SEASONAL INCIDENCE, POPULATION DYNAMICS AND EFFICACY OF DIFFERENT COMBINATION OF INSECTICIDE AGAINST SUCKING PESTS OF CHILLI (*CAPSICUM ANNUM* L.)

M.Sc. (Ag.) Thesis

by

Renuka

DEPARTMENT OF ENTOMOLOGY

COLLEGE OF AGRICULTURE

INDIRA GANDHI KRISHI VISHWAVIDYALAYA

RAIPUR (CHHATTISGARH)

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SEASONAL INCIDENCE, POPULATION DYNAMICS AND EFFICACY OF DIFFERENT COMBINATION OF INSECTICIDE AGAINST SUCKING PESTS OF CHILLI (*CAPSICUM ANNUM* L.)

Thesis

Submitted to the

Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.)

by

Renuka

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CERTIFICATE – I

This is to certify that the thesis entitled **"Seasonal incidence, population dynamics and efficacy of different combination of insecticide against sucking pests of chilli (*Capsicum annum* L.)"** submitted in partial fulfilment of the requirements for the degree of **Master of science in Agriculture** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, is a record of the bonafide research work carried out by **Renuka** under my/our guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma or certificate course. All the assistance and help received during the course of the investigations have been duly acknowledged by him.

Chairman

Date: 14 - 01 - 2020

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

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Member	Dr. Gajendra Chandrakar	----------------------------
Member	Dr. A.S. Kotasthane	----------------------------
Member	Dr. Ravi R. Saxena	----------------------------

CERTIFICATE – II

This is to certify that the thesis entitled **"Seasonal incidence, population dynamics and efficacy of different combination of insecticide against sucking pests of chilli (*Capsicum annum* L.)"** submitted by **Renuka** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur, in partial fulfillment of the requirements for the degree of Master of science in Agriculture in the Department of Entomology has been approved by the ***external evaluator*** and Student's Advisory Committee after oral examination, ***under the chairmanship of Head of the Department.***

Major Advisor

Date: 06/03/2020

Signature of Head of the Department

(Name………………………………)

Faculty Dean ------------------------------------

Approved/Not approved

Director of Instructions---------------------------------

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LIST OF ABBREVIATIONS

ABBREVIATION	DESCRIPTION
%	Per cent
/	Per
+	Plus
>	More then
<	Less than
@	At the rate of
^{0}C	Degree Celsius
g	Gram
km	Kilometre
mm	Millimetre
ha^{-1}	Hectare
q/ha	Quintal per hectare
ml/ha	Millilitre per hectare
RH	Relative humidity
EC	Emulsifiable concentration
SC	Soluble concentrate
SG	Soluble granule
WG	Water dispersible granule
V/V	Volume per volume
ppm	Parts per million
viz.	Namely
et al.	And other / co-workers
i.e.	That is
a.i.	Active ingredient
Fig.	Figure
CD	Critical difference
SEm	Standard error of mean
m	Meter
cm	Centimeter
hrs	Hours
RBD	Randomized block design
SMW	Standard Meteorological Week
MT	Metric ton
r	Correlation coefficient
l	Litre

THESIS ABSTRACT

a)	Title of Thesis	:	**"Seasonal incidence, population dynamics and efficacy of different combination of insecticide against sucking pests of Chilli (*Capsicum annum* L.)"**
b)	Full Name of the Student	:	Renuka
c)	Major Subject	:	Entomology
d)	Name and Address of the Major Advisor	:	Dr. D.K. Rana (Principal Scientist and Head) Department of Entomology, College of Agriculture, Raipur-492012
e)	Degree to be Awarded	:	Master of Science in Agriculture (Entomology)

Renuka
Signature of the Student

Signature of Major Advisor

Date: 14-01-2020

Signature of Head of the Department

ABSTRACT

The present investigation entitled **"Seasonal incidence, population dynamics and efficacy of different combination of insecticide against sucking pests of Chilli (*Capsicum annum* L.)"** was carried out at the Horticulture Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh) during season *Rabi* 2018-19.

Incidence of thrips (*Scirtothrips dorsalis*), mite (*Polyphagotarsonemus latus* Bank), aphid (*Aphis gossypii*), and tobacco caterpillar (*Spodoptera litura*) were revealed as major insect pests on chilli crop. Lady bird beetle and spider as

natural enemies on sucking pests of chilli were also recorded. The peak activity of thrips (22.2/plant), mite (1.44/plant), aphid (18.97/plant) and tobacco caterpillar (2.30/plant) were recorded during first week of March, second week of April, first week of February and fourth week of January, respectively. The incidence of natural enemies *viz.* lady bird beetle and spider population was recorded as maximum 4.9 per plant during third week of April and 3.21 per plant during the first week of January, respectively.

The thrips had positive and significant correlation with maximum temperature (r = 0.396*) and wind velocity (r = 0.543*) and negative significant correlation with morning relative humidity (r = -0.398*). The population of mite showed positive significant correlation with maximum temperature (r = 0.393*) and wind velocity (r = 0.516*). The population of aphid showed positive significant correlation with morning relative humidity (r= 0.410*) and significant negative with maximum temperature (r= -0.456*) and highly significant negative correlation with minimum temperature (r= -0.494**). Aphid population showed significant negative correlation with lady bird beetle (r= -0.464*).

Efficacy of Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha against thrips, mite and aphid was found to be most effective chemical because it recorded the lowest insect mean population along with maximum healthy fruit yield (94.66 q/ha) with highest cost benifit ratio of 1 :7.44. The second best treatment was Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha and fruit yield 92.72 q/ha. No adverse effect was observed on natural enemies *viz.* coccinellid and spider population after application of Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP.

शोध ग्रंथ का सारांश

अ) शोध ग्रंथ का शीर्षक	:	**"मिर्च (कैप्सिकम एनम) के चूसक कीटों के खिलाफ मौसमी घटना, जनसंख्या की गतिशीलता और कीटनाशक के विभिन्न संयोजन कि प्रभावकारिता पर अध्ययन"**
ब) छात्रा का पूरा नाम	:	रेणुका
स) प्रमुख विषय	:	कीट विज्ञान
द) मुख्य सलाहकार नाम और पता	:	डॉ डी. के. राणा, (प्रमुख वैज्ञानिक एवं विभागाध्यक्ष) कीट विज्ञान विभाग, कृषि महाविद्यालय, रायपुर- 492012
इ) प्रदान की जाने वाली उपाधि	:	एम .एस .सी .(कृषि) कीट विज्ञान

Renuka

छात्रा का हस्ताक्षर

मुख्य सलाहकार का हस्ताक्षर

दिनांक 14-01-2020

विभागाध्यक्ष के हस्ताक्षर

सारांश

वर्तमान शोध **"मिर्च (कैप्सिकम एनम) के चूसक कीटों के विरुद्ध मौसमी प्रकोप, जनसंख्या की गतिशीलता और कीटनाशक के विभिन्न संयोजन की प्रभावकारिता पर अध्ययन "** का कार्य रबी वर्ष 2018-19 के दौरान उद्यानिकी प्रक्षेत्र , इंदिरा गाँधी कृषि विश्वविद्यालय रायपुर (छत्तीसगढ़) में किया गया ।

मिर्च की फसल पर प्रमुख कीटों के रूप में थ्रिप्स (सिरटोथ्रिप्स डारसेलिस), माईट (पॉलीफेगोटार्सोनिमस लेटस), एफिड (एफिस गॉसिपि) तथा तंबाकू की इल्ली (इस्पोडोप्टेरा लिटुरा) पाए गए । मिर्च के चूसक कीटों पर प्राकृतिक शत्रुओं के रूप में लेडी बर्ड बीटल

और मकड़ी भी दर्ज की गयी। थ्रिप्स (22.2 प्रति पौधे), माईट(1.44 प्रति पौधे), एफिड(18.97 प्रति पौधे) और तम्बाकू की इल्ली (2.30 प्रति पौधे) की चरम गतिविधि क्रमशः मार्च के पहले सप्ताह, अप्रैल के दूसरे सप्ताह, फरवरी के पहले सप्ताह और जनवरी के चौथे सप्ताह में दर्ज की गयी । प्राकृतिक शत्रुओं जैसे लेडी बर्ड बीटल और मकड़ी की जनसँख्या क्रमशः अप्रैल के तीसरे सप्ताह में अधिकतम 4.9 प्रति पौधे और जनवरी के पहले सप्ताह में 3.21 प्रति पौधे दर्ज की गयी थी ।

थ्रिप्स का अधिकतम तापमान (r=0.396*) तथा वायु के वेग (r=0.543*) के साथ सकरात्मक और सार्थक सहसम्बन्ध था और प्रातः की सापेक्ष आर्द्रता (r= -0.398*)के साथ नकरात्मक सार्थक सहसम्बन्ध था। माइट की जनसंख्या ने अधिकतम तापमान (r=0.393*) और वायु के वेग (r=0.516*) के साथ सकरात्मक सार्थक सहसम्बन्ध दर्शाया । एफिड की संख्या ने प्रातः की सापेक्ष आर्द्रता (r=0.410*) के साथ सकरात्मक सार्थक सहसम्बन्ध तथा अधिकतम तापमान(r= -0.456*) के साथ सार्थक नकरात्मक सहसम्बन्ध और न्यूनतम तापमान (r= -0.494**) के साथ अत्यधिक नकरात्मक और सार्थक सहसम्बन्ध दर्शाया एफिड की संख्या ने लेडी बर्ड बीटल के साथ सार्थक सकरात्मक सहसम्बन्ध (r= -0.464*) दर्शाया।

थ्रिप्स, माइट और एफिड के विरुद्ध इमामैक्टिन बेंजोएट 3.5% +लेम्डा सायहेलोथ्रिन 5% WP @ 21.25 g a.i./ हेक्टेयर की दक्षता, अत्यधिक प्रभावी रसायन पाई गई क्योंकि इसमें सबसे कम माध्य कीट संख्या के साथ सबसे अधिक स्वस्थ फलों की पैदावार को 1:7.44 के उच्चतम लागत के लाभ अनुपात के साथ दर्ज किया गया। दूसरा उत्तम उपचार इमामैक्टिन बेंजोएट 3.5%+ लेम्डा सायहेलोथ्रिन 5% WP @ 16 g a.i./ हेक्टेयर पाया गया और अधिकतम फल उपज 92.72 क्विंटल/ हेक्टेयर इमामैक्टिन बेंजोएट 3.5% + लेम्डा सायहेलोथ्रिन 5% WP @ 21.25 g a.i./ हेक्टेयर के उपयोग के पश्चात प्राप्त हुई जिसका प्राकृतिक शत्रुओं जैसे लेडी बर्ड बीटल और मकड़ी की संख्या पर कोई प्रतिकूल प्रभाव नहीं देखा गया ।

CHAPTER- I
INTRODUCTION

Originated from Mexico, Southern Peru and Bolivia (Villalon 1981), Chilli got introduced to India for the first time from Brazil by the Portuguese towards the end of fifteenth century. Its cultivation became popular in the seventeenth century and since then, it has gained importance as a marked spice and vegetable crop which became a necessary ingredient in many cuisines (Greenleaf, 1986).

Throughout tropical and warm- temperate regions of the world, "Chilli (*Capsicum annuum* L.)" is known for being one of the most important crops grown as "vegetable and commercial spice crop". This spice crop is of great significance preferred for its fruits as it is used in "green as well as ripe dried form". Chilli peppers are valued for their sensory attributes of pungency, flavour and colour which confers them as one of the most the popular spices in many parts of the world (Pino *et al.* 2007). In curry, chilli is used as a paste, powder, broken split or whole form. The chilli pepper pods, which are berries, are used either fresh or in the processed form, such as dried, whole, frozen, canned and as value added products like chilli powder, oleoresin, capsanthin, chilli paste, chilli sauce and chilli oil.

Chillies are a part of human diet and are rich in vitamins, especially vitamin 'A' and 'C'. Besides traditional use of chilli such as vegetables, spices, condiments, sauces and pickles, it is also being used in pharmaceuticals, cosmetics and beverages (Tiwari *et al.*, 2005). "Green chillies per 100 gm of edible portion has a moisture content of 85.7 gm, protein 2.9 gm, fat 0.6 gm and minerals 1.0 gm" (Das, 2001). The intensity of red colour of chillies is primarily due to the presence of two pigments namely "capsanthin and its isomer capsorubin". Pungency is due to capsaicin which also posseses anti-cancerous properties. This is a key element for making drugs for heart diseases and pain relieving balm. Chillies are powerful anti-oxidant and anti-inflammatory agents. Herbalists have promoted peppers for their health enhancing effects such as "clearing the lungs and sinuses, protecting the stomach by increasing flow of digestive juices, triggering the brain to release endomorphins (natural painkillers) and protecting the body against cancer through antioxidant activity.” Chilli has a very beneficial effect on the circulatory system. It counteracts cholesterol build up and reduces platelet aggregation, thereby reducing the risk of heart attack.

The genus and family to which chilli belongs are *Capsicum* and Solanaceae, respectively. Mainly five among the *Capsicum* spp. are cultivated which includes “*C. annuum*, *C. baccatum*, *C. chinense*, *C. frutescens*, and *C. pubescens*.” *C. annuum* L. is the most widely cultivated species all over the world for its pungent (Chilli syn. Hot pepper) and non-pungent (Sweet pepper) fruits. “Chilli plant is an herbaceous, annual crop, having a basal and terminal gathering of leaves. The leaves are found alternate to opposed (interchange at base of the plant and restricted towards the inflorescence). The leaves are weathered, herbaceous, and are generally highly petiolate or sub sessile and rarely sessile type. Some chilli variety found that the leaves are reticulated venation and absent a basal meristem. The blossoms are hermaphrodite’s type. The flowers can be single or gathered into terminal, cymose or axillary inflorescences. The flowers are typically actinomorphic.The single flowers are off-white, greyish (in sometimes purplish) color shade while the stem isdensely branched and up to 60 cm (24 inch) tall. Root system of chilli plant is restricted to upper soil layer of 30cm depth. Root is highly branched with a tap root at centre. Root system resembles that of grasses. Chilli plants withstand drought better than excess soil moisture. The flowers of chilli crop are separatedperianth with a corolla and calyx (with five petals and five sepals, respectively) anandroecium have five stamens found and two carpels which forming a gynoecium witha superior ovary (Patel *et al*., 2001). Stamens are epipetalous and present in multiplesof four or five. They commonly have a hypogynous disk. The fruit is a berry and it may be yellow, green or red when ripe.”

India is the second largest producer of chillies in the world at present and about one fourth of the world’s chilli production is being contributed by India. World‘s hottest chilli (Bhut Jolokia) is cultivated in hilly terrains of Assam in a small town Tezpur, India (Purkayastha 2012). In India, chilli is grown in 2, 87,050 ha area with a production of 34,06,030 MT (Anonymous, 2017). Almost all the states in India grow this crop with Andhra Pradesh occupying the maximum acreage of agricultural land followed by Telangana, Karnataka, West Bengal, Gujarat and Maharashtra.

