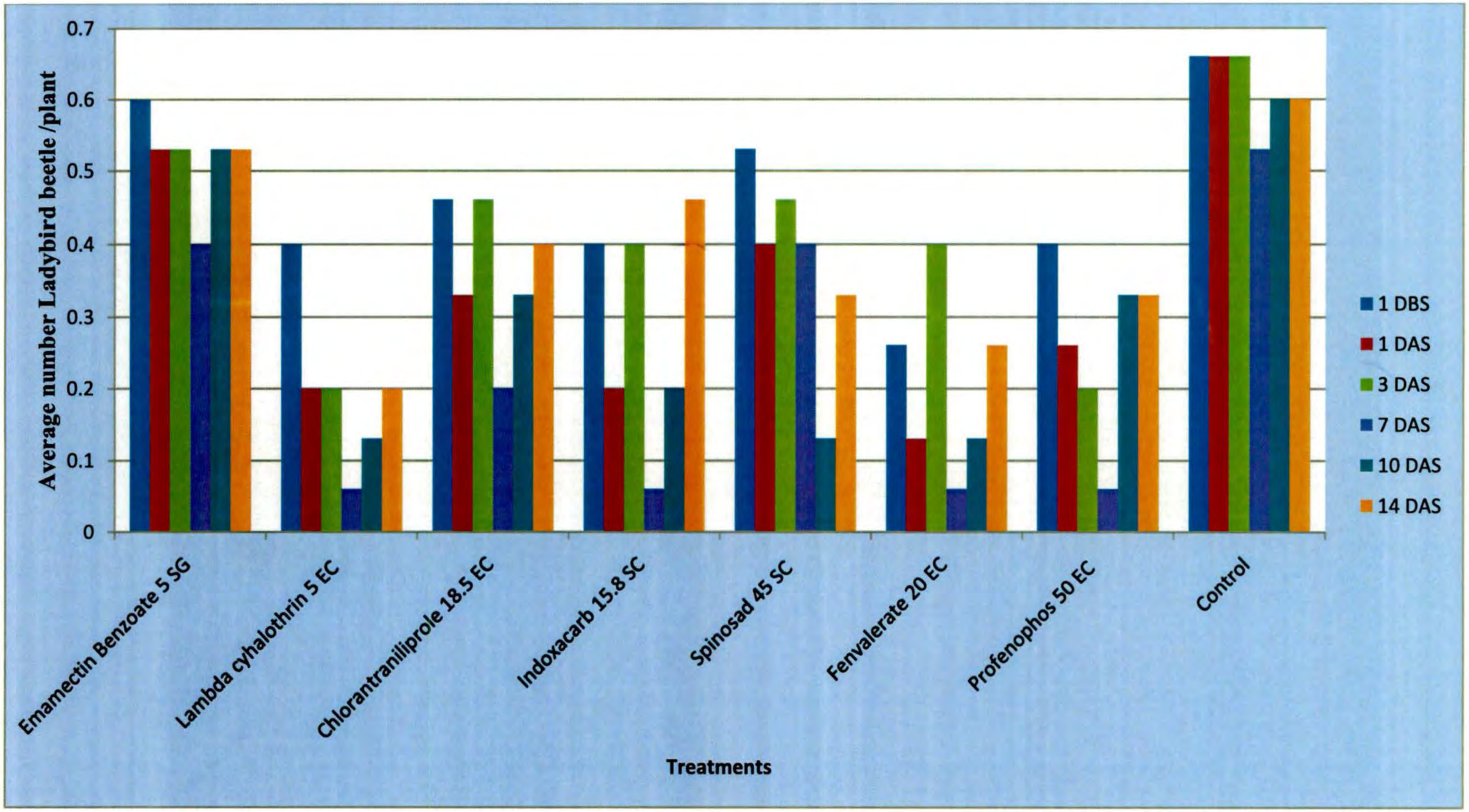


Fig.16.Population of Ladybird beetle per plant before and after second spray

4.3.5 Effect of different insecticide against Spider

After first spray

4.3.5.1 Pre-count one day before first spray.

The data on spider population on one day before first spray is presented in Table 30. and graphically represented in Fig. 17.The results were statistically non-significant indicating uniform distribution of predators Spider population. The average number of spider ranged from 0.13 to 0.73/plant in different insecticidal treatments.

4.3.5.2 One day after first spray.

The data generated one day after first spray is presented in Table 30. and depicted in Fig. 17.Which shows that all the treatments were recorded low population of spider than compare to control. Population of spider in emamectin benzoate 5 SG @ 4gm/10 (0.26 /plant) lit was higher and chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.26 /plant) , indoxacarb 15.8 SC @ 5ml/10 lit shows similar trend. The maximum population of spider (0.60/ plant) was observed in untreated control.

4.3.5.3 Three day after first spray.

The data shown three day after first spray is presented in Table 30. and depicted in Fig. 17. Though all the treatments were recorded lower population of spider than untreated control. But it was non-significant and population of spider in emamectin benzoate 5 SG @ 4gm/10 lit (0.46 /plant) was more. chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.33 /plant) , spinosod 45 SC @ 2.5 ml/10 lit (0.26 /plant) , fevalerate 20 EC @ 20 ml/ 10 lit shows maximum reduction. The highest population of spider (0.53 / plant) was observed in untreated control.

4.3.5.4 Seven day after first spray.

The data recorded seven day after first spray are presented in Table 30. and graphically presented in Fig. 17.Where all the treatments were recorded lower population of spider compare to untreated control. Population of spider in emamectin benzoate 5 SG @ 4gm/10 lit (0.33 /plant) was higher while chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.33 /plant) , fevalerate 20 EC @ 20 ml/ 10 lit (0.20 /plant) recorded the highest reduction. The highest population of spider (0.60 / plant) was observed in untreated control.

4.3.5.5 Ten day after first spray.

The data pertaining to spider is presented in Table 30. and depicted in Fig. 17. All the treatments were recorded lower population of spider than untreated control. Population of spider in emamectin benzoate 5 SG @ 4gm/10 lit was higher (0.46 /plant) was higher. lambda cyhalothrin 5 EC @ 5 ml/10 lit (0.33 /plant) ,fevalerate 20 EC @ 20 ml/ 10 lit (0.26 /plant) chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.26 /plant) shows maximum reduction . The maximum population of spider (0.66 / plant) was observed in untreated control.

4.3.5.6 Fourteen day after first spray.

The data generated fourteen days after first spray are presented in Table 30. and depicted in Fig. 17. Population of spider in emamectin benzoate 5 SG @ 4gm/10 (0.46 /plant lit was higher and chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.46 /plant) , fevalerate 20 EC @ 20 ml/ 10 lit (0.40 /plant) shows higher reduction.

Table 30. Effect of different insecticides on Spider after first spray.

Sr. No	Treatment	Dose ml/ 10 lit.	Av. Spider adult/ plant					
			1 DBS	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS
1.	Emamectin Benzoate 5 SG	4 gm	0.46 **(0.97)**	0.20 **(0.83)**	0.46 **(0.97)**	0.33 **(0.90)**	0.46 **(0.97)**	0.46 **(0.97)**
2.	Lambda cyhalothrin 5 EC	5 ml	0.26 **(0.86)**	0.20 **(0.83)**	0.13 **(0.79)**	0.26 **(0.86)**	0.33 **(0.90)**	0.33 **(0.90)**
3.	Chlorantraniliprole 18.5 SC	3 ml	0.46 **(0.97)**	0.26 **(0.86)**	0.33 **(0.90)**	0.33 **(0.90)**	0.20 **(0.83)**	0.46 **(0.97)**
4.	Indoxacarb 15.8 EC	5 ml	0.40 **(0.94)**	0.20 **(0.83)**	0.26 **(0.87)**	0.06 **(0.75)**	0.26 **(0.86)**	0.26 **(0.87)**
5.	Spinosad 45 SC	2.5 ml	0.33 **(0.90)**	0.13 **(0.79)**	0.26 **(0.86)**	0.06 **(0.75)**	0.26 **(0.86)**	0.46 **(0.97)**
6.	Fenvalerate 20 EC	8 ml	0.26 **(0.86)**	0.20 **(0.83)**	0.20 **(0.83)**	0.20 **(0.83)**	0.26 **(0.87)**	0.40 **(0.94)**
7.	Profenophos 50 EC	20 ml	0.20 **(0.82)**	0.13 **(0.79)**	0.13 **(0.79)**	0.20 **(0.83)**	0.26 **(0.86)**	0.46 **(0.97)**
8.	Control		0.73 **(1.10)**	0.60 **(1.04)**	0.53 **(1.01)**	0.60 **(1.03)**	0.66 **(1.07)**	0.60 **(1.04)**
	SE(m) ±		**0.07**	**0.06**	**0.05**	**0.06**	**0.05**	**0.05**
	CD at 5 %		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
	CV (%)		**14.27**	**12.42**	**10.35**	**12.86**	**10.77**	**10.10**

Figure in parenthesis are $\sqrt{x + 0.5}$ transformed values.