Chhattisgarh has an area of 37,320 ha under chilli crop with production of 2,68,440 MT (Anonymous, 2017). Chilli is grown in all part of Chhattisgarh during rainy, spring and summer season. Since it is grown throughout the year, there is carryover of insect pest from sowing to harvest and from one season to other. A pre- requisite for successful pest management is the knowledge of seasonal cycle of insect ecosystem. Insecticides are the major and indefensible component in the pest management system. Though it gives a quick satisfactory control but causes many undesirable effects like toxicity to crop plants, natural enemies and non-target species, environmental pollution, accumulation of toxic residues in soil and food matter and development of insect resistance. Further, resurgence of target pests following insecticidal application has become a wide spread phenomenon. The awareness for safer use of the pesticide has always been in the limelight. Information on the predator- parasite safety is scanty. Nearly twenty insect pests attack the crop out of which fruit borers *viz., Helicoverpa armigera* (Hübner) and *Spodoptera litura* (Fabricius) are notable and cause the maximum damage to chilli crop both during vegetative and fruit formation stages. The loss observed ranges from 10 to 30 per cent. Due to thrips, *Scirtothrips dorsalis* (Hood) and mites, *Polyphagotarsonemus latus* (Banks) attack, about 34 per cent yield loss has been reported. Chilli consumes the maximum cocktail of pesticides among all the vegetable crops. Repeated use of the same chemical may lead to development of resistance in insects. This puts forward a matter of concern for an urgent need to propose newer molecules for pest management.

Hence, keeping the above issues as the basis for the present study, the investigation was carried out with the following objectives:

1. Studies on the seasonal incidence of major insect pests on chilli crop.
2. Studies on the population dynamics of major insect pests on chilli crop.
3. Studies on the bio-efficacy of newer insecticides against sucking pests on chilli crop.

CHAPTER- II
REVIEW OF LITERATURE

The crop, Chilli has been studied by several experimenters for different facets of insect-pests of chilli and their control and management practices. Many literatures are available in India and abroad related to such studies. Reviews related to the current investigation entitled "Seasonal incidence, population dynamics and efficacy of different combination of insecticide against sucking pests of Chilli (*Capsicum annum* L.)" has been briefed under the following topics:

2.1 Studies on the seasonal incidence of major insect pests on chilli crop

Shrivastava *et al.* (1971) observed the infestation of aphids occurring on the crop during whole cropping season and their peak activity was noticed during second fortnight of January.

Baloch *et al.* (1994) observed the three species of insect pest *Bemasia tabaci, Scirtothrips dorsalis* and *Amrasca devastans* found to be associated with chilli during summer season of 1993.

Saha and Raychaudhary (1995) found that highest population of *Aphis gossypii* on chillies during the pre-flowering and flowering stage of the crop. During flowering stage the plant has greater concentration of nitrogen, sugar, lipid, and phenol content.

Kumar (1995) reported that crop loss caused by *Scirtothrips dorsalis* in field planting of chilli and sweet pepper from Karnataka and found more than 90 per cent yield reduction on chilli pepper compared to 11-12 per cent in sweet pepper because of thrips infestation, qualitative yield loss of 88-92 per cent was observed in sweet pepper.

Michal *et al.* (1996) mentioned that the highest predator population under 86 per cent RH.

Suresh *et al.* (1996) revealed that *A. gossypii* and *A. biguttula biguttula* were active on *Solanum melongena* throughout the crop period. The peak season of infestation by the above two pest was mid- February and last week of August, respectively.

Kulat (1999) reported that chilli crops being severely infested by *Aphis gossypii* during January-February 1999 and causing death of 20-25 per cent of plants around Nagpur District of Maharashtra.

Saha and Raychaudhari (1999) reported that chilli crop less infested with *Aphis gossypii* which has wide spectrum of natural enemies.

Singh (2001) reported that the four insect species *Scirtothrips dorsalis, Aphis gossypii, Helicoverpa armigera,* and *Spodoptera litura* were found to be infesting the chilli crop. *Scirtothrips dorsalis* and *Aphis gossypii* appeared in last week of October and reaching its peak at December. The incidence of leaf feeding, or *H. armigera* was recorded for November and reaching its peak at January. Among the natural enemies, *Coccinella rependa, Coccinella septum punctata, Chysoperla cornea, Brumus sp.* and spiders were recorded preying up on chilli thrips and aphids under Raipur condition.

Tripathi (2002) observed "three major insects i.e. thrips *(Scirtothrips dorsalis),* aphid *(Aphis gossypii)* and jassid *(Amrasca biguttula biguttula)* and three major predators- coccinella *(Menochilus sexmaculatus* and *Coccinella septum punctata),* syrphid *(Syrphus* spp.) and spiders to be associated with chilli crop. The populations build up of insect pest and their natural enemies initiated with increasing trend from September under Raipur condition."

Venzon *et al.* (2006) reported that the aphid infestation occurred on crop during the crop period and their peak activity was noticed during second fortnight of January.

Pandey *et al.* (2007) reported that the aphid infestation occurred on crop during the crop period and their peak activity was noticed during second fortnight of January.

Bhede *et al.* (2008) observed mite incidences being highest during 40^{th} meteorological week. During this time period, "the prevailing maximum-minimum temperatures, morning-evening relative humidities, rainfall and bright sunshine hours were 35.8^0C, 18.0^0C, 76 %, 34%, 0.00 mm and 11 h, respectively".

Sarkar *et al.* (2008) revealed that the aphid attack occurred on crop during the cropping season and their peak activity was noticed during second fortnight of January.

Patel *et al.* (2009) revealed incidence of thrips during September first week with peak period being November and March.

Roopa *et al.* (2009) reported the presence of mite, (*P. latus*) throughout the period of plant growth during summer on chilli. The peak population of mite was observed 6.34 per leaf which was noticed on 17th standard week (April 23-29), then declined sharply due to rain (19.2 mm) and attained second peak in short period *i.e.* on 20th standard week (May 14-20). The maximum mite population was reported in the 42nd standard week.

Barot *et al.* (2012) revealed that "the population dynamics of thrips, *Scirtothrips dorsalis* Hood at Main Vegetable Research Station, Anand Agricultural University,Anand (Gujarat) during the *Rabi* 2010-11. Thrips attack started from 1st week after transplanting *i.e.* last week of August (35th standard week) and remained in field till to the crop maturity (3rd week of February) in the range of 0.50 to 10.54 with an average of 4.37 thrips/twig. Thrips attained first (8.80 thrips/twig), second (5.66 thrips/twig) and third as well as the highest peak (10.54thrips/twig) during 2nd week of November, 3rd week of December and 3rd week of February, respectively."

Meena *et al.* (2013) observed that "the incidence of thrips (*Scirthothrips dorsalis* Hood), whitefly *(Bemisia tabaci* Genn), aphid (*Aphis gossypii* Glover) and mite *(Polyphagotarsonemus latus* Banks) appeared on the chilli crop soon after transplanting, while the aphid appeared little late during both the years. The peak population of thrips (14.5 and 14.7 per 3 leaves/ plant) was recorded in the first week of October, while the whitefly and aphid attained their peak in first and second week of September."

Rashid *et al.* (2013) reported that the thrips incidence was started on chilli crop soon after transplanting and peak incidence of thrips was found during last week of February.

Pathipati *et al.* (2014) reported that the infestation and severity of insect pests were highly influenced by weather parameters. Peak population of thrips was recorded during 52nd Standard Meteorological Week (1.80/leaf). Mite population steadily reached two peaks levels during 47th and 3rd SMW and over all its peak (16.0/leaf) was recorded in 3rd SMW in 2007-08 and in 52nd SMW (21.27/leaf).

Yadav (2016) Insect pest succession on chilli crop against thrips, *Scirtothrips dorsalis* (Hood) was studied during 2014-2015 at the Horticulture Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). Four insect species, *i.e.*, thrips (*Scirtothrips dorsalis*), aphid (*Aphis gossypii*), whitefly (*Bemisia tabaci*), fruit borer (*Helicoverpa armigera*) and mite (*Polyphagotarsonemus latus*) were observed during the course of the study. Most insects are active from vegetative to crop fruiting (February to June). The peak population of thrips (*Scirtothrip sdorsalis* Hood), whiteflies (*Bemisia tabaci* Genn) and fruit borer (*Helicoverpa armigera*) were observed on chilli crop from mid - April to mid - May with 45.86, 6.28 and 1.56 insect per plant.

G Venu *et al*. (2018) conducted field experiments during 2014-2015, to study the seasonal incidence and impact of weather parameters on chilli thrips. The results revealed that the infestation and severity of insect pests were highly influenced by weather parameters. Seasonal incidence of thrips was recorded from leaves and fruits at weekly intervals during the crop growth period. The population of thrips on leaves increased gradually from 43rdstd. week and attained a peak during January 3rd week (3rdstd. week) (99.86/terminal). The peak population (169 thrips/50 fruits) of thrips on fruits was observed on 4thstd.

2.2 Studies on the population dynamics of major insect pests on chilli crop

Borah and Langthasa (1995) studied on population dynamics in chilli. The crop was planted on 20th October 1992, showed minimum incidence of *Scirtothirps dorsalis* and highest yield of chilli.

Vardharajan and Veervel (1995) studied on seasonal dynamics of chilli pest, *Scirtothrips dorsalis* by monitoring the pest with yellow sticky trap at Annamalai Nagar. The occurrence of the pest was minimum during last week of July when the maximum temperature was 35°C and the rainfall was 44 mm and the peak occurrence was recorded during the first week of September when the maximum temperature was 35°C and there was no rainfall.

Marmat (2000) reported that aphid and jassid population significant negatively correlated with evening relative humidity. Jassid was first observed in the 3rd week of September and aphid was observed middle August to December.

Chatterjee (2004) revealed that yellow mite population was significantly correlated with temperature and did not vary significantly with relative humidity.

Debaraj and Singh (2004) recorded that the population variation of cabbage aphid in relation to abiotic and biotic factors at three different zones in Manipur showed that the aphids were prevalent from late autumn to late spring but less abundant during summer the peak population varied from one place to another. Maximum density of the pests were recorded at Mao (1257.67aphids/3 leaves) followed by Kangpokpi (1110.69 aphids/3 leaves) and imphal (345.56 aphids/3 leaves) during peak period.

Patil & Nandihalli (2019) stated that the seasonal fluctuation in the population of mite pests on aubergine (mahyco hybrid-10) and chilli (*Capsicum* sp.) (cv. ByadagiKaddi) was studied during the summer *Rabi* seasons at Garag & Narendra villages near Dharwad, Karnataka, India. Rainfall was highly detrimental and showed a highly significant negative correlation with the mite population. The age of the crop exhibited a significant negative association with *P. latus* population.

Patel *et al.* (2012) a study on population dynamics of thrips, *Scirtothrips dorsalis* Hood infesting chilli (cv. GVC 111) in relation to weather parameters was carried out at Main Vegetable Research Station, Anand Agricultural University, Anand (Gujarat) during the *Rabi* 2010- 11. The infestation of thrips started from 1st week after transplanting *i.e.* last week of August (35th standard week) and remained in field till to the crop maturity (3rd week of February) in the range of 0.50 to 10.54 with an average of 4.37 thrips/twig. Thrips attained first (8.80 thrips/twig), second (5.66 thrips/twig) and third as well as the highest peak (10.54 thrips/twig) during 2nd week of November, 3rd week of December and 3rd week of February, respectively. Correlation coefficient values worked out for thrips incidence and weather parameters revealed that significant positive relationship existed with Bright Sun Shine Hours, Maximum Temperature and Vapour Pressure Deficit (morning, afternoon and mean), whereas significant negative correlation was found with Minimum Temperature, Relative Humidity (morning, afternoon and mean), Vapour Pressure (morning, afternoon and mean) and rainfall.

Roopa and Kumar (2014) studied the seasonal incidence of thrips on *Capsicum* at Karnataka during 2012 and result revealed that *Scirtothrips dorsalis* Hood was observed throughout the cropping season with varying intensity ranging from 0.07 to 5.88 with a mean of 3.53 thrips per top three leaves per plant. The infestation of thrips, was initiated in the third week of September and remained continue upto fourth week of December. The data on correlation between incidence of thrips and weather parameters showed significant relationship. A negative relationship was observed with maximum temperature (-0.76), minimum temperature (-0.47), morning relative humidity (-0.24) and sunshine hours (-0.13), while, positive correlation was observed with the rainfall (0.24) and evening relative humidity (0.47).

Saini *et al*. (2015) study was done on population dynamics of sucking insect pests of chilli at Horticulture farm, RCA, Udaipur. Pests *viz.,*thrips (*Scirtothrips dorsalis* Hood); whitefly (*Bemisia tabaci* Genn.) and jassids (*Amrasca biguttula biguttula* Ishida) were three pests recorded. Occurrence of whitefly was found in last week of July, while that of thrips and jassids in second week of August. Thrips reached the peak during the third week of September (10.2/ 3 leaves). While, whitefly and jassid touched peak in second week of September (6.8 whiteflies and 5.4 jassids/ 3 leaves, respectively). There was a negative non-significant correlation between Thrips and temperature and rainfall, while positive with relative humidity. There was positive and non-significant correlation by Whitefly with temperature, relative humidity and rainfall.

Zainab *et al.* (2016) studied bio-efficacy of new pesticides at various test concentrations in case of chilli thrips, *Scirtothrips dorsalis.* The highest incidence was observed on first week of October. There was significant positive correlation between thrips and temperature and had negative with rainfall, relative humidity.

Samanta *et al.* (2017) study was done to test frequency of yellow mite and thrips against their natural enemies. Results showed positively correlation between population fluctuation of yellow mite, thrips and spiders to that with mean temperature and had negative correlation with total rainfall. Other abiotic factors (mean relative humidity, wind speed and bright sunshine) showed non-significant correlation with the incidence of yellow mite, thrips and spider population.

Rajput *et al.* (2017) study was done to know the population dynamics of major insect pests against chilli (*Capsicum annum* L.). Results found were that thrips showed highly significant negative correlation with evening relative humidity while significant positive correlation with maximum temperature. While in case of leafhopper population positive significant correlation was found with minimum temperature. The significant and positive correlation was found between yellow mite and maximum temperature while, significant negative with evening relative humidity. Highly significant and negative correlation was found between fruit borer and morning and evening relative.

Havanoor *et al.* (2018) concluded from his experiment that significant positive correlation was found between thrips and maximum temperature whereas, negative non-significant correlation with minimum relative humidity, rainfall, , maximum relative humidity and minimum temperature. Negative correlation was found by Mites with maximum temperature while, positive with minimum temperature, rainfall and positive and significant with maximum relative humidity. Whereas, aphid population showed no significant impact.

2.3 Studies on the bio-efficacy of newer insecticides against sucking pests on chilli crop

Kumar *et al.* (2001) study was done to analyse the efficacy of acephate at 1000 and 1500 g/ha, triazophos at 350 and 700 g/ha, imidacloprid at 50 and 70 g/ha and cypermethrin at 150 and 300 g/ha against the different pests of chilli. Results showed that imidacloprid (70g/ha) was found to be the best treatment against aphid (99.72% reduction). Acephate (1500 g/ha) against thrip (87.32% reduction).

Kadam and Dethe (2002) analysed fipronil formulations for controlling thrips damaging chilli and concluded that four sprays of fipronil 5 SC could control its infestation when applied at an interval of 15 days starting from 30 days after transplanting.

Patil *et al.* (2002) analysed efficiency of imidacloprid 17.8SL in controlling sucking pest complex of chilli. Results were that Imidacloprid was found to control against these pests when applied at 125 and 150 ml/ha and were found better than dimethoate and monocrotophos. Imidacloprid at a dose of 150ml/ha gave highest yield and reduction in yield was found with the application of imidacloprid at 125 and 100 ml/ha, dimethoate 750 ml/ha and monocrotophos 650 ml/ha.

Targe and Kurtadikar (2003) investigated the efficacy of newly developed pesticides against thrips and aphid at Marathwada Agricultural University, Parbhani. Imidacloprid 17.8 SL @ 112 ml/ha showed best results in controlling these pests populations and was found at par with UPI 301 @ 1250 g/ha. There was significant difference found in yield of green chilli in respect of different treatments.

Jadhav *et al.* (2004) analysed efficiency of fipronil 5% in controlling the infestation of sucking pest on chilli. Results showed that fipronil 5% SC @ 100g.a.i./ha delivered lowest population of sucking pests with highest yield.

Tatagar (2004) analysed his experiment by taking three different doses of vertimec 1.9 EC at 0.57 ml/L, 1.21 ml/L and 2.23 ml/L for three years and found that among these different dosages, Vertimec 1.9 EC @ 0.56 ml/L was best for the control of thrips at a concentration of 0.48 LC/plant and recommended in comparision of its higher dosages.

Jain and Ameta (2006) analysed the imidacloprid (confidor-200 SL) and beatacyfluthrin (bulldock- 0.25 SC)for contrilling sucking insect pests of chilli like thrips, whitefly and fruit borer. Conclusion found was that imidacloprid was best in control of sucking pest whereas betafluthrin was best for contrilling fruit borer. Combination of two sprays of confidor @ 200 ml/ha and later one spray of betafluthrin @ 750 ml/ha as found best for management of these pests.

Nagaraj *et al.* after analysis confirmed that thiomethaxam 25 WG (2.94 thrips/leaf and 1.67 damage) was best in controlling mean thrips population and leaf curl index, slightly lesser best results were found for imidacloprid (3.1 thrips/leaf and 1.45 damage) followed by thiacloprid 21.72 SC (3 thrips/leaf and 1.54 damage) and clothianidin 50 WG (3.24 thrips/leaf and 1.5 damage). whereas an increase in thrip population was found in the application of acetamipirid 20 SP (3.9 thrips/leaf and 2.93 damage), which increased consecutively with the application of spinosad 45 SC (4.24 thrips/leaf and 3.1 LCI) and oxydemeton methyl 25 EC (4.21 thrips/leaf and 3.2 LCI).

Shahaji (2007) analysed nine pesticidal treatments *viz.*,, thimethoxam 0.002%, abamectin 0.0009%, fipronil 0.01%, profenofos 0.10%,acephate 0.11%, imidacloprid 0.05%, fenazaquin 0.05%, propargite 0.02% and spinosad 0.003% against chilli thrips and mite. Results showed that fipronil 0.01% was most effective against chilli thrips. while vertimec 0.0009% was best for controlling chilli mite.

Reddy (2009) phytotoxicity of new formulation was evaluated for insecticides against chilli thrips . Fipronil 80 WG @ 50 g a.i/ha controlled thrips best compared to that of different dosage of Regent 5% SC @ 40g a.i/ha, fipronil 80 WG @ 40 g a.i/ha, and acephate 75% sp @ 468.75 g a.i/ha, whereas confidor 200 SL was least effective.

Ditya *et al.* (2010) stated chlorfenapyr is a pyrrole group of insecticides and could be used as broad spectrum insecticide cum acaricide against the control of whiteflies, aphids, thrips, mites, caterpillars, leaf miners, etc.

Mandal (2012) analysed the difentheuron (Pegasus 50 WP @ 1 g/L) with the later use of acetamiprid (Ekka 20 SP @ 1 g/L) at 10 days interval 30 days after date of transplanting of crop, and the treatment was found to be superior over all other packages in regards of contrilling thrips population count (1.86/leaf).

Das (2013) under his evaluation study of imidacloprid found its good knock down effect on aphid's population.

Sreenivas *et al.* (2013) stated that Spinetoram 12% SC @ 56 g.a.i ha^{-1} showed optimum effect against thrips (4.52 leaf^{-1}), *Spodoptera litura* (2.17 basin^{-1}) and *Helicoverpa armigera* (1.02 plant^{-1}) when applied at 10 days interval and found the highest green chilli yield of 165.4 q ha^{-1}.

Varghese and Mathew (2013) found reduced population of chilli mites after application of spiromesifen 45 SC at 100 g a.i. ha^{-1} and propargite 57 EC at 570 g a.i. ha^{-1} acetamiprid 20 SP @ 20 g a.i. ha^{-1} .

Vanisree *et al.* (2013) observed effect of spinosad @ 0.015 per cent against *S.dorsalis*as was found to show best results in control as well as for yield enhancement. It also showed best cost benefit ratio compared to that of diafenthiuron @ 0.045%, flubendiamide @ 0.012 %. fipronil @ 0.01%. Indoxacarb @ 0.015 % and pymetrozine @ 0.02% . Further flubendiamide showed poor efficacy against *S.dorsalis*on chillies.

Jadhav *et al.* (2015) observed best results by the use of fipronil 5 SC @ 0.005% against thrips population (57.3%) and gave high green chilli yield (9.98 t/ha) while slightly better results were found by the use of lambda cyhalothrin 5 EC @0.005%, spinosad 45 SC @ 0.018% and clothianidin 50 WP g @ 0.006% .

Kumar *et al.* (2015) analysed different insecticides and found that spirotetramat 120 + imidacloprid 120-240 SC @ 90 g + 90 g a.i./ha showed best results in control of thrips, whiteflies, aphids, jassids, and mites at its application of 5 and 10 days interval after each spray. It also gave the highest marketable yield of 133.07 q/ha.

Samota *et al.* (2017) analysed “efficiency of newly developed insecticides and biopesticides against thrips, *Scirtothrips dorsalis* Hood on chilli”. 11 treatments along with control were analysed to test the efficacy. The order of effectiveness found was acetamiprid>thiamethoxam>imidacloprid>fipronil> standard check >spinosad> NSKE >*B. bassiana*>*M. anisopliae*.

Sathyan *et al.* (2017) showed that fipronil 5 SC @ 0.15%, imidacloprid 17.8 SL @ 0.02%, tolfenpyrad 15 EC @ 0.1% and diafenthiuron 50WP @ 0.12%. the insecticides dimethoate 30 EC @ 0.15%, acetamiprid 20 SP @ 0.02% and thiacloprid 21.7 SC @ 0.1% found to control thrips population. of rose as compared to thiamethoxam 25 WG @ 0.02%, chlorpyriphos 20 EC @ 0.25% and chlorfenapyr 10 SC @ 0.1%. the maximum percent reduction over untreated check was obtained from fipronil 5 SC (82.35%), imidacloprid 17.8 SL (78.55%), tolfenpyrad 15 EC (73.52%) and diafenthiuron 50 WP (72.95%).

Samanta *et al.* (2017) analysed that diafenthiuron 50 WP @ 375 g a.i. ha^{-1} ,fenpyroximate 5 SC @ 25 g a.i. ha^{-1}and spiromesifen 24SC @ 120 g a.i. ha^{-1} controlled yellow mite optimally among different treatments studied. while diafenthiuron 50 WP @ 375 g a.i. ha-1, chlorfenapyr 10 SC @ 75 g a.i. ha^{-1}, and spiromesifen 24 SC @ 120 g a.i. ha^{-1} were found to be lesser effective against thrips. Diafenthiuron 50 WP @ 375 g a.i. ha^{-1} (17.64 q ha^{-1}) showed Highest fruit yield and slight less yield was found by the use of spiromesifen 24 SC @ 120 g a.i. ha^{-1} (16.05 q ha^{-1}).

CHAPTER - III
METHODS AND MATERIALS

In this chapter a brief description of methods and materials adopted during the course of investigation are discussed. The current study entitled "Seasonal incidence, population dynamics and efficacy of different combination of insecticide against sucking pests of Chilli (*Capsicum annum* L.)" was conducted during *Rabi* season, 2018.

3.1 Location of experimental site

The field experiment was carried out at the Horticulture Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh during *Rabi* season of 2018.

3.2 Geographical situation

Raipur, is situated in the central- eastern part of Chhattisgarh at 22°33' N to 21°14' N latitude and 82°6' to 81°38' E longitude and at an altitude of 298.15 meters from mean sea level.

3.3 Climatic condition

Raipur, the capital of Chhattisgarh state, comes under the seventh agro climatic region of India *i.e.* eastern plateau and hills. Raipur has a tropical wet and dry climate, temperature remains moderate throughout the year, except from March to June, which can be extremely hot. Sometimes temperature in April-May rises above 48°C (118 °F). The climatic condition is dry sub-humid with normal rainfall of 1300 mm per annum (51 inch), mostly during the monsoon season from late June to early October. The source of rainfall is South-western monsoon. This region receives 1200-1400 mm rainfall annually, of which nearly 75-80 per cent is received during the rainy season (June to September) and the rest 20-25 per cent is received during winter season (October to February).

January is the coolest and May is the hottest month. The minimum and maximum temperature ranged from 20.4 to 31.4˚C and 29.6 to 43.7˚C, respectively. The relative humidity is high from June to October varying from 70 to 90 per cent and wind velocity is high from May to August with its peak in June-July months.

3.3.1 Weather conditions during the cropping period

The meteorological data of temperature, rainfall, relative humidity and wind velocity during cropping period *i.e.* (November 2018 to May 2019) is presented in table 3.1.

The crop received 4.47mm of rainfall during the entire cropping period. The maximum temperature during this period varied between 22.1˚C in the third week of December and 44.2˚C in last week of May, whereas, minimum temperature varied between 8.5˚C in the first week of January and 29.4˚C in the third week of May.

Relative humidity throughout the cropping season varied between 40 to 90 per cent in the morning and 12 to 57 per cent in the evening.

3.4 Cultural operations

3.4.1 Field preparation

For obtaining good tilt and growth of crop, the field was prepared by cross ploughing methods through tractor drawn cultivator followed by harrowing and planking. After that to get weed free and stubble-free seed bed, weeds and crop residues were removed.

3.4.2 Transplanting

35 to 45 days (13/11/18) after sowing, the seedlings were transplanted in rows 60 cm apart. Spacing between the plants was kept 60 cm.

3.4.3 Fertilizer

The recommended dose of fertilizer i.e. 100:50:50 kg N, P, K per hectare was applied to the crop. Half dose of nitrogen and full dose of phosphorus and potash were applied to the crop. Remaining nitrogen was applied as top dressing.

3.4.4 Weed control

One time of hoeing and two times manual weeding was done. For raising a healthy crop, recommended package of practices was followed.

3.4.5 Irrigation

Crop was irrigated by plot to plot system as per requirement of the crop.

Table 3.1: Weekly meteorological data during crop growth period from November to May, 2018-2019

			Temperature(°C)			Relative Humidity			
SMW	**Month**	**Date**	**Maximum**	**Minimum**	**Rainfall (MM)**	**RH I (%)**	**RH II (%)**	**Wind Velocity(Kmph)**	**Sun Shine (hours)**
46	November	Nov 12-18	31.5	14.4	0.0	86	29	1.1	9.1
47		Nov 19-25	31.4	15.3	0.0	88	28	1.1	7.8
48		Nov 26-02	29.3	13.6	0.0	89	33	1.0	7.5
49	December	Dec 03-09	28.2	14.3	0.0	87	38	0.9	4.4
50		Dec 10-16	27.4	15.7	0.0	86	51	1.0	1.2
51		Dec 17-23	22.1	11.0	47.2	90	57	3.1	4.5
52		Dec 24-31	25.1	8.6	0.0	86	28	1.3	7.5
1	January	Jan 01-07	27.4	8.5	0.0	88	28	0.7	6.6
2		Jan 08-14	27.1	10.2	0.0	87	34	0.9	6.1
3		Jan 15-21	28.1	9.2	0.0	85	21	0.9	6.8
4		Jan 22-28	26.3	14.3	23.6	85	53	2.0	4.0
5		Jan 29-04	26.4	9.5	0.0	87	24	1.3	8.2
6	February	Feb 05-11	28.8	12.5	3.4	81	36	1.5	7.6
7		Feb 12-18	30.2	13.6	9.0	84	34	1.8	8.3
8		Feb 19-25	33.1	17.0	0.0	81	30	1.7	9.1
9		Feb 26-04	31.0	17.3	0.2	72	36	2.4	7.8
10	March	Mar 05-11	33.3	17.6	0.0	70	32	8.3	8.9
11		Mar 12-18	35.6	21.6	0.0	72	33	3.2	6.8
12		Mar 19-25	34.5	19.8	9.2	80	28	2.4	8.4
13		Mar 26-01	38.2	20.6	10.8	64	19	2.0	8.7
14	April	Apr 02-08	39.7	23.4	0.0	50	18	3.4	8.3
15		Apr 09-15	40.8	24.5	0.0	47	20	4.3	8.3
16		Apr 16-22	38.0	24.1	11.2	61	27	4.3	9.0
17		Apr 23-29	42.0	26.3	0.0	45	15	2.9	10.1
18		Apr 30-06	40.8	26.2	10.6	60	26	4.1	8.2
19	May	May 07-13	40.7	26.8	0.0	42	12	2.6	9.3
20		May 14-20	42.8	27.5	0.0	40	15	3.4	10.3
21		May 21-27	44.2	29.4	0.0	41	18	5.1	9.8