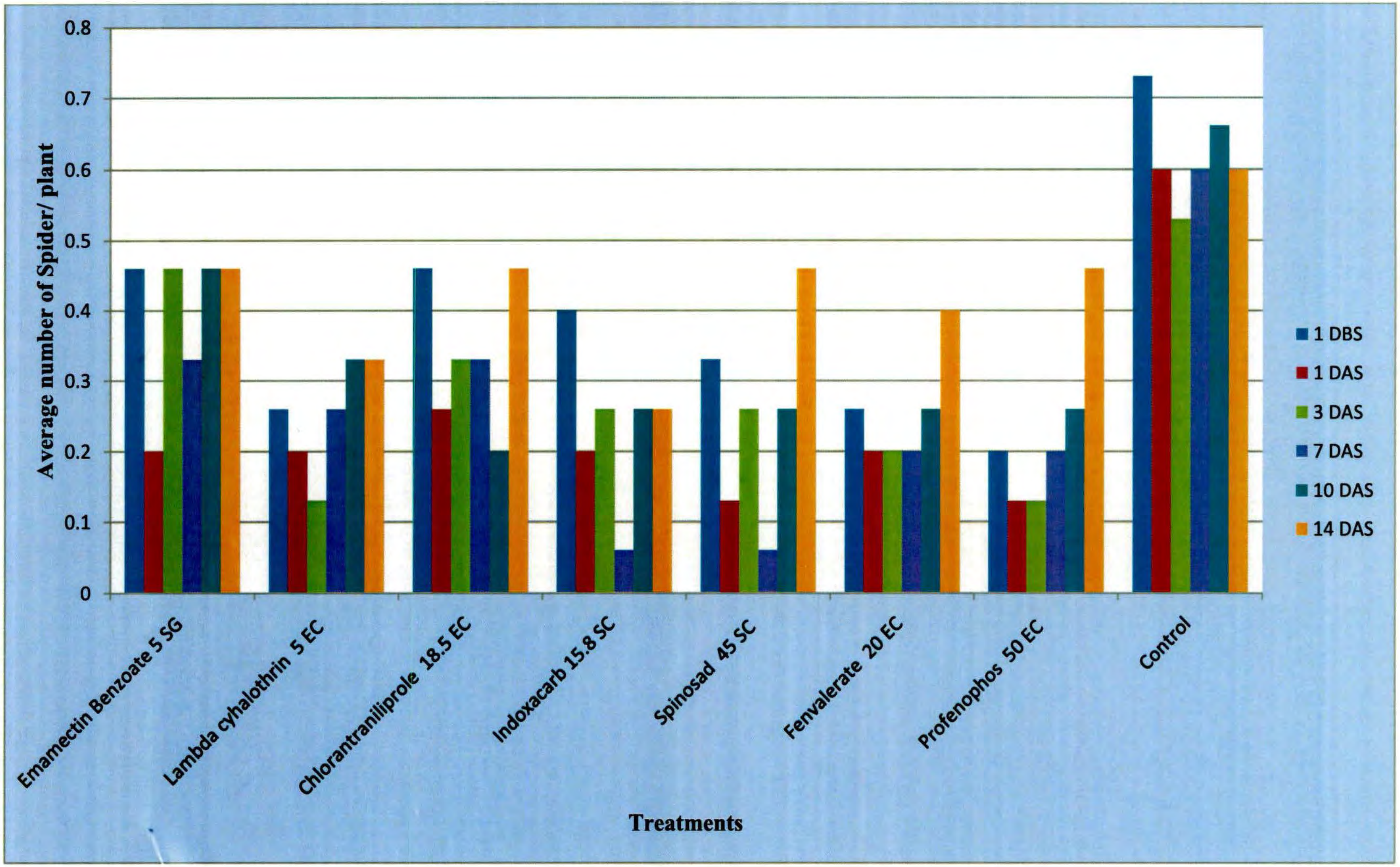


Fig. 17. Population of Spider per plant before and after first spray

4.3.6 After second spray

4.3.6.1 Pre-count one day before second spray.

The data on spider population on one day before second spray is presented in Table 31. and graphically represented in Fig. 18.The results were statistically non-significant indicating uniform distribution of population. The average number of spider ranged from 0.13 to 0.73/plant in different insecticidal treatments.

4.3.6.2 One day after second spray.

The data generated one day after spray is presented in Table 31. and depicted in Fig. 18. Population of spider in emamectin benzoate 5 SG @ 4gm/10 lit (0.40 /plant) was higher whereas chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.26 /plant) , spinosod 45 SC @ 2.5 ml/10 lit (0.20 /plant) shows higher reduction. The highest population of spider (0.60/ plant) was observed in untreated control.

4.3.6.3 Three day after second spray.

The data shown three day after spray is presented in Table 31. and depicted in Fig. 18.Though all the treatments were recorded low population of spider compare to untreated control. Population of spider in emamectin benzoate 5 SG @ 4gm/10 lit (0.53 /plant) was higher and profenophos 50 EC @ 20 ml/10 lit (0.46 /plant) chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.33 /plant) , spinosod 45 SC @ 2.5 ml/10 lit (0.20 /plant) , fevalerate 20 EC @ 20 ml/ 10 lit shows maximum reduction. The maximum population of spider (0.66 / plant) was observed in untreated control.

4.3.6.4 Seven day after second spray.

The data generated seven day after spray is presented in Table 31. and depicted in Fig. 18. Population of spider in emamectin benzoate 5 SG @ 4gm/10 lit (0.46 /plant) was maximum and spinosod 45 SC @ 2.5 ml/10 lit (0.46 /plant) chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.33 /plant) , lambda cyhalothrin 5 EC@ 5 ml/10 lit (0.26 /plant) recorded th similar trend.The highest population of spider (0.66 / plant) was observed in untreated control but stastically non-significant.

4.3.6.5 Ten day after second spray.

The data recorded ten day after spray is presented in Table 31. and depicted in Fig. 18. Population of spider in emamectin benzoate 5 SG @ 4gm/10 lit (0.33 /plant) was maximum .

whereas chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.46 /plant) , fevalerate 20 EC @ 20 ml/ 10 lit (0.26 /plant), spinosod 45 SC @ 2.5 ml/10 lit (0.26 /plant) shows maximum reduction.

4.3.6.6 Fourteen day after second spray.

The population built up was observed Fourteen day after spray in Table 31. and depicted in Fig. 18.Though all the treatments were recorded lower population of spider than untreated control. Population of spider in emamectin benzoate 5 SG @ 4gm/10 lit (0.53 /plant) was higher and chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.40 /plant) , fevalerate 20 EC @ 20 ml/ 10 lit (0.33 /plant) profenophos 50 EC @ 20 ml/10 lit (0.33 /plant) recorded similar trend. The maximum population of spider (0.73 / plant) was observed in untreated control.

The above results are in agreement with Tillman and Mulrooney (2000) who evaluated toxicity of insecticide which didn't affect natural enemies abundance.

Stadebaker and Kring (2003) reported that abamectin and emamectin benzoate were safe for natural enemies which are similar to present results.

Govindan *et al.*, (2012) observed that emamectin benzoate 5 SG was safer to predatory spider. The results showed that emamectin benzoate 5 SG was found to be safer at all concentrations. The highest spider population was recorded in plots treated with emamectin benzoate 5 SG .

Parthiban *et al.*, (2012) evaluated the safety of new formulation Emamectin benzoate 5 WG at different doses (100, 125 and 150 g/ha) against the standard check, Emamectin benzoate 5 SG (135 and 170 g/ha), Lambda cyhalothrin 5 CS (300 ml/ha) and Pyridalyl 10% EC at 500 ml/ha for their safety to spider predators. The results showed that Emamectin benzoate 5 WG was found to be safer to spider at all concentrations tested.

Table 31. Effect of different insecticides on Spider adult after second spray.