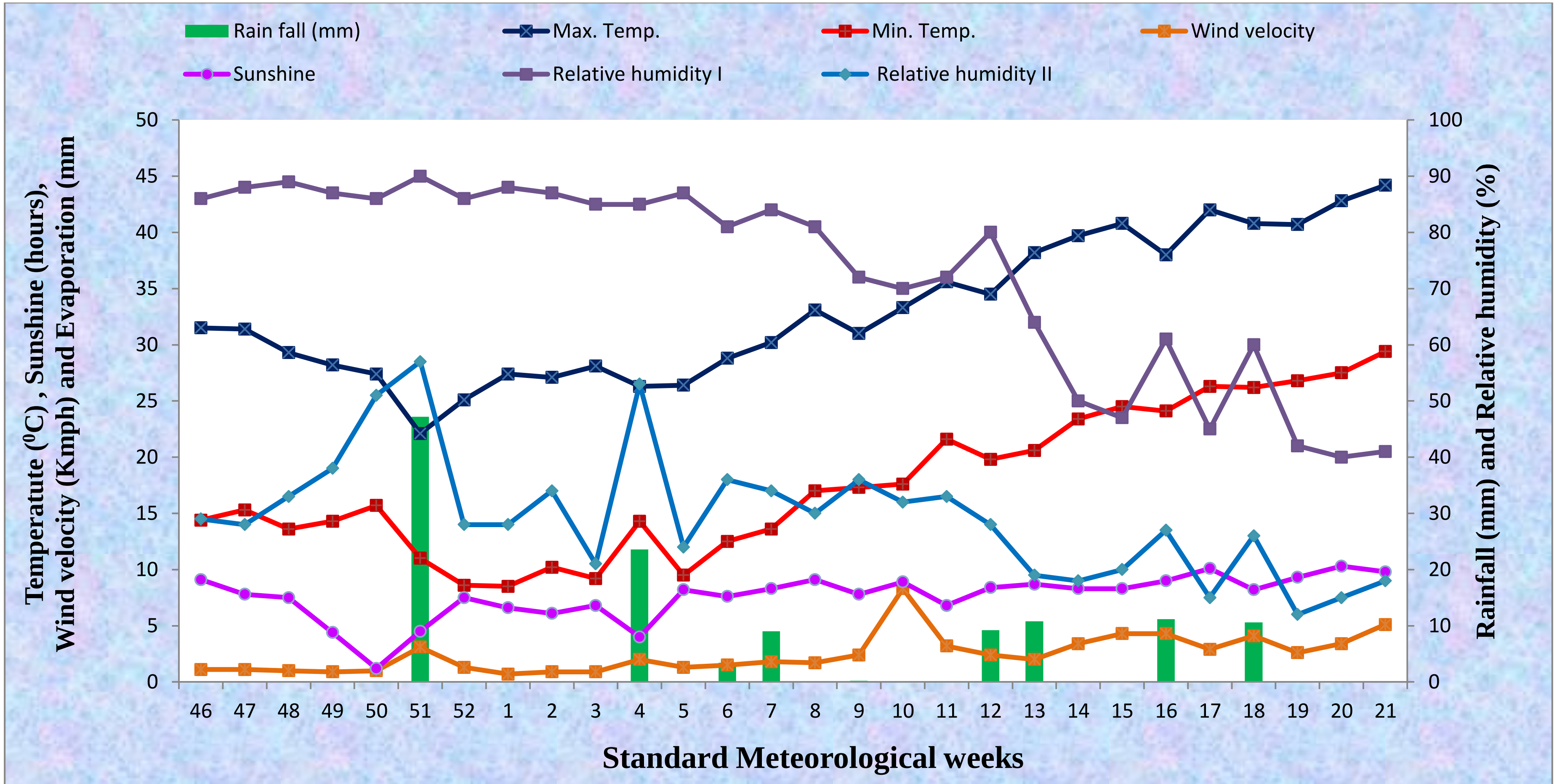


Fig.3.1 : Weekly meteorological data recorded during the crop growth (13th November, 2018 to 27th May, 2019)

3.5 Studies on the seasonal incidence of major insect pests on chilli crop

The studies were conducted to know the insect pests of chilli during the year 2018-19 at Horticulture Farm at IGKV, Raipur (C.G.) the popular chilli variety was sown during *Rabi* 2018 under natural conditions without spraying the insecticides in an area of 20m × 10m to record the incidence of insect pests.

3.5.1 Experimental details

Season	*Rabi* -2018
Variety	popular hybrid variety of C.G. (Shilpa)
Plant spacing	60 cm x 60 cm
Plot size	20 m x 10 m
No. of plants	25
Date of sowing	07-10-2018
Date of transplanting	13-11-2019

3.5.2 Method of observation

To determine the seasonal incidence of insect pests on chilli crop, weekly populations were recorded on randomly selected twenty five plants from four corners and center starting from 15 days after transplanting to the late stage of the cropping season. The population of sucking pests *viz.*, thrips, mite and aphids were recorded at weekly intervals during morning hours. The population of thrips were recorded by using a hard paper sheet (bond paper) of white colour A4 size (21 cm×30 cm) was placed under the plant. The topical portion of plant were gently shaken with hand, the insects populations fall down on the paper. The insects population on paper were counted with the help of 10X magnification power.

The population of mites and aphids were recorded by using 10X magnifying hand lens from three leaves per plant one each from the upper, middle, and lower position on five selected plants from each spots.

The population of leaf eating caterpillars/fruit borers were recorded from randomly selected five plants in each spots.

The population of natural enemies and their period of activity were recorded at weekly interval on randomly selected five plants in each spot.

Observation was recorded on the following parameters:-

- Appearance of insects.
- Stage of crop.
- Peak period of activity.
- Disappearance of insect.

3.6 Studies on the population dynamics of major insect pests on chilli crop

3.6.1 Experimental details

Season	*Rabi* -2018
Variety	popular hybrid variety of C.G.(Shilpa)
Plant spacing	60 cm x 60 cm
Plot size	20 m x 10 m
No. of plants	25
Date of sowing	07-10-2018
Date of transplanting	13-11-2019

3.6.2 Method of observation

To find out the incidence of major insect pests on chilli the observations were recorded at weekly interval on five randomly selected spots each consisting of five plants. The observations were recorded starting from one week after transplanting to till harvest of the crop. Effect of weather parameters on population dynamics of major insect pests of chilli-data on temperature (maximum, minimum), relative humidity (morning, evening) recorded at the meteorological observatory, college of Agriculture Raipur. Weather parameters, population of various insect pests *viz.*, thrips, aphids, mites and fruit borer was recorded at weekly interval and the simple correlation coefficient was work out.

3.6.3 Statistical analysis

The data was statistically analysed by subjecting to the correlation between weather parameters and the population of insect pests which were determined using the Karl Pearson's coefficient of correlation formula:

$$r = \frac{\sum XY - \frac{\sum X \sum Y}{N}}{\sqrt{\left(\sum X^2 - \frac{(\sum X)^2}{N}\right)\left(\sum Y^2 - \frac{(\sum Y)^2}{N}\right)}}$$

Where,

r_{xy} = Simple correlation coefficient

X = Variable *i.e*. abiotic component. (Average temperature, relative humidity and total rainfall)

Y = Variable *i.e.* mean number of insect pests per plant

N = Number of observations.

The correlation coefficient (r) values were subjected to the test of significance using t-test:

$$t = \frac{r_{xy}\sqrt{n-2}}{\sqrt{1-r_{xy}^2}} \quad \sim t \text{ n-2 d.f.}$$

Where,

r = Correlation Coefficient

n = No. of observations

The calculated t-value obtained was compared with correlation coefficient table at 5 % and 1% level of significance.

3.7 Studies on the bio-efficacy of newer insecticides against sucking pest on chilli crop

Among the five insecticides evaluated, for the management of sucking pests *viz., Scirtothrips dorsalis* Hood, *Polyphagotarsonemus latus* Bank and *Aphis gossypii*. The insecticides were applied through manually operated high volume Knapsack sprayer. The insecticides were applied at economic threshold level.

3.7.1 Experimental details

Season	*Rabi* 2018
Variety	Popular hybrid variety of C.G.(Shilpa)
Design	RBD
Replications	04
Plant spacing	60 cm x 60 cm
Plot size	4.5 m x 3 m
Treatment	6

Table 3.2 Treatment details

S.N.	Treatment	Dose (ml or g/ha)
1	Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP	129g/ha
2	Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP	188g/ha
3	Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP	250g/ha
4	Emamectin Benzoate 5% SG	200ml/ha
5	Lambda cyhalothrin 5% EC	300ml/ha
6	Control (Untreated)	-

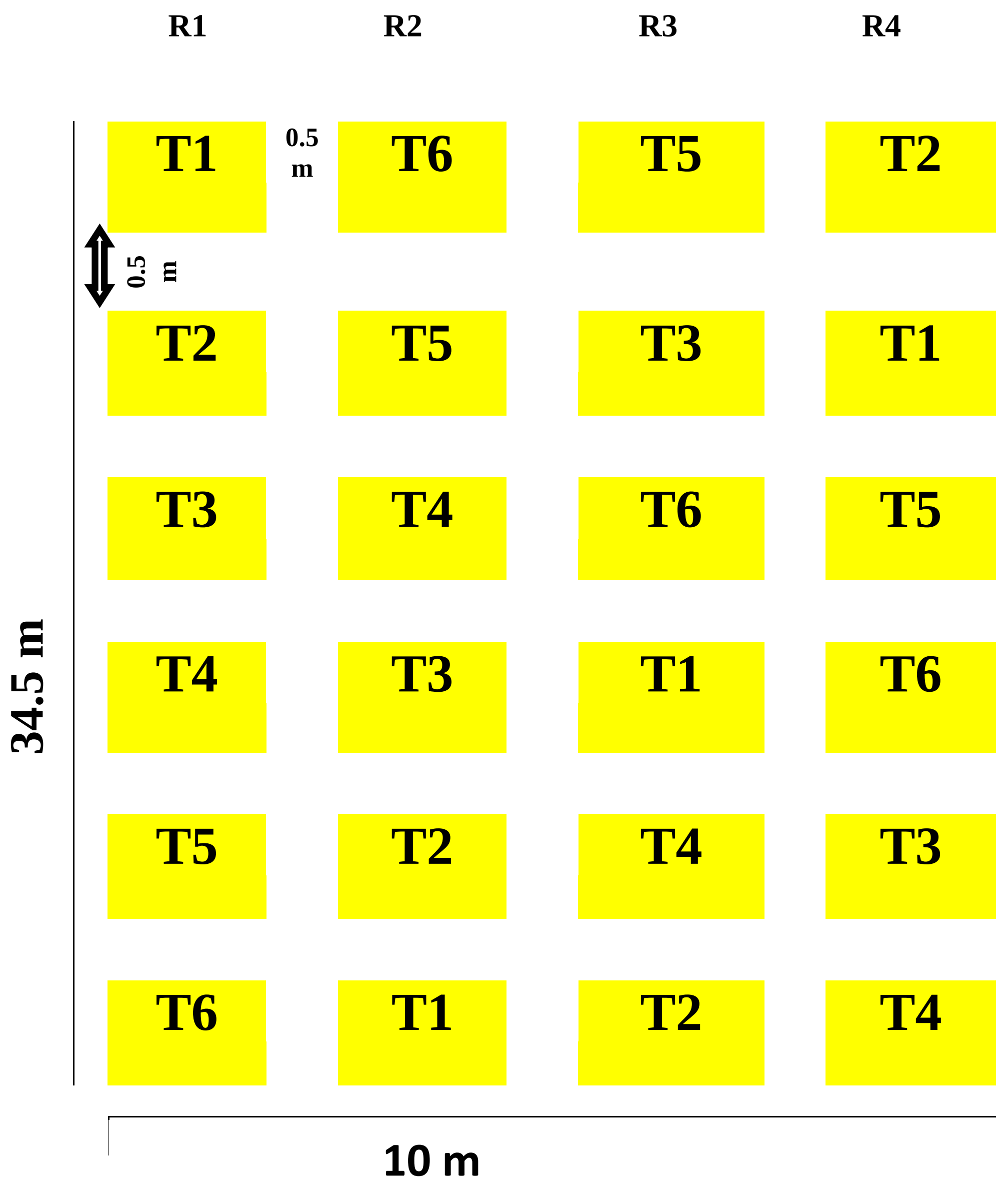


Fig. 3.2: Field layout of experimental block

3.7.2 Method of observations

The first spraying of insecticides was given as soon after an economic threshold level of thrips incidence was observed. Other spraying of insecticides if required was done at 15 days interval.

Bio-efficacy study

- Pre- treatment pest population - One day before spraying.
- Post - treatment pest population – 1 day, 3 days, 7 days, 10 days and 15 days after spraying.
- Number of plants selected - 5 plants/plot.

Observations recorded

In this experiment, major insect pests *viz.*, thrips (*Scirtothrips dorsalis*), aphid (*Aphis gossypii*), mite (*Polyphagotarsonemus latus*) were observed from each plot, 24 hours before 1st spraying of insecticides and the post treatment counts were taken on randomly selected five plants after 1, 3, 5, 7, 10 and 15 days of application. Similar observations were also being recorded after the second application of insecticides.

3.7.3 Statistical analysis

Conducted all the above three experiments in Randomized Block Design. The data obtained were transformed using square root transformation, by the formula (+ 0.5). This transformed data was then analyzed by the method of analysis of variance as described by Gomez and Gomez (1984). The "F" test was used at 5 per cent level of significance. Critical difference (CD) values were analyzed at 5 per cent level of significance. The skeleton of analysis of variance and formula used for various estimations are given in table 3.5.

Table 3.3: The skeleton of analysis of variance for efficacy of insecticides

Source of Variation	df	SS	MSS	Fcal	Ftab	S.Em±	CD (5%)
Replication (R)	(R – 1)						
Treatment (T)	(T – 1)						
Error (E)	(R – 1) (T – 1)						
Total	RT – 1						

The following formulae were used for the estimation of standard error, critical difference and coefficient of variance:

a. $\text{S.Em}\pm = \sqrt{\frac{EMS}{R}}$

b. $\text{C.D.} \;=\; \sqrt{\frac{2\ \text{EMS}}{\text{R}}}\quad (\text{at } 5\%\ \text{d.f.})$

c. $\text{C.V.}\,(\%) = \frac{\sqrt{\text{EMS}}}{\text{GM}} \times 100$

Where,

R = Number of replications,	df = Degree of freedom
T = Number of treatments,	S.S. = Sum of square
C.D. = Critical difference,	C.V. = Coefficient of variance
M.S.S = Mean sum of squares,	E.M.S. = Error mean square
S.Em ± = Standard error of mean,	G.M. = Grand mean

3.8 To assess the benefit cost ratio

A ratio of less than one means a loss but a ratio of more than one indicates a profit and the economic viability of the treatment compared with the control treatment. Thus, cost: benefit ratio is an indicator of the relative economic performance of the treatments. For benefit cost analysis, record of costs incurred in each treatment and that of control was maintained. It is to be noted here that expenses incurred referred to those only on pest management *i.e.* cost of insecticides and labour charges for insecticide spraying. The price of the harvested yield of each treatment and that of control was also calculated at market rate. Thereafter, Benefit cost ratio (B: C ratio) was calculated.

B: C ratio= Adjusted net return(Rs/ ha)/ Cost of pest management(Rs/ha)

Cost of pest management (Rs/ ha) = Cost of insecticides+labour charges/ha

B: C ratio = Adjusted net return (Rs/ ha) = [Net return from individual treated plot (Rs/ ha) – Net return from untreated control plot (Rs/ ha)]

CHAPTER -IV
RESULTS AND DISCUSSION

The portion of the dissertation deals with the results and its related discussion with brief description of the findings obtained under various objectives under entitled, "Seasonal incidence, population dynamics and efficacy of different combination of insecticide against sucking pests of Chilli (*Capsicum annum* L.)". The present results have been compared with the previous findings of the relevant aspects in justified manner to draw an actual conclusion. The following sub headings of results and discussion are presented here:

4.1 Studies on the seasonal incidence of major insect pests on chilli crop.

4.2 Studies on the population dynamics of major insect pests on chilli crop.

4.3 Studies on the bio-efficacy of different combination of insecticides against sucking pests on chilli crop.

4.1 Studies on the seasonal incidence of major insect pests on chilli crop

The data of varied major insect pests and their natural enemies occurrence on chilli was noted on variety Shilpa during *Rabi* 2018, starting from 13th November to till maturity of crop growth period at weekly interval along with prevailing weather condition has been presented in table 3.1 and Fig.3.1

"Thrips (*Scirtothrips dorsalis*), mite (*Polyphagotarsonemus latus*), aphid (*Aphis gossypii*) and tobacco caterpillar (*Spodoptera litura*) and predators *viz.*, lady bird beetle (*Cheilomenes sexmaculata*), spider (*Oxyopes* sp.)" were inscribed at the time of crop growth period have been presented in table 4.1 and 4.2

The population of thrips and aphid were associated throughout period of crop growth whereas mite and tobacco caterpillar population was associated to the crop from stage of late vegetative to fruiting.

4.1.1 Sucking pest

4.1.1.1 Chilli thrips, *Scirtothrips dorsalis* (Hood)

The incidence of thrips (nymph and adult) first appeared in fourth week of November (48 SMW). Initially recorded on nymph and adult population of chilli thrips was 0.74 per plant. The highest population of thrips (22.2/plant) was observed at the time of first week of March (10 SMW), during this period, maximum temperature (33.3ºC) and minimum temperature (17.6ºC), morning (70%) and evening (32%) relative humidity, wind velocity (8.3 km/hours) and bright sunshine hours (8.9 hours) prevailed. After that gradually decreased the population of thrips, reaching to 7.89 thrips/plant at third week of May. The population of thrips ranged between 0.74 to 22.2/plant during November to May months and the seasonal mean was 11.67 (Table 4.1).

Rashid *et al.* (2013) had mentioned a report that the thrips showed their peak incidence during "last week of February". Patel *et al.* (2009) recorded thrips incidence from first week of September with peak in November and March. Bhede *et al.* (2008) reported the highest incidence of thrips in the 40th SMW.

4.1.1.2 Chilli mite, *Polyphagotarsonemus latus* (Bank)

The chilli mite incidence first appeared in last week of January (5 SMW). Initially the population of mite was 0.33 per plant. During the second week of April (15 SMW), mite population shooted to a peak level of 1.44 mite per plant. During this period, the maximum temperature was 40.8ºC and minimum temperature (24.5ºC), morning (47%) and evening (20%) relative humidity, wind velocity (4.3 km/hours) and bright sunshine hours (8.3 hours) prevailed. The seasonal mean was 0.40. Thereafter, the mite population was gradually declined and disappeared by third week of May. The population of mite ranged between 0.09 to 1.44 mite/plant.

Similar findings were obtained by Roopa *et al.* (2009) who reported the peak population of chilli mite *P. latus* 6.34 per leaf was noticed on 17th SMW (April 23-29), then declined sharply in 20th SMW (May 14-20).

4.1.1.3 Aphid, *Aphis gossypii*

The population of aphid nymph and adult was observed from initially vegetative stage to late fruiting stage. It was first appeared during last week of November (48 SMW). Initially, aphid nymph and adult population was 0.37/plant. Thereafter, population increased progressively up to first week of February (6

SMW); recorded highest population (18.97/plant), at the time maximum (28.8ºC) and minimum (12.5ºC) temperature, rainfall (3.4 mm), morning (81%) and evening (36%) relative humidity, wind velocity (1.5 km/hr) and bright sunshine hours (7.6 hours) were revealed. After that, there was decrease the density of aphid. Population of aphid 0.31/plant was recorded at last stage of crop and the seasonal mean was 4.38. Population of aphid ranged from 0.31 to 18.97/plant during November to May months (Table 4.1).

Shrivastava *et al.* (1971), Venzon *et al.* (2006), Pandey *et al.* (2007) and Sarkar *et al.* (2008) also revealed that the aphid infestation was seen on crop during whole cropping season and their peak activity was seen throughout second fortnight of January.

4.1.2 Defoliator

4.1.2.1 Tobacco caterpillar, *Spodoptera litura*

Tobacco caterpillar was first appeared during the first week of January with 0.26 mean population of larvae per plant. The density of pest gradually increased and achieved the peak in the last week of January (5 SMW) with 2.30 larvae per plant, at the time maximum (26.4ºC) and minimum (9.5ºC) temperature, rainfall (0.0mm), morning (87%) and evening (24%) relative humidity, wind velocity (1.3 km/hr) and bright sunshine hours (8.2 hours) were revealed with 0.58 seasonal mean. The population decreased slowly and completely disappeared during the third week of May. Population of caterpillar ranged from 0.12 to 2.30/plant during November to May months.

4.1.3 Natural enemies

The lady bird beetle (*Cheilomenes sexmaculata*) and spider (*Oxyopes* sp.) population observed in crop growth period from vegetative to fruiting stage. These natural enemies feed on aphid.

4.1.3.1 Lady bird beetle

Lady bird beetle population (0.7/plant) recorded first on the chilli crop at second week of November. Occurrence of lady bird beetle started from early vegetative stage to second last week of crop growth period. The highest population of lady bird beetle (4.9/plant) was noted during third week of April. The lowest lady bird beetle population (0.3/plant) during second week of February. The population of lady bird beetle ranged from 0.3 to 4.9/pant was during November to May month (Table 4.2).

4.1.3.2 Spider

The population of spider (0.81/plant) recorded first on the chilli crop at third week of November (47 SMW). Occurrence of spider started from early vegetative stage to second last week of crop growth period. The highest population of spider (3.21/plant) was recorded during first week of January (1 SMW). The lowest population of spider (0.21/plant) during first week of March. The population of spider ranged from 0.21 to 3.21/plant was during November to May month (Table 4.2).

Sardana (2006) revealed that coccinellids and predatory spiders were present right through the crop growth throughout September to mid- March. Whereas, Nonita *et al*. (2006) revealed that the aphid incidence was observed to be in progress throughout second week of April and first week of August. The coccinellids emerge during the first week of May in the field and sustained their activities awaiting the July end.

Table 4.1: Seasonal incidence of major insect pests on chilli crop at weekly interval, during the crop growth period (*Rabi* 2018-19)

SMW	Month and Date	No. of thrips/three leaves/plant	No. of mites/three leaves/plant	No. of aphids/three leaves/plant	Tobacco caterpillar(larvae/plant)
46	Nov 12-18	0	0	0	0
47	Nov 19-25	0	0	0	0
48	Nov 26-02	0.74	0	0.37	0
49	Dec 03-09	2.6	0	0.98	0
50	Dec 10-16	3.7	0	1.24	0
51	Dec 17-23	6.2	0	1.88	0
52	Dec 24-31	5.5	0	2.43	0
1	Jan 01-07	7.2	0	3.98	0.26
2	Jan 08-14	8.34	0	5.39	0.70
3	Jan 15-21	10.69	0	8.57	1.02
4	Jan 22-28	11.23	0	11.69	0.56
5	Jan 29-04	13.75	0.33	15.41	2.30
6	Feb 05-11	11.64	0.74	18.97	1.02
7	Feb 12-18	15.78	0.29	13.58	0.86
8	Feb 19-25	17.01	0.91	10.99	1.38
9	Feb 26-04	20.5	0.8	8.16	1.32
10	Mar 05-11	22.2	1.18	6.69	1.91
11	Mar 12-18	20.12	1.3	4.59	2.30
12	Mar 19-25	20.3	1.06	2.93	0.42
13	Mar 26-01	17.7	0.38	1.84	0.36
14	Apr 02-08	19.89	1.08	0.96	0.42
15	Apr 09-15	19.4	1.44	0.78	0.44
16	Apr 16-22	17.01	0.42	0.61	0.32
17	Apr 23-29	15.2	0.65	0.42	0.28
18	Apr 30-06	13.13	0.41	0.31	0.20
19	May 07-13	11.03	0.16	0	0.17
20	May 14-20	8.01	0.09	0	0.12
21	May 21-27	7.89	0	0	0.0
	Seasonal mean	**11.67**	**0.40**	**4.38**	**0.58**

Table 4.2: Natural enemies recorded at weekly interval during the crop growth period on chilli crop (*Rabi* 2018-19)

SMW	Month and date	Coccinellids/plant	Spiders/plant
46	Nov 12-18	0.7	0
47	Nov 19-25	1.4	0.81
48	Nov 26-02	1.9	1.73
49	Dec 03-09	2.7	1.62
50	Dec 10-16	2.9	1.51
51	Dec 17-23	3.2	1.81
52	Dec 24-31	3.9	2.23
1	Jan 01-07	4.4	3.21
2	Jan 08-14	4.2	2.32
3	Jan 15-21	2.3	2.01
4	Jan 22-28	1.3	1.62
5	Jan 29-04	0.5	1.13
6	Feb 05-11	0.4	0.91
7	Feb 12-18	0.3	0.82
8	Feb 19-25	0.39	0.34
9	Feb 26-04	0.5	0.41
10	Mar 05-11	0.7	0.21
11	Mar 12-18	0.9	0.52
12	Mar 19-25	1.5	1.21
13	Mar 26-01	2	1.23
14	Apr 02-08	3.3	1.61
15	Apr 09-15	3.9	2.5
16	Apr 16-22	4.9	2.2
17	Apr 23-29	3.9	2.1
18	Apr 30-06	2.9	1.62
19	May 07-13	1.6	1.23
20	May 14-20	0.61	0.54
21	May 21-27	0.4	0.3
	Seasonal mean	**2.06**	**1.35**

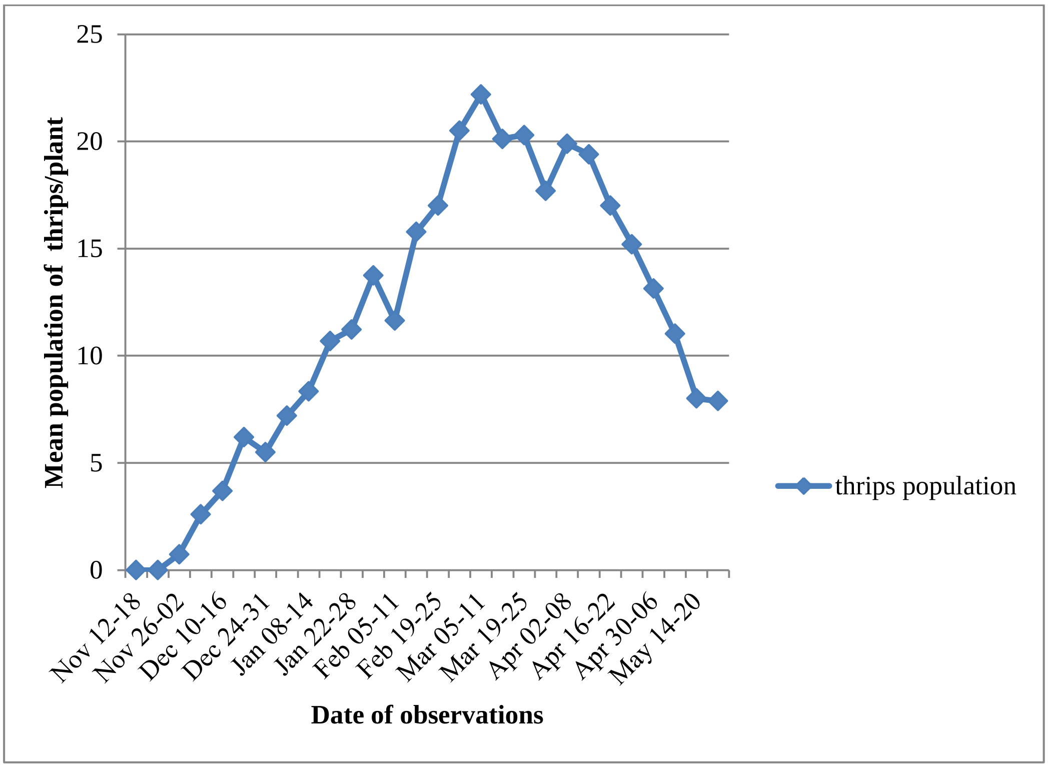


Fig.4.1: Mean population of thrips, *S. dorsalis* on chilli crop during *Rabi* 2018-19

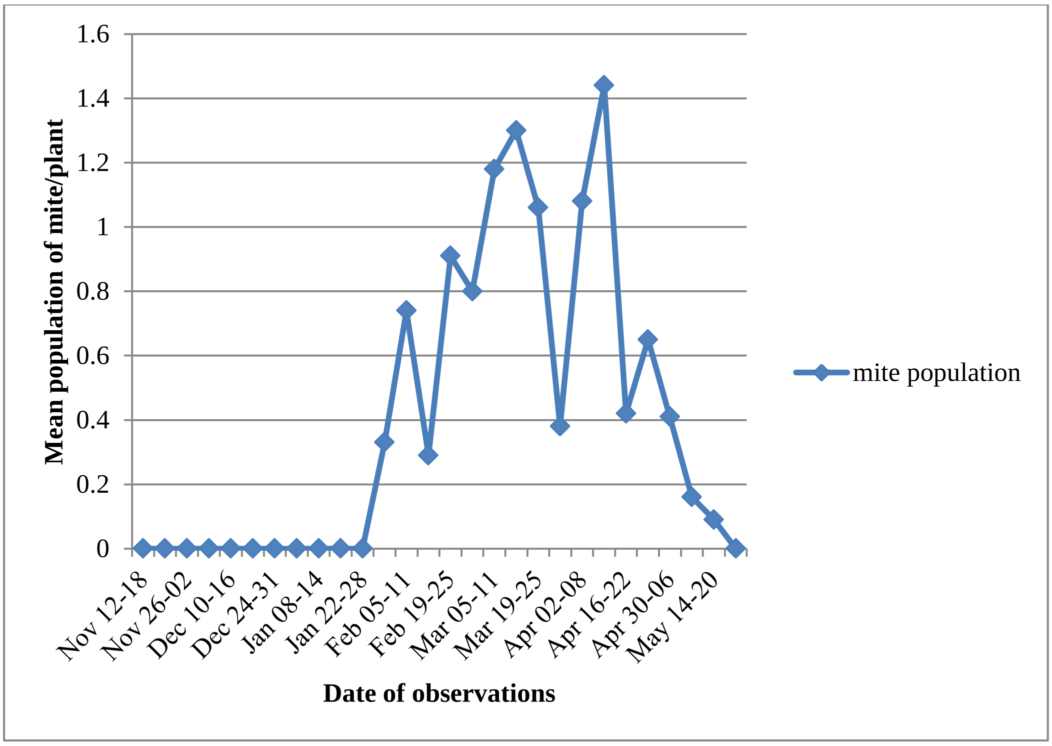


Fig.4.2: Mean population of mite, *P. latus* on chilli crop during *Rabi* 2018-19