Sr. No	Treatment	Dose ml/10 lit.	Av. Spider adult / plant					
			1 DBS	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS
1.	Emamectin Benzoate 5 SG	4 gm	0.53 **(1.01)**	0.40 **(0.94)**	0.53 **(1.01)**	0.46 **(0.97)**	0.33 **(0.90)**	0.53 **(1.01)**
2.	Lambda cyhalothrin 5 EC	5 ml	0.40 **(0.90)**	0.06 **(0.71)**	0.26 **(0.86)**	0.26 **(0.86)**	0.06 **(0.75)**	0.13 **(0.79)**
3.	Chlorantraniliprole 18.5 SC	3 ml	0.53 **(1.04)**	0.26 **(0.87)**	0.33 **(0.90)**	0.33 **(0.90)**	0.46 **(0.97)**	0.40 **(0.94)**
4.	Indoxacarb 15.8 EC	5 ml	0.26 **(0.87)**	0.13 **(0.79)**	0.33 **(0.90)**	0.46 **(0.97)**	0.13 **(0.79)**	0.20 **(0.83)**
5.	Spinosad 45 SC	2.5 ml	0.40 **(0.94)**	0.20 **(0.83)**	0.20 **(0.83)**	0.46 **(0.97)**	0.26 **(0.86)**	0.20 **(0.83)**
6.	Fenvalerate 20 EC	8 ml	0.33 **(0.90)**	0.26 **(0.86)**	0.26 **(0.87)**	0.13 **(0.79)**	0.26 **(0.86)**	0.33 **(0.90)**
7.	Profenophos 50 EC	20 ml	0.46 **(0.97)**	0.40 **(0.94)**	0.46 **(0.97)**	0.46 **(0.97)**	0.13 **(0.79)**	0.33 **(0.90)**
8.	Control		0.66 **(1.07)**	0.60 **(1.04)**	0.66 **(1.07)**	0.66 **(1.08)**	0.73 **(1.10)**	0.73 **(1.11)**
	SE(m) ±		**0.06**	**0.05**	**0.07**	**0.07**	**0.06**	**0.05**
	CD at 5 %		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
	CV (%)		**12.70**	**10.59**	**14.27**	**13.06**	**12.45**	**11.18**

Figure in parenthesis are $\sqrt{x + 0.5}$ transformed values.

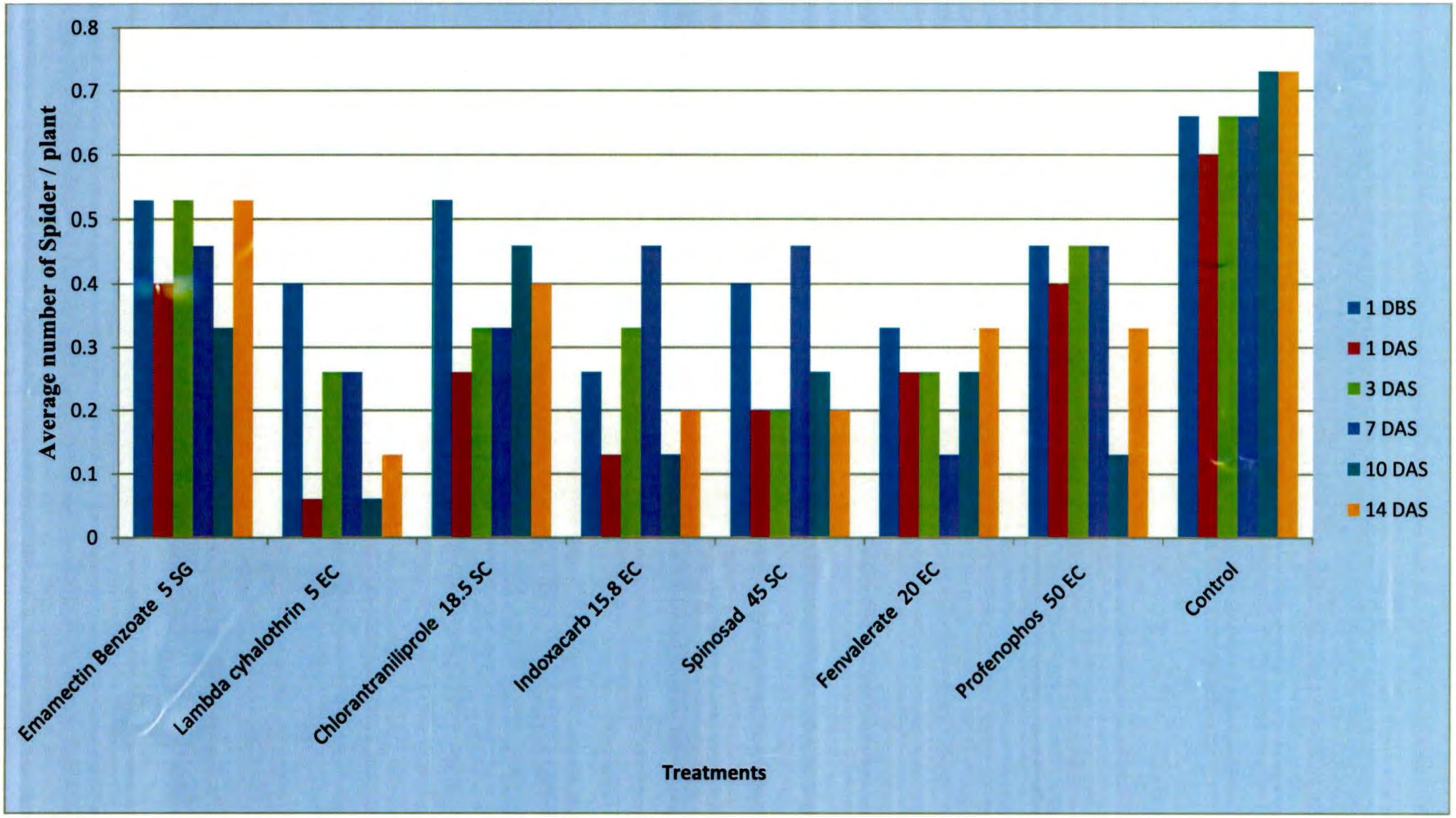


Fig.18. Population of Spider per plant before and after second spray

4.3.7 Effect of different insecticide against Parasitoid pupae

After first spray

4.3.7.1 Pre-count one day before first spray.

The data on Parasitoid (*Charops obtusus, Apantelus spp*, Braconids, *Campoletis chlorideae*) population on one day before first spray is presented in Table 32. and graphically represented in Fig. 19.The results were statistically non-significant indicating uniform distribution of population. The average number of Parasitoid ranged from 0.20 to 0.60/plant in different insecticidal treatments.

4.3.7.2 One day after first spray.

The data generated one day after spray is presented in Table 32. and depicted in Fig. 19 .These reveals that all the treatments were recorded lower population of parasitoid than untreated control. Population of parasitoid in chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.26 /plant) was non-significant, Lambda cyhalothrin 5 EC @ 5 ml/10 lit (0.26 /plant) indoxacarb 15.8 SC @ 5 ml/ 10 lit i,e 0.20 /plant) were recorded similar trend. The highest population of Parasitoid (0.60/ plant) was observed in untreated control.

4.3.7.3 Three day after first spray.

The data presented three day after spray is presented in Table 32. and depicted in Fig. 19. These shows that all the treatments were recorded low population of Parasitoid compare to untreated control. Population of parasitoid in chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.33/plant) and emamectin benzoate 5 SG @ 4 ml/10 lit (0.33 /plant) ,spinosod 45 SC @ 2.5 ml/10 lit (0.33 /plant), fevalerate 20 EC @ 20 ml/ 10 lit revealed maximum reduction . whereas maximum population of Parasitoid (0.66 / plant) was observed in untreated control.

4.3.7.4 Seven day after first spray.

The data recorded on seven day after spray is presented in Table 32. and depicted in Fig. 19. All the treatments were recorded lower population of Parasitoid than untreated control. Population of Parasitoid in chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.40 /plant) was non-significant. emamectin benzoate 5 SG @ 4 ml/10 lit (0.26 /plant), fevalerate 20 EC @ 20 ml/ 10 lit (0.20 /plant) shows similar trend.The highest population of parasitoid (0.73 / plant) was observed in untreated control.

4.3.7.5 Ten day after first spray.

The data are presented in Table 32. and depicted in Fig. 19. Population of Parasitoid in chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.46 /plant) and fenvalerate 20 EC @ 20 ml/ 10 lit (0.46 /plant) was higher and Lambda cyhalothrin 5 EC @ 5 ml/10 lit (0.40 /plant) ,fevalerate 20 EC @ 20 ml/ 10 lit (0.46 /plant) shows maximum reduction. The highest population of parasitoid (0.60 / plant) was observed in untreated control.

4.3.7.6 Fourteen day after first spray.

The data generated one day after spray is presented in Table 32. and depicted in Fig. 19 . Population of parasitoid in chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.46 /plant) was maximum. whereas fevalerate 20 EC @ 20 ml/ 10 lit (0.33/plant), Lambda cyhalothrin 5 EC @ 5 ml/10 lit (0.33 /plant) ,spinosod 45 SC @ 2.5 ml/10 lit (0.26 /plant) has highest reduction. The maximum population of Parasitoid (0.73 / plant) was observed in untreated control.

Table 32. Effect of different insecticides on Parasitiod pupae after first spray.