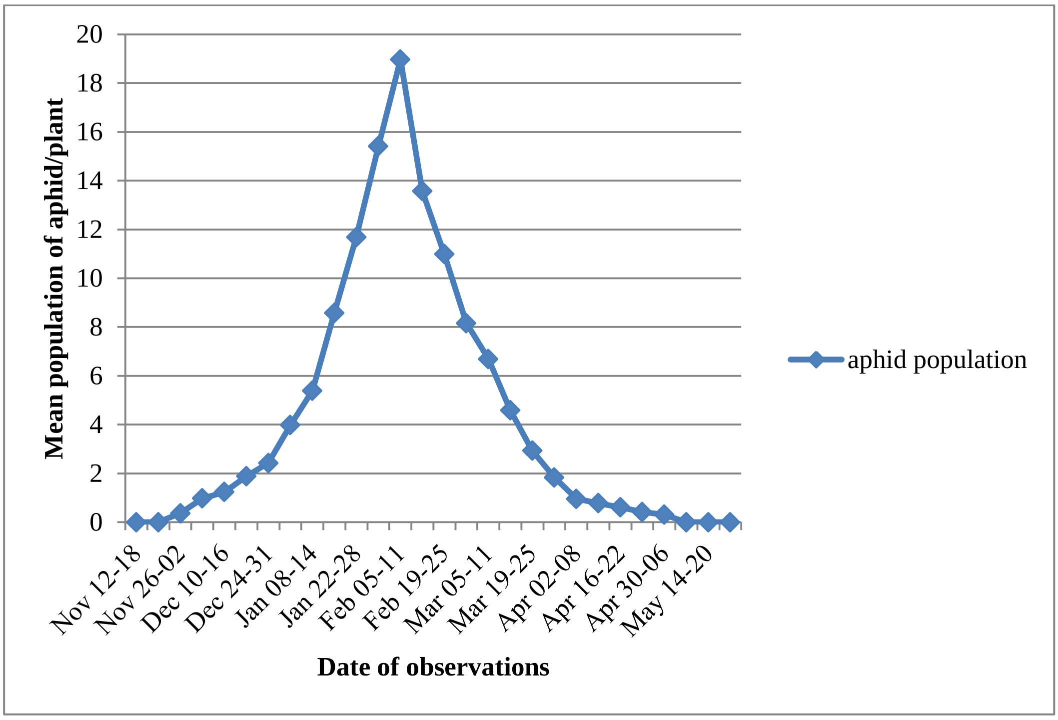


Fig.4.3: Mean population of aphids, *A. gossypii* on chilli crop during *Rabi* 2018-19

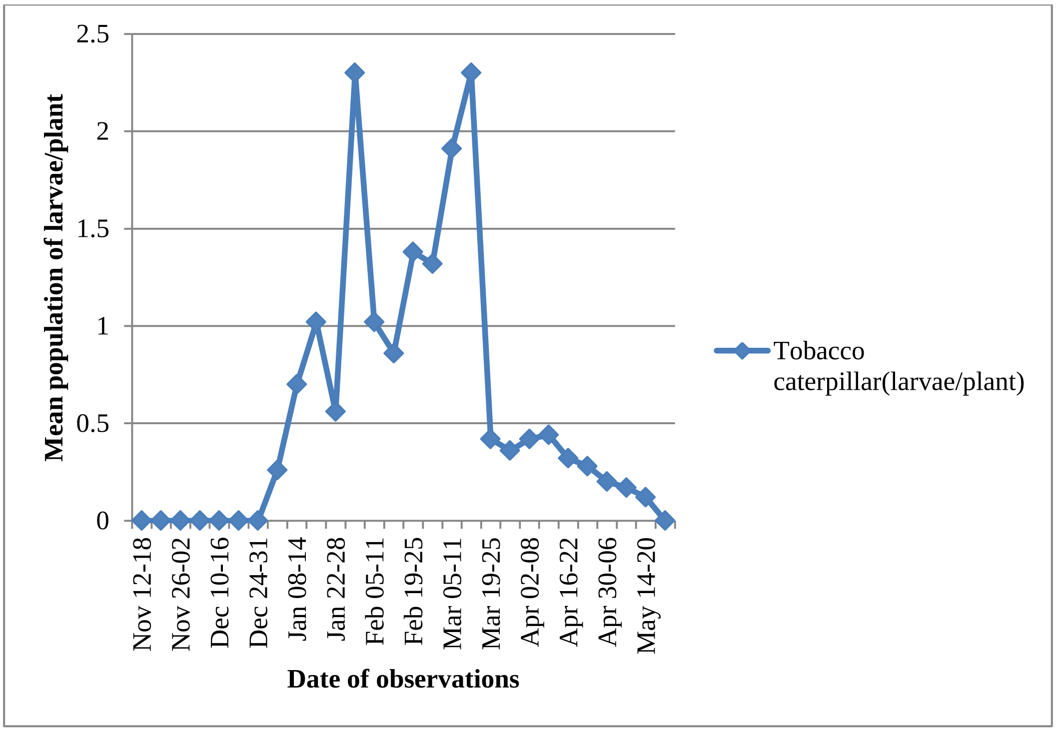


Fig. 4.4: Mean population of tobacco caterpillar, *S. litura* on chilli crop during *Rabi* 2018-19

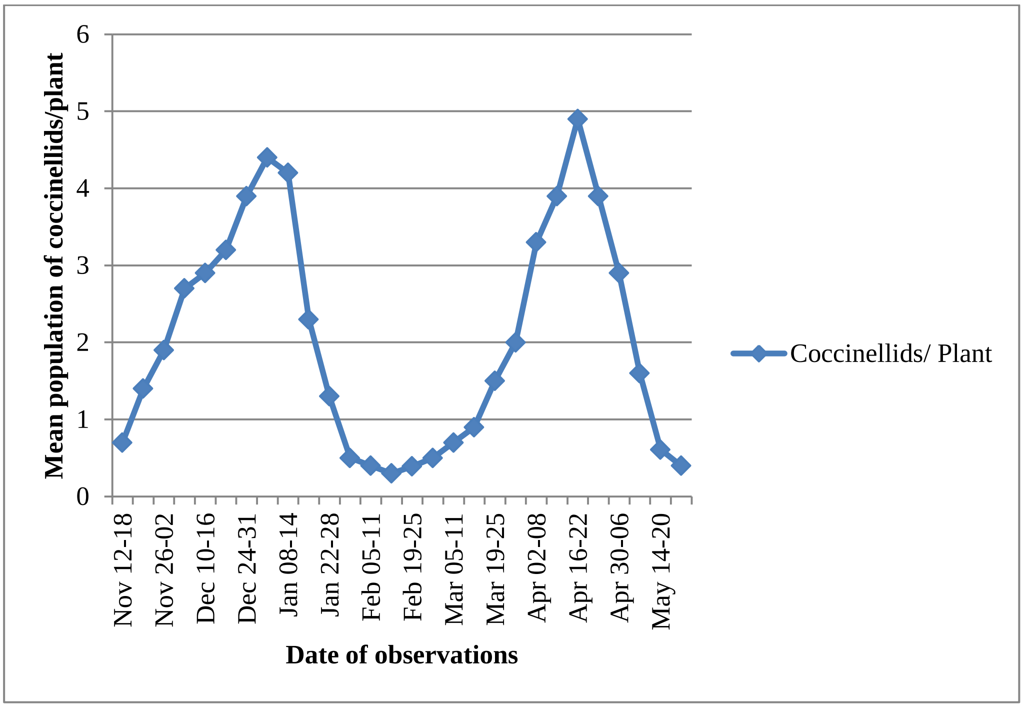


Fig.4.5: Mean population of Lady bird beetle, *C. sexmaculata* on chilli crop during *Rabi* 2018-19

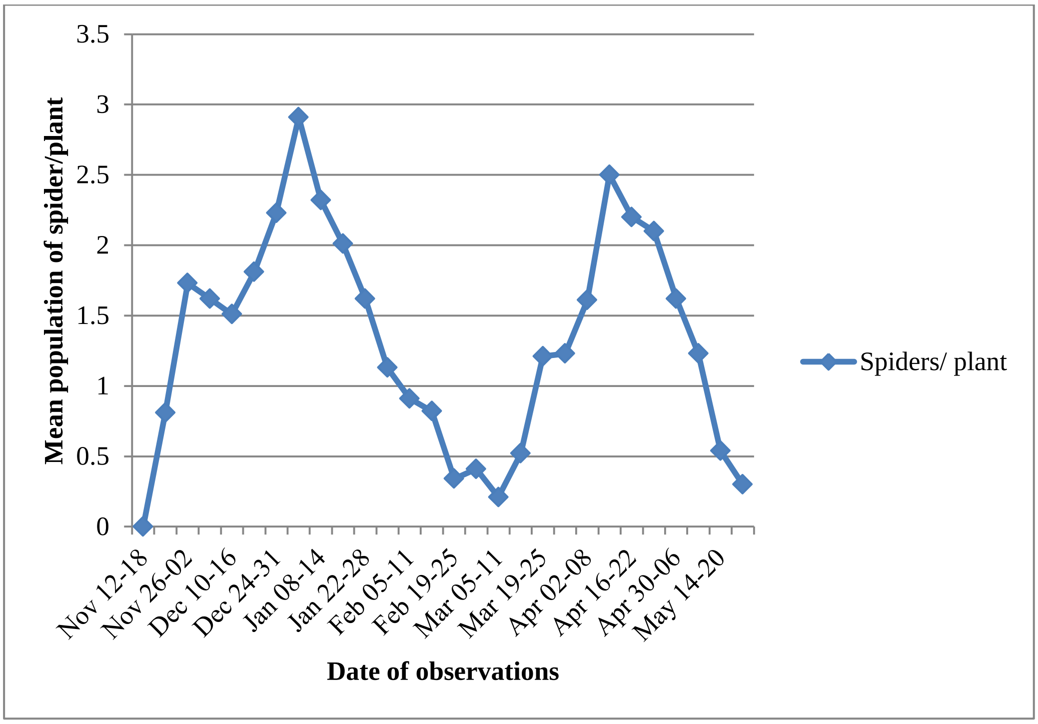


Fig.4.6: Mean population of Spider, *Oxyopes* sp. on chilli crop during *Rabi* 2018-19

Table 4.3: Insect pests and natural enemies of chilli crop during *Rabi* 2018-19

Name of insect	Scientific name	Population range/plant	Active period	Peak activity period
Thrips	*Scirtothrips dorsalis* (Hood)	0.74 - 22.2	26^{th} November to 27^{th} May	First week of March
Mite	*Polyphagotarsonemus latus* (Bank)	0.09 - 1.44	29^{th} January to 20^{th} May	Second week of April
Aphid	*Aphis gossypii*	0.31 - 18.97	26^{th} November to 6^{th} April	First week of February
Tobacco caterpillar	*Spodoptera litura*	0.12 - 2.30	1^{st} January to 20^{th} May	Second week of March
Lady bird beetle	*Cheilomenes sexmaculata*	0.3-4.9	12^{th} November to 27^{th} May	Third week of April
Spider	*Oxyopes* sp.	0.3-3.0	12^{th} November to 27^{th} May	First week of January

4.2 Studies on the population dynamics of major insect pests on chilli crop

"Data recorded on infestation of various pest population were correlated with prevailing temperature, relative humidity, rainfall, wind velocity and sunshine hours" obtained from observatory of the university (Table: 3.1 and Fig: 3.1)

4.2.1 Chilli thrips

The activity of thrips was maximum observed during first week of March. The population of thrips showed positive significant correlation with maximum temperature (r = 0.396*). The regression equation being y = 0.4325x - 2.6025 indicating that with an increase in 1^0C temperature there will be increase in population by 0.4325 insect. The thrips population also showed significant positive correlation with wind velocity (r = 0.543*). The regression equation being y = 2.1969x + 6.2797 indicating that with an increase in 1 kmph wind velocity there will be increase in population by 2.1969 insect. The negatively and significant with morning relative humidity (r = -0.398*). The regression equation being y = -0.1563x + 23.025 indicating that with an increase in 1 per cent morning relative humidity there will be decrease in population by 0.1563 insect. While other parameters has non- significant association. The population of thrips in chilli had non- significant positive correlation with minimum temperature and bright sunshine hours, while non- significant negative correlation with rainfall and evening relative humidity.

These present results are similar with the Samanta *et al.* (2017) who studied that significant positive correlation with temperature, which indicates that thrips population increases with the increase in temperature. Similar results were also obtained by Patel *et al.* (2009) who reported that thrips incidence showed a significant positive correlation with maximum temperature but exhibited a significant negative correlation with rainfall and morning afternoon and mean relative humidity and vapour pressure. Zainab *et al.* (2016) found that population of thrips showed significant positive correlation with maximum temperature and negatively correlated with rainfall, relative humidity, which corroborate the present study.

4.2.2 Chilli mite

The activity of mite was maximum observed during second week of April. The population of mite showed positive significant correlation with maximum temperature (r=0.393*). The regression equation being y = 0.0299x - 0.5845 indicating that with an increase in 1^0C temperature there will be increase in population by 0.0299 insect. The mite population also showed significant positive correlation with wind velocity (r =0.516*). The regression equation being y = 0.1452x + 0.0451 indicating that with an increase in 1 kmph wind velocity there will be increase in population by 0.1452 insect. While other parameters has non-significant association. The population of mite in chilli had non-significant positive correlation with minimum temperature and sunshine hours, while non- significant negative correlation with rainfall, morning and evening relative humidity.

These present results are similar with the Samanta *et al.* (2017) who studied that significant positive correlation with temperature which indicates that mite population increases with the increase in temperature. Similar results were obtained by Chatterjee (2004) who reported that yellow mite population was significantly correlated with the temperature. Similar to our findings, Patil and Nandihalli (2009) have also reported that yellow mite population showed negative correlation with morning and evening humidity and rainfall.

4.2.3 Chilli aphid

The activity of aphid was maximum observed during first week of February. The population of aphid showed positive significant correlation with morning relative humidity (r=0.410*). The regression equation being y = 0.1268x - 4.8237 indicating that with an increase in 1 per cent RH there will be increase in population by 0.126 insect. The aphid population also showed significant negative correlation with maximum temperature (r=-0.456*). The regression equation being y = - 0.3918x + 17.314 indicates that with an increase in 1^0C temperature there will be decrease in population by 0.39 and population of aphid shows highly significant negative correlation with minimum temperature (r=-0.494**). The regression equation being y = -0.411x + 11.618 indicating that with an increase in 1^0C minimum temperature there will be decrease in insect population by 0.411. While other parameters has non- significant association. The population of aphid in chilli had non- significant positive correlation with rainfall and evening relative humidity, while non- significant negative correlation with wind velocity and sunshine.

These present results are similar with the Debaraj and Singh (2004) reported the negative correlation between temperature and aphid. Roopa and Kumar (2014) revealed that the aphid population exhibited a negative correlation with maximum temperature, minimum temperature and sunshine hours.

4.2.4 Tobacco caterpillar

The activity of *Spodoptera litura* was maximum observed during second week of March. The population of *S. litura* in chilli had non- significant positive correlation with morning, evening relative humidity, sunshine and wind velocity. While non- significant negative correlation with maximum, minimum temperature and rainfall.