Sr. No	Treatment	Dose ml/10 lit.	Av.Parasitiod pupae/ plant					
			1 DBS	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS
1.	Emamectin Benzoate 5 SG	4 gm	0.33 **(0.90)**	0.20 **(0.83)**	0.40 **(0.94)**	0.26 **(0.86)**	0.26 **(0.86)**	0.26 **(0.87)**
2.	Lambda cyhalothrin 5 EC	5 ml	0.26 **(0.86)**	0.20 **(0.83)**	0.46 **(0.97)**	0.20 **(0.83)**	0.40 **(0.94)**	0.33 **(0.90)**
3.	Chlorantraniliprole 18.5 SC	3 ml	0.33 **(0.90)**	0.26 **(0.86)**	0.40 **(0.93)**	0.40 **(0.94)**	0.46 **(0.97)**	0.46 **(0.97)**
4.	Indoxacarb 15.8 EC	5 ml	0.33 **(0.90)**	0.20 **(0.83)**	0.26 **(0.86)**	0.20 **(0.83)**	0.40 **(0.94)**	0.33 **(0.90)**
5.	Spinosad 45 SC	2.5 ml	0.33 **(0.90)**	0.20 **(0.82)**	0.53 **(1.01)**	0.13 **(0.79)**	0.20 **(0.83)**	0.26 **(0.86)**
6.	Fenvalerate 20 EC	8 ml	0.40 **(0.94)**	0.26 **(0.86)**	0.26 **(0.87)**	0.20 **(0.83)**	0.46 **(0.97)**	0.33 **(0.90)**
7.	Profenophos 50 EC	20 ml	0.33 **(0.90)**	0.26 **(0.83)**	0.26 **(0.87)**	0.20 **(0.83)**	0.26 **(0.86)**	0.26 **(0.87)**
8.	Control		0.66 **(1.07)**	0.60 **(1.04)**	0.60 **(1.04)**	0.73 **(1.10)**	0.60 **(1.04)**	0.73 **(1.10)**
	SE(m) ±		**0.06**	**0.05**	**0.05**	**0.06**	**0.06**	**0.06**
	CD at 5 %		**0.18**	**0.16**	**0.17**	**0.18**	**0.18**	**0.18**
	CV (%)		**12.16**	**11.02**	**10.59**	**12.01**	**11.32**	**11.28**

Figure in parenthesis are $\sqrt{x + 0.5}$ transformed values.

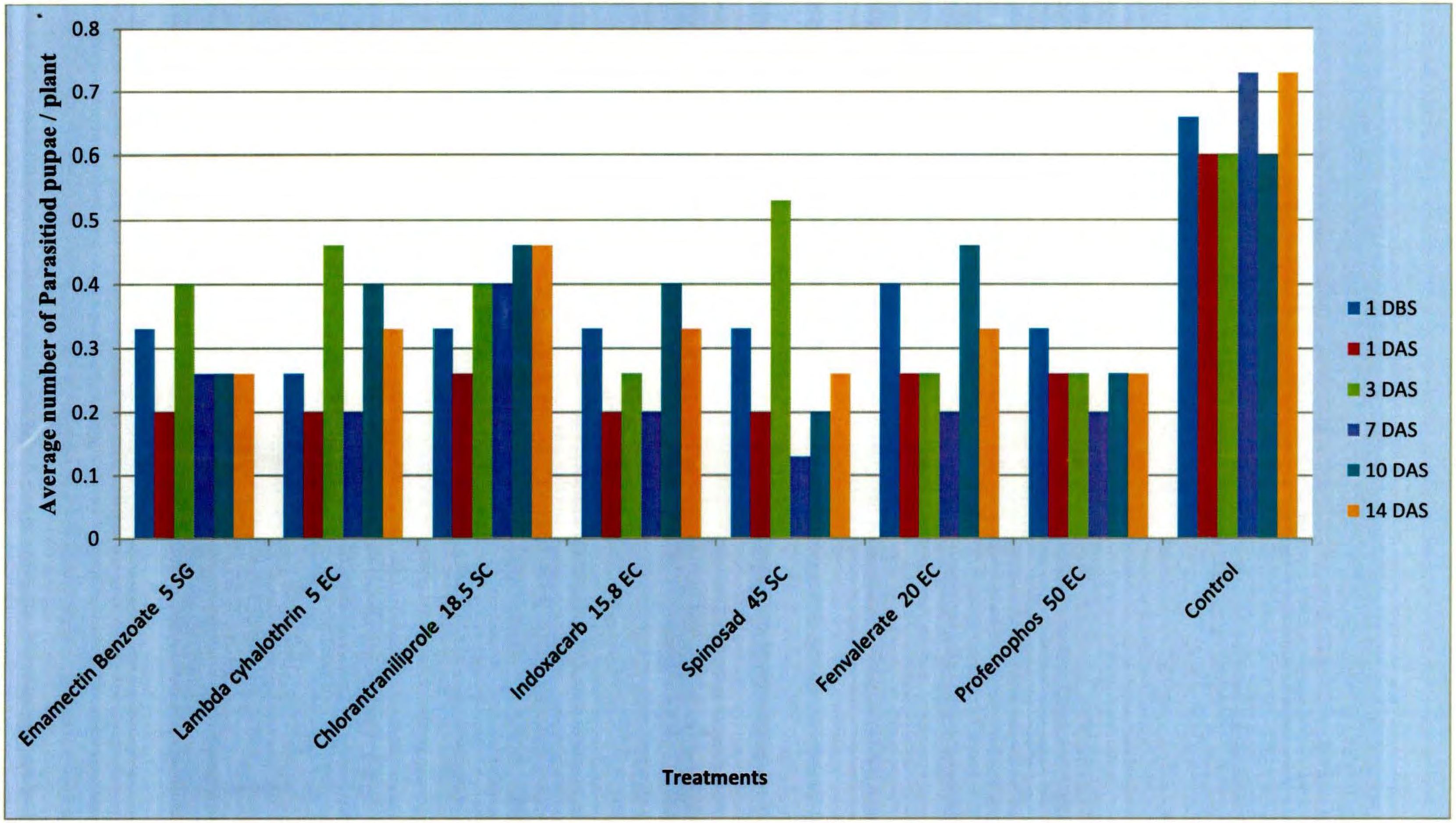


Fig.19. Population of Parasitiod pupae per plant before and after first spray

4.3.8 After second spray

4.3.8.1 Pre-count one day before second spray.

The data on Parasitiod (*Charops obtusus, Apantelus spp*, Braconids, *Campoletis chlorideae*) population on one day before second spray is presented in Table 33. and graphically represented in Fig. 20.The results were statistically non-significant indicating uniform distribution of population. The average number of parasitiod ranged from 0.13 to 0.73/plant in different insecticidal treatments.

4.3.8.2 One day after second spray.

The data recorded one day after spray is presented in Table 33 and depicted in Fig. 20. population of parasitiod in chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.53 /plant) was higher and lambda cyhalothrin 5 EC @ 5 ml/10 lit (0.26 /plant) ,indoxacarb 15.8 SC @ 5 ml/ 10 lit (0.33/plant) ,spinosod 45 SC @ 2.5 ml/10 lit (0.33/plant) were recorded similar trend. The highest population of Parasitiod (1.00/ plant) was observed in untreated control.

4.3.8.3 Three day after second spray.

The data shown three day after spray is presented in Table 33. and depicted in Fig. 20. Population of parasitiod in chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.66/plant) was non-significant and emamectin benzoate 5 SG @ 4 ml/10 lit (0.46 /plant) and spinosod 45 SC @ 2.5 ml/10 lit (0.40 /plant) indoxacarb 15.8 SC @ 5 ml/ 10 lit (0.40/plant) were recorded similar trend.The highest population of parasitiod (0.93/ plant) was observed in untreated control.

4.3.8.4 Seven day after second spray.

The data recorded seven day after spray is presented in Table 33. and depicted in Fig. 20. Where all the treatments were recorded low population of parasitiod compare to untreated control. Population of parasitiod in chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.53 /plant) was higher spinosod 45 SC @ 2.5 ml/10 lit (0.46/plant) shows similar trend .The maximum population of parasitiod (0.66/ plant) was observed in untreated control.

4.3.8.5 Ten day after second spray.

The data generated ten day after spray is presented in Table 16 and depicted in Fig. 20. Population of parasitiod in chlorantraniliprole 18.5 SC @ 5 ml/10 lit (0.46 /plant) and fevalerate 20 EC @ 20 ml/ 10 lit (0.46 /plant) was non-significant whereas profenophos 50 EC @ 20 ml/10 lit (0.40 /plant), indoxacarb 15.8 SC @ 5 ml/ 10 lit (0.26/plant) shows similar results.

4.3.8.6 Fourteen day after second spray.

The data pertaining to the population of parasitoid is presented in Table 33 and depicted in Fig. 20.Though all the treatments were recorded lower population of parasitiod compare to untreated control. Population of parasitiod in chlorantraniliprole 18.5 SC @ 5 ml/10 lit(0.53 /plant) was higher. While profenophos 50 EC @ 20 ml/10 lit (0.46 /plant) fevalerate 20 EC @ 20 ml/ 10 lit (0.40/plant) lambda cyhalothrin 5 EC @ 5 ml/10 lit (0.26 /plant) were recorded nearly similar population.

Brugger *et.al,*(2010) studies are similar which showed higher selectivity of chlorantraniliprole 18.5 SC to parasitoid wasps.