Table 4.4: Coefficient correlation among major insect pests on chilli and weather parameters

	Max. Temp. (^{0}C)	Min. Temp. (^{0}C)	Rain fall (mm)	RH I (%)	RH II (%)	Wind Velocity (Kmph)	Sun Shine (hours)
Thrips	0.396*	0.372	-0.005	-0.398*	-0.244	0.543*	0.358
Mite	0.393*	0.372	-0.170	-0.339	-0.204	0.516*	0.155
Aphid	-0.456*	-0.494**	0.042	0.410*	0.285	-0.193	-0.094
Tobacco caterpillar	-0.141	-0.186	-0.182	0.149	0.028	0.196	0.101

*Significant at 5% level of significance (table value- 0.374)
** Significant at 1% level of significance (table value- 0.478)
RH I – Morning relative humidity
RH II – Evening relative humidity

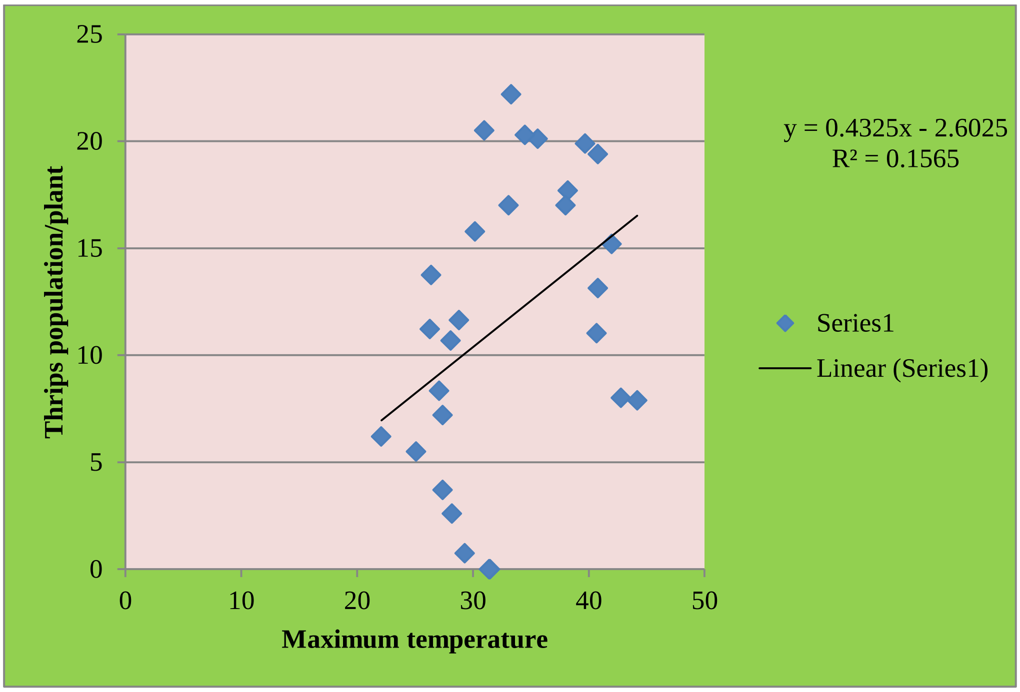


Fig. 4.7: Regression line of thrips population on maximum temperature

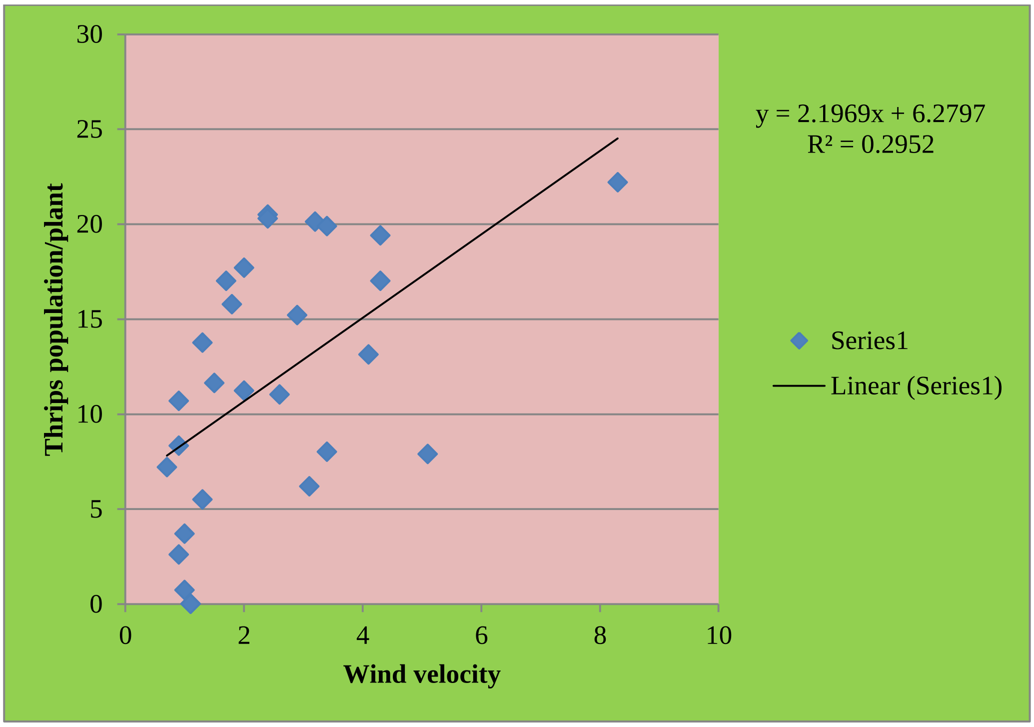


Fig. 4.8: Regression line of thrips population on wind velocity

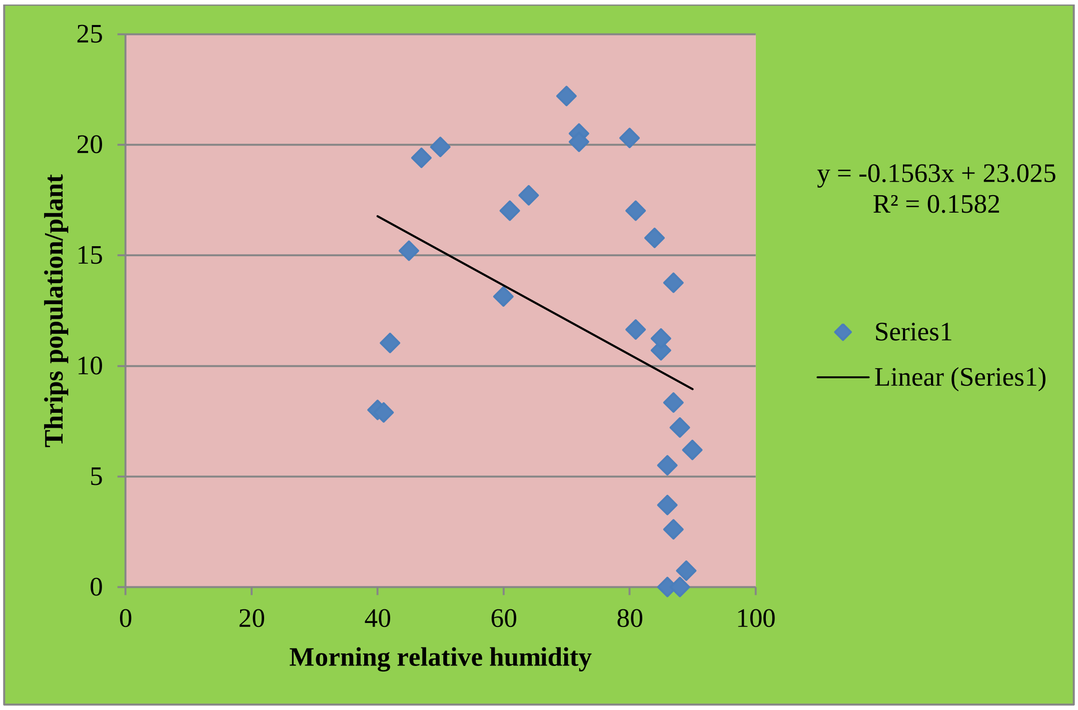


Fig. 4.9: Regression line of thrips population on morning relative humidity

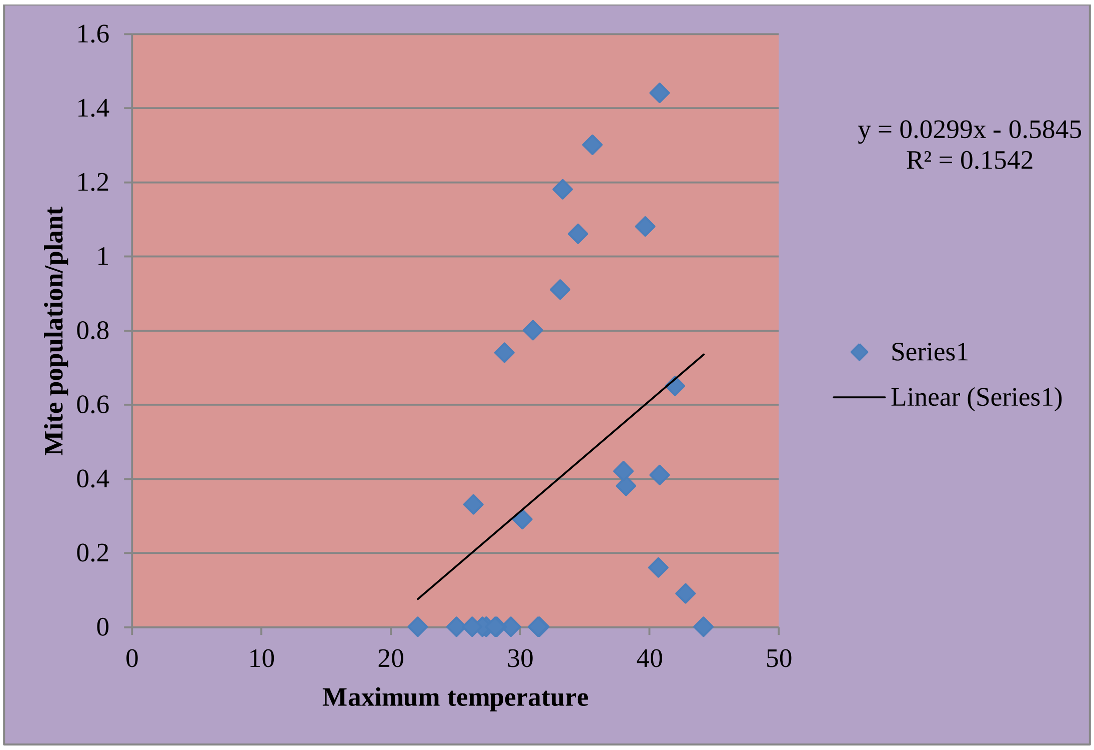


Fig. 4.10: Regression line of mite population on maximum temperature

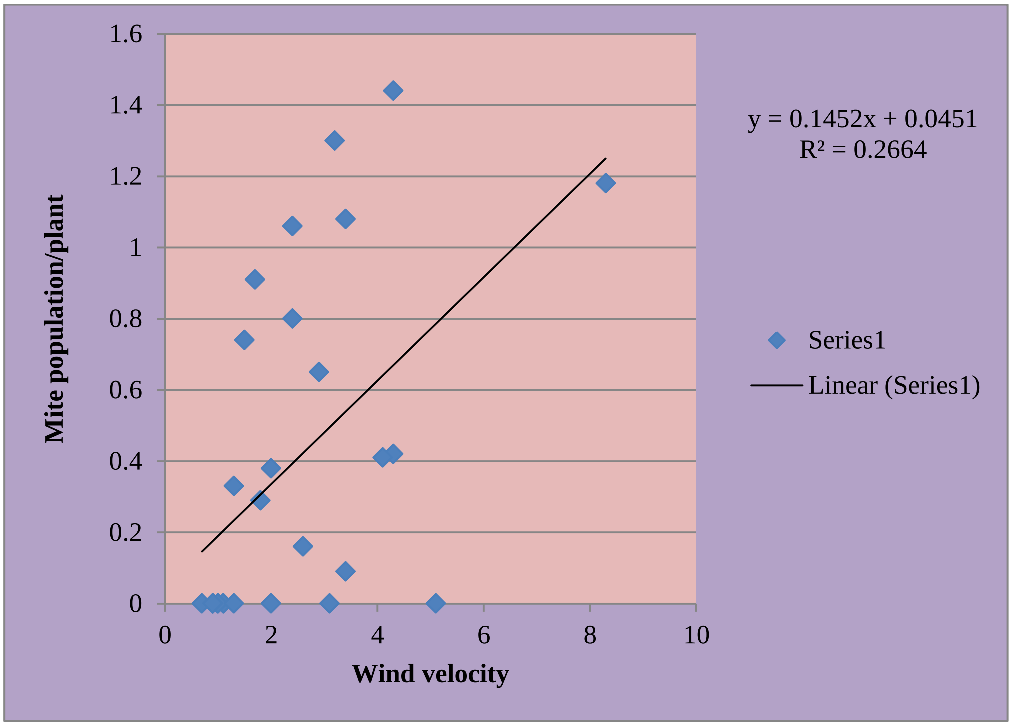


Fig. 4.11: Regression line of mite population on wind velocity

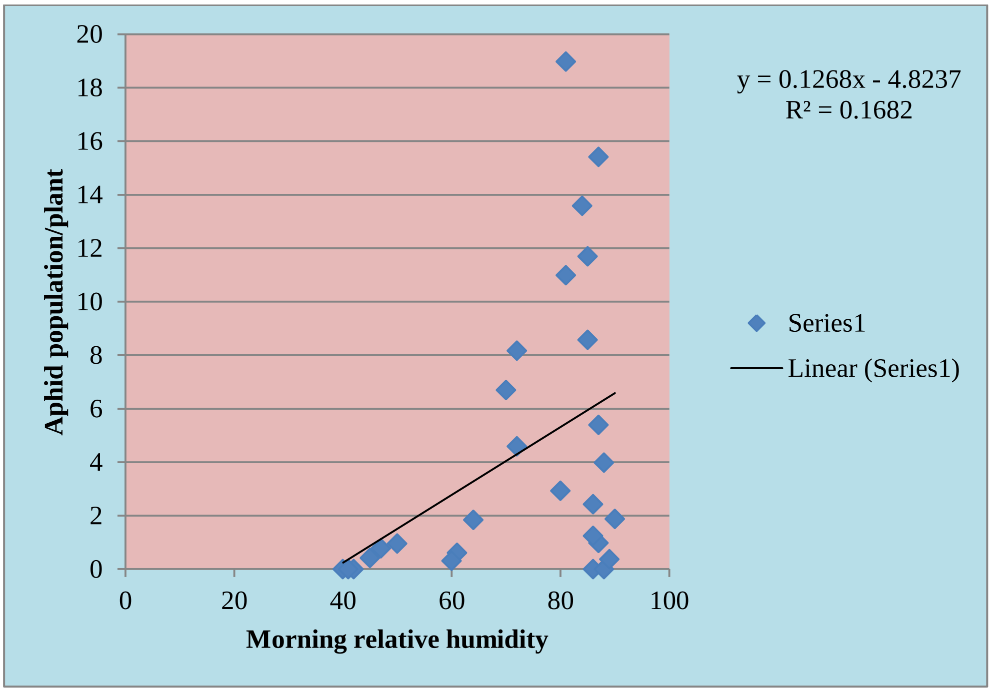


Fig. 4.12: Regression line of aphid population on morning relative humidity

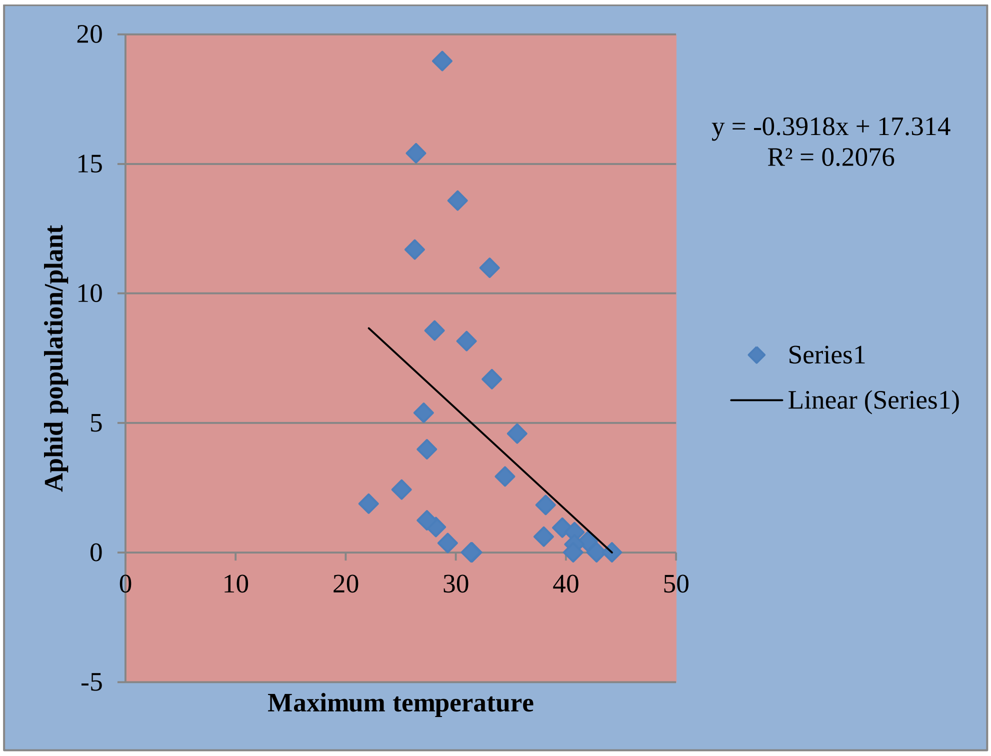


Fig. 4.13: Regression line of aphid population on maximum temperature

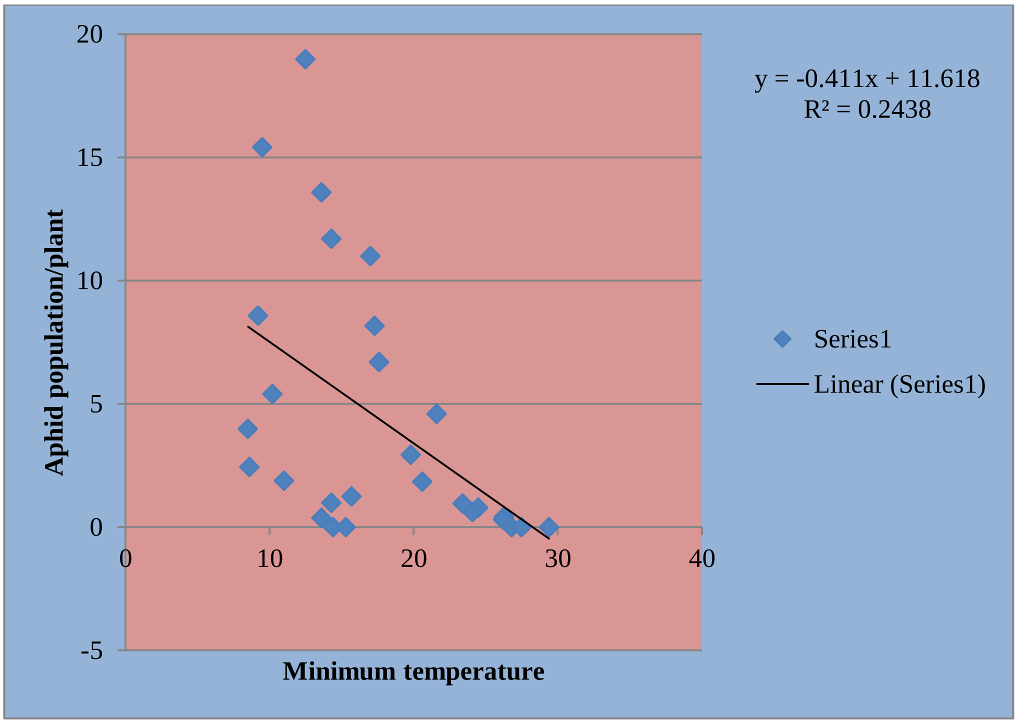


Fig. 4.14: Regression line of aphid population on minimum temperature

4.2.5 Correlation between insect pests and their natural enemies

The population of two predator *viz.*, lady bird beetle (*Cheilomenes sexmuculata*) and spider (*Oxyopes* sp.) were recorded to curb sucking pests on chilli. The population of lady bird beetle, spider and the insect pests of chilli *viz.*, thrips, mite and aphid were correlated. The level of highest population of lady bird beetle (4.9/plant) and spider (3.0/plant) were noticed during third week of April and first week of January, respectively.

Thrips and mite population showed non-significant negative correlation with lady bird beetle and spider.

Aphid population showed significant negative correlation with lady bird beetle (r=0.464*). The regression equation with lady bird beetle [$y = -1.7025x + 7.887$; $R^2 = 0.216$] and non- significant negative correlation with spider.

Table 4.5: Correlation between insect pests and natural enemies

Insect pests	**Natural enemies**	
	Lady bird beetle	Spider
Thrips	-0.094	-0.114
Mite	-0.117	-0.191
Aphid	-0.464*	-0.198

* Significant at 5% level of significant (table value- 0.374)
** Significant at 1% level of significance (table value- 0.478)

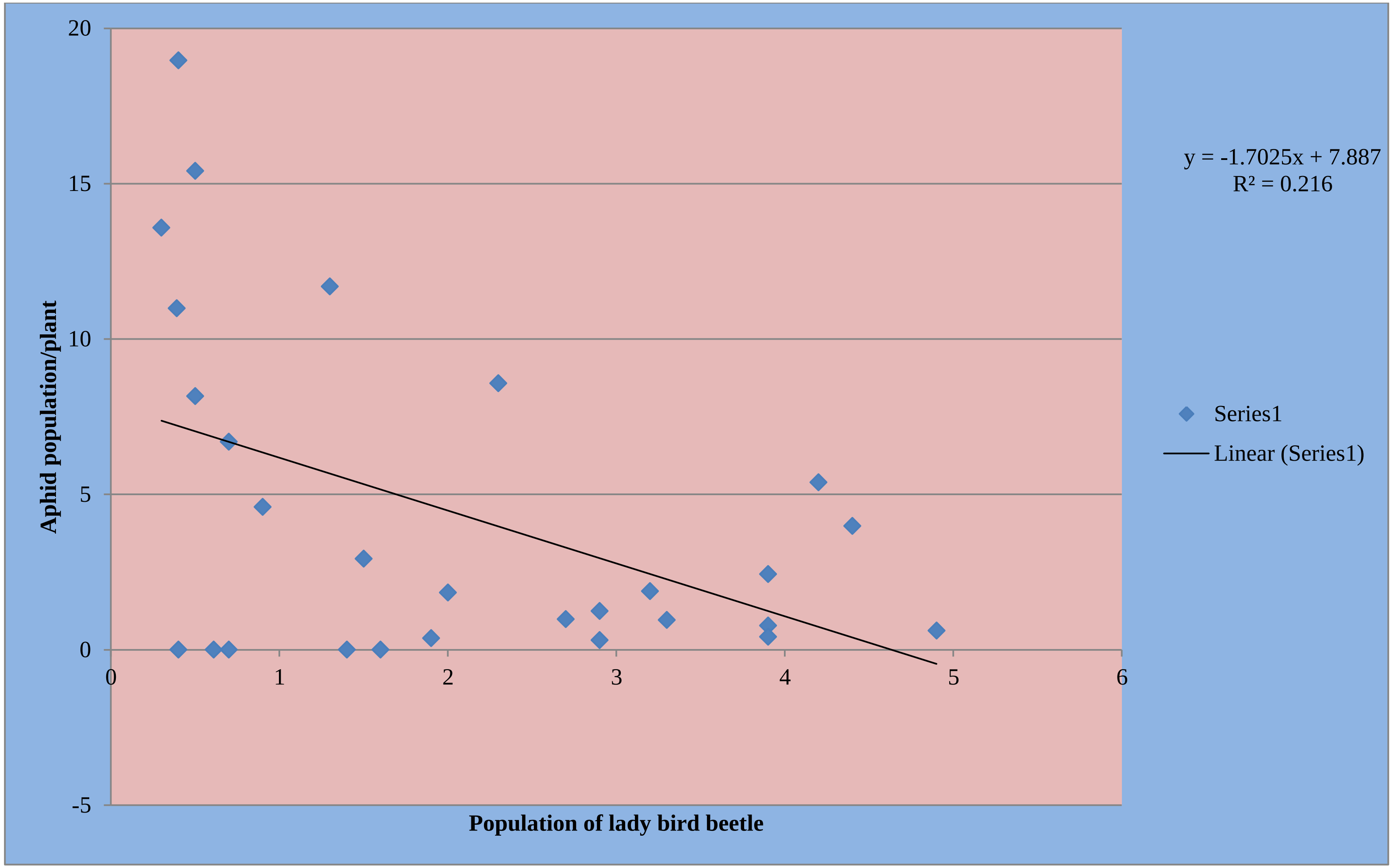


Fig. 4.15: Regression line of aphid population on lady bird beetle

Thrips (*Scirtothrips dorsalis*)

Aphid (*Aphis gossypii*)

Spodoptera litura

Plate: 4.1 Insect pests on chilli during experiment

Grub (Coccinellids)

Adult (Coccinellid)

Oxyopes sp.

Plate: 4.2 Natural enemies associated with insect pests on chilli during experiment

4.3 Studies on the bio-efficacy of newer insecticides against sucking pests on chilli crop

A field experiment was conducted at horticulture Farm at IGKV, Raipur (C.G.) during *Rabi* 2018 under field condition to determine the bio-efficacy of newer insecticides against sucking pest on chilli. Spraying of various insecticides was done twice. First application at when substantial pests population was observed in experimental field and the second spraying was done at 15 day after first spray.

4.3.1 Efficacy of insecticide molecules against thrips, *Scirtothrips dorsalis*

First spray

The data on mean population of thrips recorded at one day after first spray indicated that all the insecticidal treatments recorded significantly lower number of thrips per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (13.10 thrips/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (14.05 thrips/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (20.05 thrips/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (21.11 thrips/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (22.14 thrips/plant). However, the maximum thrips population (24.11 thrips/plant) was noticed in control plot.

The data on mean population of thrips recorded at three days after first spray indicated that all the insecticidal treatments recorded significantly lower number of thrips per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (11.02 thrips/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (12.09 thrips/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (17.09

thrips/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (19.02 thrips/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (20.09 thrips/plant). However, the maximum thrips population (26.02 thrips/plant) was noticed in control plot.

The data on mean population of thrips recorded at seventh days after first spray indicated that all the insecticidal treatments recorded significantly lower number of thrips per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (9.04 thrips/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (13.03 thrips/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (15.03 thrips/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (18.19 thrips/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (19.13 thrips/plant). However, the maximum thrips population (28.19 thrips/plant) was noticed in control plot.