Yadav *et.al* (2008) reported that spinosad (Tracer) 45 SC had less impact on natural enemies , spinosad was safe for natural enemies.

Table 33. Effect of different insecticides on Parasitiod pupae after second spray.

Sr. No	Treatment	Dose ml/10lit.	Av. Parasitiod pupae/plants					
			1 DBS	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS
1.	Emamectin Benzoate 5 SG	4 gm	0.46 **(0.97)**	0.33 **(0.90)**	0.46 **(0.97)**	0.53 **(1.01)**	0.33 **(0.90)**	0.40 **(0.97)**
2.	Lambda cyhalothrin 5 EC	5 ml	0.86 **(0.97)**	0.26 **(0.86)**	0.53 **(1.01)**	0.33 **(0.90)**	0.40 **(0.97)**	0.46 **(0.96)**
3.	Chlorantraniliprole 18.5 SC	3 ml	0.53 **(1.01)**	0.53 **(1.01)**	0.66 **(1.07)**	0.53 **(1.01)**	0.46 **(0.96)**	0.66 **(1.07)**
4.	Indoxacarb 15.8 EC	5 ml	0.53 **(1.00)**	0.33 **(0.90)**	0.40 **(0.94)**	0.53 **(1.00)**	0.26 **(0.87)**	0.46 **(0.97)**
5.	Spinosad 45 SC	2.5 ml	0.40 **(0.94)**	0.33 **(0.90)**	0.40 **(0.94)**	0.46 **(0.97)**	0.46 **(0.97)**	0.46 **(1.04)**
6.	Fenvalerate 20 EC	8 ml	0.86 **(0.97)**	0.33 **(0.91)**	0.26 **(0.87)**	0.53 **(1.01)**	0.46 **(1.04)**	0.40 **(0.97)**
7.	Profenophos 50 EC	20 ml	0.60 **(1.03)**	0.53 **(1.00)**	0.40 **(0.94)**	0.53 **(1.01)**	0.40 **(0.97)**	0.46 **(0.96)**
8.	Control		0.86 **(1.17)**	0.73 **(1.11)**	0.93 **(1.19)**	0.66 **(1.06)**	0.73 **(1.11)**	0.86 **(1.17)**
	SE(m)+		**0.06**	**0.06**	**0.08**	**0.06**	**0.07**	**0.08**
	CD at 5 %		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
	CV (%)		**10.98**	**11.74**	**14.28**	**11.66**	**13.11**	**14.87**

Figure in parenthesis are $\sqrt{x + 0.5}$ transformed values.

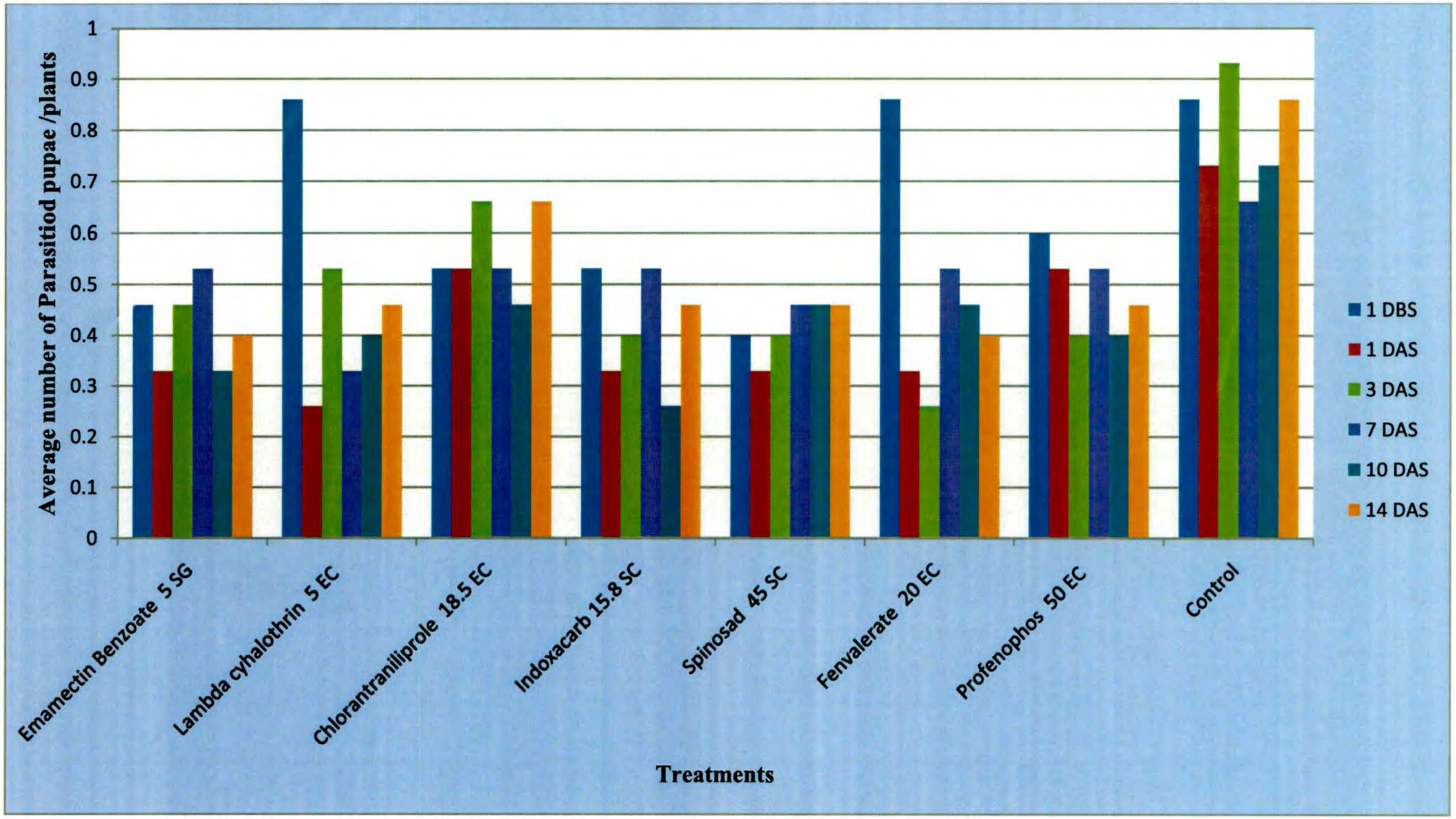


Fig.20. Population of Parasitiod pupae per plant before and after second spray

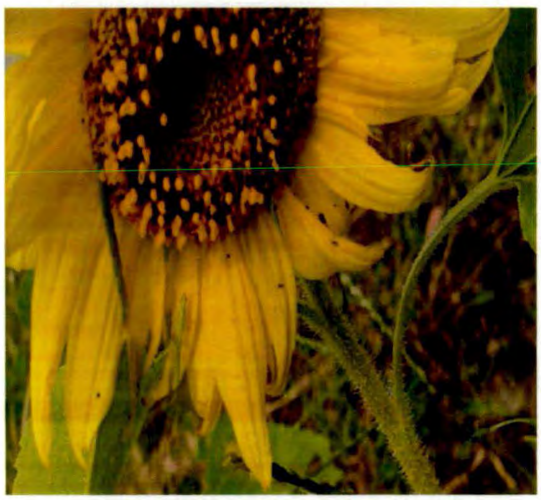
Predatory Sipder

C.carnea

C.carnea Grub

Chrops. spp

Ladybird bettle



C.carnea spp.

Plate No . 3 Natural enemies in sunflower

Table 34.Yield enhancement in sunflower in response to different treatments.

Tr. No.	Treatments	Dosages (ml/10 lit)	Mean Yield (kg/ha)
T_1	Emamectin Benzoate 5 SG	4 gm	1435
T_2	Lambda cyhalothrin 5 EC	5ml	1536
T_3	Chlorantraniliprole 18.5 EC	3 ml	1625
T_4	Indoxacarb 15.8 EC	5ml	1752
T_5	Spinosad 45 SC	2.5 ml	1707
T_6	Fenvalerate 20 EC	8 ml	1622
T_7	Profenofos 50 EC	20 ml	1676
T_8	Untreated control	--	1176
	SE(m)±	0.07	37.0
	CD at 5%	0.21	111.0

Yield

The data on yield of sunflower seed was recorded in kg/plot that was converted into kg/ha presented in table no.34 and fig no. 21.

The result revealed that all the insecticide treatments were significantly superior over untreated control in increasing yield. The highest sunflower yield was recorded in plots treated with Indoxacarb 15.8 SC @ 5ml/10 lit (1752kg/ha) followed bySpinosad 45 SC @2.5ml/10 lit(1707 kg/ha),Profenofos 50 EC @ 20ml/10 lit(1676 kg/ha) which were at par with with each other howeverChlorantraniliprole 18.5 @ EC 5ml/10 lit(1625 kg/ha), Fenvalerate 20 EC @ 8 ml/10 lit(1622 kg/ha) , Lambda cyhalothrin 5 EC @ 5ml/10 lit(1536 kg/ha) and Emamectin Benzoate 5 SG @4 gm/10 lit(1435 kg/ha). The lowest yield obtained from untreated plot (1176 kg/ha)

Ravi *et.al,*(2007) documented that highest seed yield was recorded in indoxacarb treated plot and it was at par with spinosad treated plots.

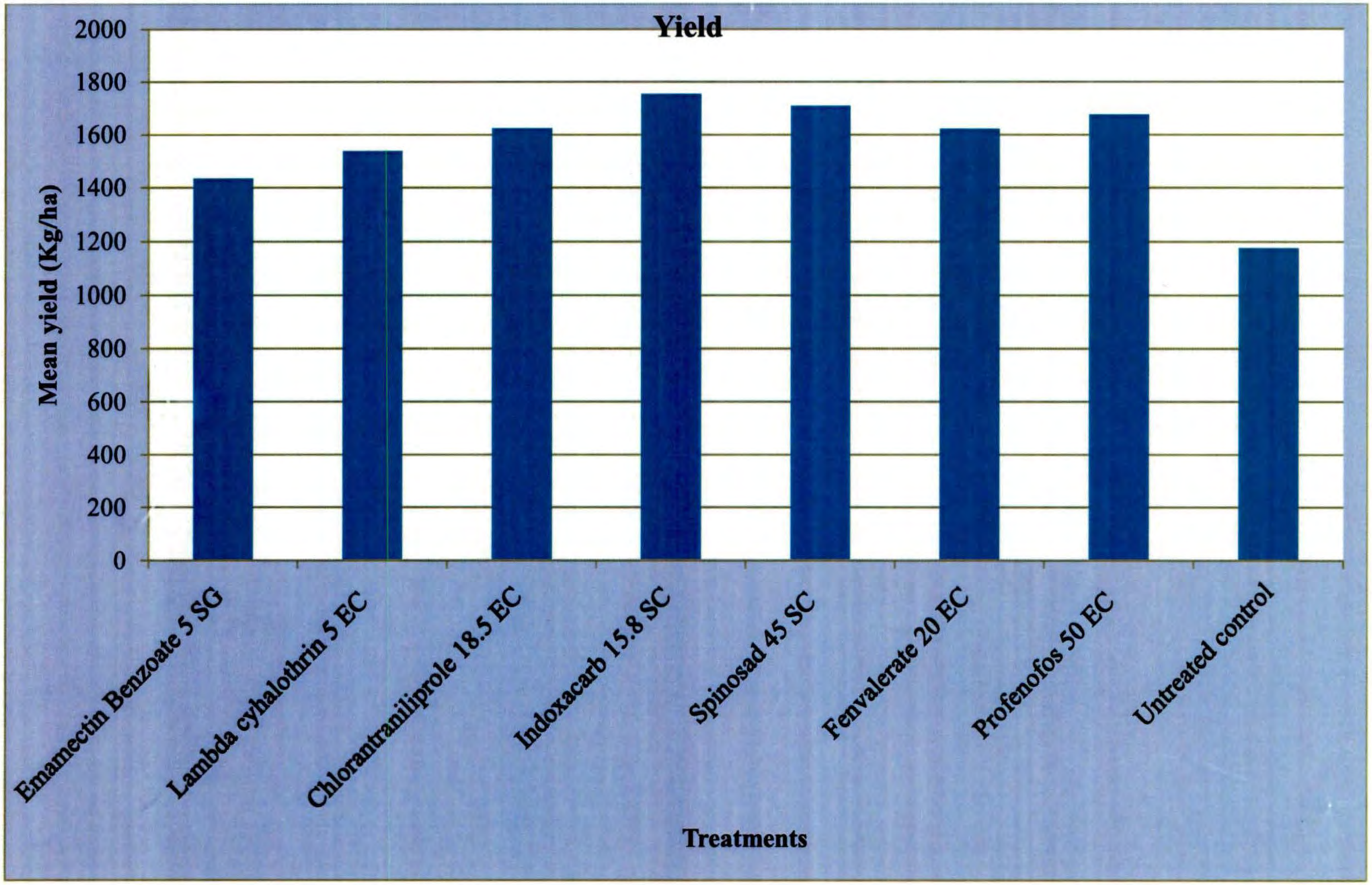


Fig. 21 Yield level of sunflower in different treatments.

Table 35. Incremental cost benefit ratio (ICBR)

Tr. No	Treatments	RequiredQuantity of insecticide(ml/ha)	Cost of insecticides required for 2 spraying (Rs) (A)	Labour charges for 2 spray (Rs) (B)	Total cost of treatment (Rs/ha) (A+B)= C	Yield (Kg /ha)	Increase yield over control (Kg/ha)	Value of increased yield (Rs/ha) (D)	Net return (D - C)	ICBR	Rank
1.	Emamectin benzoate 5 SG	220 gm/ha	2640	500	3140	1435	258	9546	6406	1:2.04	
2.	Lambda cyhalothrin 5 EC	250 ml/ha	300	500	800	1536	360	13320	12520	1:15.65	III
3.	Chlorantraniliprole 18.5 SC	150 ml/ha	3600	500	4100	1625	449	16613	12513	1:3.05	VI
4.	Indoxacarb 14.5SC	250 ml/ha	2250	500	2750	1752	576	21312	18562	1:6.74	IV
5.	Spinosad 45% SC	125 ml/ha	3000	500	3500	1707	530	19610	16110	1:4.60	V
6.	Fenvalerate 20EC	400 ml/ha	320	500	820	1622	445	16465	15645	1:19.07	II
7.	Profenophos 50 EC	150 ml/ha	180	500	680	1676	500	18500	17820	1:26.20	I
8.	Untreated control	-			-	1176	-	-			

*labour charges 250 Rs per day for spraying.*price of sunflower per quintal Rs 3700

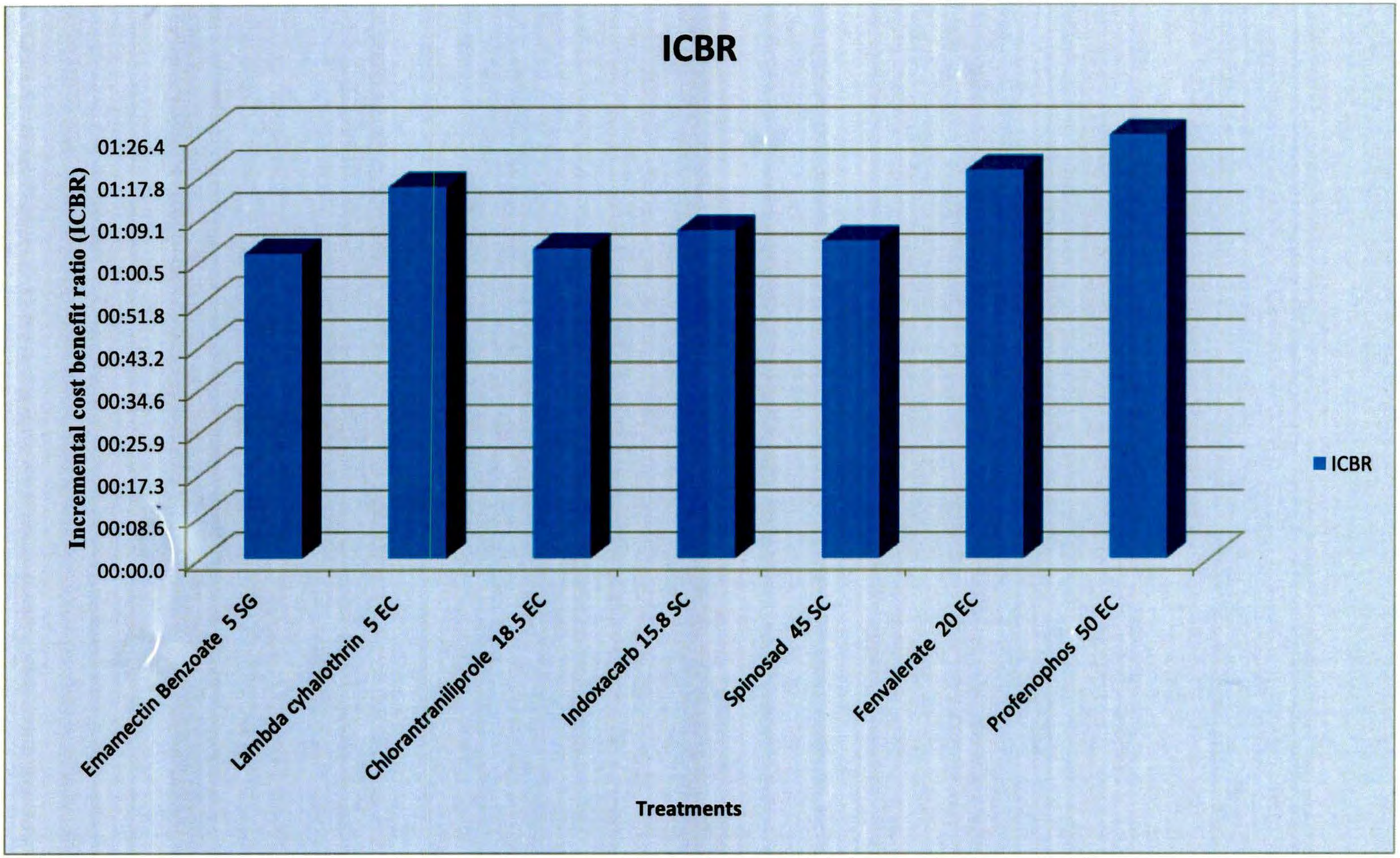


Fig. 22 Incremental cost benefit ratio (ICBR)

Incremental cost benefit ratio (ICBR)

The data presented in table 35. and fig 22 revealed that the insecticide treatment of Profenophos 50 EC @ 150 ml/ha(1:26.20) emerged as cost effective treatment followed by fenvalerate 20EC @ 400 ml/ha(1:19.07), lambda cyhalothrin 5 EC @250 ml/ha (1:15.65), Indoxacarb 14.5 SC @ 250 ml/ha (1:6.74), spinosad 45% SC@125 ml/ha(1:4.60), chlorantraniliprole 18.5 SC @150 ml/ha (1:3.05), emamectin benzoate 5 SG @220 gm/ha(1:2.04).

Though, the Chlorantraniliprole 18.5 SC @150 SC ml/ha emerged as effective treatment among all the treatment it secured VI rank in cost effective treatments.

Summary and Conclusions

Chapter V

SUMMARY AND CONCLUSIONS

Present on "Bio-efficacy of different insecticides against major pests of sunflower" and effect of insecticides on natural enemies, the field experiment was conducted at research farm, department of agricultural entomology, college of agriculture, Badnapur. During *kharif* season of the year 2016-2017.

The experiment was laid out in a randomized block design (RBD) with eight treatments each replicated for three times. The experimental unit was 4.5 x 4.2m^2 size. The treatments comprised of emamectin benzoate 5 SG@ 4 gm/10 lit ,lambda cyhalothrin 5 EC@ 5ml/10 lit , chlorantraniliprole 18.5 SC @ 5ml/10 lit , indoxacarb 15.8 EC @ 5ml/10 lit, spinosad 45 SC @2.5ml/10 lit, fenvalerate 20 EC@ 8 ml/10 lit, profenofos 50 EC @20ml/10 L and untreated control.

The observation on sucking pests like (Thrips, Jassids, Whitefly and Aphids) and defoliator like (capitulium borer, *Spodoptera litura,* hairy caterpillar and green semilooper) and natural enemies like (ladybird beetle, chrysopa, spider and parasitoids (Charops obtusks, Apantelus sp., Braconids, Campoletis chlorideae) (*Charops obtusks, Apantelus sp*., braconids, *Campoletis chlorideae*) were recorded at 7 days interval on randomly selected 5 plants on each plots. The data on count was then analysed individually, consolidated and cumulative mean was worked out and incidence of population of sucking pest, defoliator and natural enemies in relation to weather parameter was also worked out. The effect on sucking pest, defoliator and natural enemies, seed sunflower yield and economics was also studied. The result so obtained are discussed as under.

5.0 The experiment was conducted with the following three objectives.

5.1 To study the bioefficacy of different Insecticides against major pests of sunflower.

5.2 To study the population dynamics of major pests of sunflower.

5.3 To study the effect of insecticides on natural enemies.

5.1.1 Bio-efficacy of different insecticides against major pests of sunflower.

In field testing of insecticides, the treatments chlorantraniliprole 18.5 SC @ 3 ml/10 lit, indoxacarb 15.8 SC @ 5ml/10 lit, spinosad 45 SC @2.5ml/10 lit were found effective in lowering overall head borer and defoliators population on sunflower and were significantly at par with each other.

The results indicated that among all insecticides chlorantraniliprole 18.5 SC @ 3 ml/10 lit and lambda cyhalothrin EC@ 5ml/10 lit, were found most effective in reducing hairy caterpillar population after two spray of insecticides.

Minimum incidence of green semilooper was found in chlorantraniliprole 18.5 SC @ 3 ml/10 lit, treated plots followed by emamectin benzoate 5 SG@ 4 gm/10 lit after two spray of insecticides.

Whereas indoxacarb 15.8 EC @ 5ml/10 lit, and emamectin benzoate 5 SG@ 4 gm/10 lit were found most effective against capitulum borer after two sprays of insecticides.

The results indicated that among all insecticides spinosad 45 SC @2.5ml/10 lit and emamectin benzoate 5 SG@ 4 gm/10 lit, were found most effective in reducing spodoptera litura population after two spray of insecticides.

5.1.2 Population dynamics of major Pest of sunflower in relation with weather parameter.

The population of sucking pests thrips, jassids, whitefly , aphids/ leaf on sunflower ranged from 0.40 to 6.20, 0.20 to 2.00 ,0.60 to 7.00 , 0.60 to 5.00 per plant respectively during the season of 2016-17. However maximum population of thrips, jassids, whitefly , aphids on sunflower to the extend of 6.20, 2.00, 7.00 ,5.00 per plant was noticed during 36th, 40th, 37th and 40th meterological weeks, respectively . Captulium borer, *spodoptera litura* , hairy caterpillar and green semilooper ranged from 0.20 to 1.00, 0.60 to 1.80, 0.60 to 1.00, 0.80 to 2.00 per plant was noticed during 37th, 35th and 39th meterological weeks, respectively during season 2016-17 population of natural enemies , ladybird beetle, *chrysoperla carnea*, spider, parasitiod ranged from 0.40 to 1.20, 0.40 to 1.40, 0.40 to 1.20 and 0.60 to 1.00 per plant respectively. The maximum population of ladybird, *chrysoperla carnea*, spider and parasitoids (Charops obtusus, Apantelus sp., Braconids, Campoletis chlorideae) on sunflower to extent of 1.20, 1.40, 1.20 and 1.00 per plant was noticed during 39th , 38th and 40th meteorological weeks, respectively

The parameter showed positive correlation between population of thrips and minimum humidity was significant. The minimum humidity showed negative correlation for multiplication of jassids population was significant. The population of whitefly with maximum temperature and minimum humidity were significant. Then aphid population with minimum temperature was highly significant correlation.

Maximum temperature and *spodoptera litura* had negative effect influence for multiplication with highly significant correlation.

The data presented coefficient correlation between ladybird beetle and maximum temperature, have negative correlation influence on multiplication it was significant correlation. Maximum temperature had negative significant correlation to chrysoperla spp and parasitoids (Charops obtusks, Apantelus spp, Braconids, Campoletis chlorideae) population. Max temperature and Rainfall had positive significant correlation for multiplication of spider

5.1.3 Effect of insecticides on natural enemies.

In field testing of insecticides, the treatments chlorantraniliprole 18.5 EC @ 5ml/10 lit and emamectin benzoate 5 SG@ 4 gm/10 lit were non-significant and found safer against natural enemies and were comparatively safer to the natural enemies of head borer and defoliators of Sunflower.

The results indicated that among all insecticides emamectin benzoate 5 SG@ 4 gm/10 lit chlorantraniliprole 18.5 SC @ 3 ml/10 lit were found most safer after two spray of insecticides.

Chlorantraniliprole 18.5 EC @ 3 ml/10 lit and emamectin benzoate 5 SG@ 4 gm/10 lit, Spinosad 45 SC @2.5ml/10 lit, were safer on *C.carnea* and ladybird beetle population after two spray of insecticides.

Emamectin b enzoate 5 SG@ 4 gm/10 lit, spinosad 45 SC @2.5ml/10 lit were safer on spider population after two spray of insecticides.

5.1.5 Incremental cost benefit ratio (ICBR)

The insecticide treatment of Profenophos 50 EC @ 150 ml/ha(1:26.20) emerged as cost effective treatment followed by fenvalerate 20EC @ 400 ml/ha(1:19.07), lambda cyhalothrin 5 EC @250 ml/ha (1:15.65), Indoxacarb 14.5 SC @ 250 ml/ha (1:6.74), spinosad

45% SC@125 ml/ha(1:4.60), chlorantraniliprole 18.5 SC @150 ml/ha (1:3.05), emamectin benzoate 5 SG @220 gm/ha(1:2.04).

Though the Chlorantraniliprole 18.5 SC @150 ml/ha emerged as effective treatment among all the treatment it secured VI rank in cost effective treatments.

5.1.6 Yield

The highest sunflower yield was recorded in plots treated with Indoxacarb 15.8 EC @ 5ml/10 L (1752.30kg/ha), Spinosad 45 SC @2.5ml/10 L (1707.0kg/ha), Profenofos 50 EC @ 20ml/10 L(1676.64 kg/ha), Chlorantraniliprole 18.5 SC @ 5ml/10 L(1625.40 kg/ha), Fenvalerate 20 EC @ 8 ml/10 L(1622 kg/ha) , Lambda cyhalothrin 5 EC @ 5ml/10 L(1536.33 kg/ha) , Emamectin Benzoate 5 SG @4 gm/10 L(1435.00 kg/ha). The lowest yield obtained from untreated plot (1176.28 kg/ha)

Conclusion

1. Application of indoxacarb 15.8 EC @ 5ml/10 lit was most effective against capitulium borer.
2. The treatment of chlorantaniliprole 18.5 EC@ 5ml/10 lit exhibited highest efficacy against hairy caterpillar and green semilooper followed by emamectin benzoate 5 SG@ 4 gm/10 lit and lambda cyhalothrin EC@ 5ml/10 lit performed better against head borer and defoliators and proved best option for chemical management .
3. Maximum population of Head borer , defoliators, sucking pest and natural enemies on sunflower was noticed during 36th to 40th meterological weeks
4. Minimum humidity was proved to be conductive for the multiplication of sucking pests. While the maximum temperature had negative impact over the activities of *spodoptera litura.*
5. Maximum temperature had a significant correlation with the all natural enemies but it was negative while rainfall proved to be conductive for the predatory spiders.
6. The present investigation also revealed that the treatment with Indoxacarb 15.8 EC @ 5ml/10 lit (1752.30) recorded highest seed of sunflower followed by Spinosad 45 SC @ 2.5ml/10 lit(1707.0) compared to all other treatments.

7. While results on incremental cost benefit ratio showed that highest ICBR was secured by profenophos 50 EC @ 150 ml/ha(1:26.20).

8. Chlorantaniliprole 18.5 EC@ 5ml/10 L proved to be safe insecticide for natural enemies.

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Thesis Abstract

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Title of the thesis	:	"EVALUATION OF DIFFERENT INSECTICIDES AGAINST DEFOLIATORS AND HEAD BORERS OF SUNFLOWER"
Name of the student	:	DESHMUKH RANJEET ASHOKRAO
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THESIS ABSTRACT

An investigation on "Evaluation of different insecticides against defoliators and head borers of sunflower" and effect of insecticides on natural enemies, was conducted at research farm, department of agricultural entomology, college of agriculture, Badnapur. During *kharif* season of the year 2016-2017. The investigation was carried out under, bio-efficacy of newer insecticides against defoliators and head borers of Sunflower, effect of different insecticides on natural enemies . The experiment was conducted under the Randomized Block Design (RBD) with eight treatments and three replications. The treatments comprised of emamectin benzoate 5 SG@ 4 gm/10 lit, lambda-cyhalothrin 5 EC@ 5ml/10 lit , chlorantraniliprole 18.5 SC @ 3 ml/10 lit , Indoxacarb 15.8 EC @ 5ml/10 lit, spinosad 45 SC @2.5ml/10 lit, fenvalerate 20 EC@ 8 ml/10 lit, profenofos 50 EC @20ml/10 lit and untreated control.

In field testing of insecticides, the treatments chlorantraniliprole 18.5 SC @ 3ml/10 lit, Indoxacarb 15.8 EC @ 5ml/10 lit, spinosad 45 SC @2.5ml/10 lit were equally effective in lowering overall head borer and defoliators population on sunflower .The results indicated that among all insecticides chlorantraniliprole 18.5 SC @ 3ml/10 lit was found most effective in reducing hairy caterplliar and green semilooper population after two spray of insecticides. Whereas Indoxacarb 15.8 EC @ 5ml/10 lit, and emamectin enzoate 5 SG@ 4 gm/10 lit were found most effective against Capitulium borer after two spray of insecticides. The results indicated that among all insecticides spinosad 45 SC @2.5ml/10 lit and emamectin benzoate 5 SG@ 4 gm/10 lit, were found most effective in reducing *S.litura* population after two spray of insecticides.

The population of sunflower sucking pests thrips, leaf hopper, whitefly, aphids on sunflower ranged from 0.40 to 6.20, 0.20 to 2.00, 0.60 to 7.00, 0.60 to 5.00 per 3 leaves respectively. Captulium borer, *Spodoptera litura* , hairy caterpillar and green semilooper ranged from 0.20 to 1.00, 0.60 to 1.80, 0.60 to 1.00, 0.80 to 2.00 per plant was noticed during 37^{th}, 35^{th} and 39^{th} meterological weeks, respectively. Population of natural enemies i.e ladybird beetle, *C.carnea* , spider, parasitoid ranged from 0.40 to 1.20, 0.40 to 1.40, 0.40 to 1.20 and 0.60 to 1.00 per plant respectively

The parameter showed positive correlation between population of thrips and min humidity was significantly correlated. The min humidity and rainfall showed negative effect for multiplication of leaf hopper population was significantly correlated. The population of whitefly with max temperature, max humidity and min humidity were significantly correlated. The aphid population with max temperature was negative for multiplication of population with highly significant correlation. Min temperature and *Spodoptera litura* had negative influence for multiplication with highly significant correlation.

The data presented regarding correlation coefficient between ladybird beetle and *C.carnea* with max temperature had negative influence on multiplication and it was highly significant. Max temperature had negative effect and rainfall had positive effect with significant correlation for multiplication of spider and parasitids.

In field testing of insecticides the treatments of chlorantraniliprole 18.5 SC @ 3 ml/10 lit and emamectin benzoate 5 SG@ 4 gm/10 lit were significantly at par with each other and found more safer to the natural enemies of head borer and defoliators of Sunflower.

The results also indicated that among all insecticides chlorantraniliprole 18.5 SC @ 3 ml/10 lit was found safer to Parasitiods and spider population after two spray of insecticides.

Emamectin Benzoate 5 SG@ 4 gm/10 lit was safer on *C.carnea* and ladybird beetle population after two spray of insecticides.

Though the chlorantraniliprole was proved to be superior to control defoliators and head borers. The highest yield was recorded by treatment of indoxacarb 15.8 EC (1752 kg/ha) and also emerged as a most cost effective treatment amongst all.

Appendix

ABBREVIATION

@	=	at the rate of
a.i.	=	active ingredient
cm	=	centimeters(s)
m	=	meter(s)
et al.	=	and other
etc.	=	etceteras
EC	=	Emulsifiable concentration
FS	=	Flowable concentration of seed treatment.
SC	=	Soluble concentration
WP	=	Wettable powder
Fig.	=	Figure
g	=	gram (s)
ha	=	hectare
kg	=	kilogram (s)
q	=	quintal
L	=	litre(s)
ml	=	mililiter (s)
%	=	per cent
Viz.,	=	videlicet (namely)
No.	=	Number
/	=	per
Rs.	=	Rupees
h	=	hours
>	=	greater than
Ltd.	=	Limited
SE	=	Standard error
CD	=	Critical difference
ed	=	edited(by)
pp	=	pages
MW	=	Meteorological week
Max	=	Maximum
Min	=	Minimum
°C	=	degree celcius
NS	=	Non signficant
r	=	correlation coefficient
LBB	=	ladybird beetle
M.S.	=	Maharashtra state
DAS	=	Days after sowing
DBS	=	Days before sowing

Weekly meteorological data for the year 2016

M.W	Duration	Temperature° C		Humidity (%)		Rain fall(mm)	Wind velocity km/hr
		Min	Max	Min	Max		
27	4-10 July	25.61	29.14	62.21	78.90	9.14	14.85
28	11-17 July	25.45	29.65	64.67	84.94	16.21	13.28
29	18-24 July	24.07	27.35	62.28	80.70	5.64	13.57
30	25-31 July	23.80	28.91	66.91	81.08	19.14	16.42
31	01-07 August	25.01	28.68	63.06	83.53	8.0	17
32	08-14 August	26.06	29.92	61.76	82.22	-	12.14
33	15-21 August	26.09	30.27	60.92	80.23	-	14.42
34	22-28 August	24.66	29.36	61.45	78.91	0.71	18.85
35	29-04 September	24.57	29.90	64.19	84.22	20.71	17.71
36	05-11 September	23.48	30.86	62.60	81.69	-	14.71
37	12-18 September	24.05	29.68	64.38	81.04	4.92	15
38	19-25 September	23.37	27.79	64.38	85.00	8.21	16
39	26-02 October	23.90	30.16	51.45	73.12	-	12.71
40	03-09 October	23.17	29.10	31.83	58.87	3.21	17.57
41	10-16 October	24.05	30.08	27.44	56.28	-	11.71
42	17-23 October	22.21	32.98	36.29	55.10	-	21.71
43	24-30 October	20.77	34.48	28.08	59.31	-	16.14
44	31-06 November	20.14	33.08	31.77	65.62	-	18
45	07-13 November	18.73	35.09	33.01	68.56	-	15.57
46	14-20 November	21.91	35.70	32.82	66.68	-	16.42
47	21-27 November	18.83	36.06	31.97	66.98	-	15

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