The data on mean population of thrips recorded at tenth days after first spray indicated that all the insecticidal treatments recorded significantly lower number of thrips per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (12.06 thrips/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (19.12 thrips/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (20.14 thrips/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (22.05 thrips/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (23.89 thrips/plant). However, the maximum thrips population (30.05 thrips/plant) was noticed in control plot.

The data on mean population of thrips recorded at fifteenth days after first spray indicated that all the insecticidal treatments recorded significantly lower number of thrips per plant as compared to control. The treatment (T3) Emamectin

Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (16.03 thrips/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (22.14 thrips/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (24.14 thrips/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (25.13 thrips/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (26.99 thrips/plant). However, the maximum thrips population (29.13 thrips/plant) was noticed in control plot.

Second spray

The data on mean population of thrips recorded at one day after second spray indicated that all the insecticidal treatments recorded significantly lower number of thrips per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (8.04 thrips/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (12.04 thrips/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (20.04 thrips/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (21.15 thrips/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (23.88 thrips/plant). However, the maximum thrips population (31.15 thrips/plant) was noticed in control plot.

The data on mean population of thrips recorded at three days after second spray indicated that all the insecticidal treatments recorded significantly lower number of thrips per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (5.02 thrips/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (11.19 thrips/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (17.19 thrips/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (18.08 thrips/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (21.96 thrips/plant). However, the maximum thrips population (34.08 thrips/plant) was noticed in control plot.

The data on mean population of thrips recorded at seventh days after second spray. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (3.06 thrips/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (10.14 thrips/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (13.14 thrips/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (16.29 thrips/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (19.02 thrips/plant). However, the maximum thrips population (36.29 thrips/plant) was noticed in control plot.

The data on mean population of thrips recorded at tenth days after second spray indicated that all the insecticidal treatments recorded significantly lower number of thrips per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (6.04 thrips/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (12.03 thrips/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (15.03 thrips/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (18.78 thrips/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (22.07 thrips/plant). However, the maximum thrips population (38.07 thrips/plant) was noticed in control plot.

The data on mean population of thrips recorded at fifteenth days after second spray. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (8.06 thrips/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (16.02 thrips/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP

@ 11 g a.i./ha (17.02 thrips/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (21.74 thrips/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (23.06 thrips/plant). However, the maximum thrips population (40.06 thrips/plant) was noticed in control plot.

Overall mean population of thrips after first and second spray

The overall minimum mean population was recorded in (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (10.69 thrips/plant) followed by (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (14.99 thrips/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (18.36 thrips/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (21.34 thrips/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (22.14 thrips/plant). However, the maximum thrips population (30.93 thrips/plant) was noticed in control plot (Table 4.1).

More or less, similar findings were recorded by the Sathyan *et al.* (2017) revealed that significantly lowest population of thrips was recorded in fipronil 5 SC @ 0.15% (8.05 thrips/3 bud) and Imidacloprid 17.8 SL @ 0.02% (9.0 thrips/3 bud) in chilli. Nagaraj *et al*. (2007) revealed that the mean thrips population recorded were minimum in thiomethaxam 25 WG @ 35 g a.i./ha (2.95 thrips/leaf). These results are in conformity with Kadam and Dethe (2002). Jadhav *et al*. (2004) reported that fipronil 5% SC @ 100g a.i./ha recorded the lowest population of sucking pests and the highest yield in chilli in comparison with Imidacloprid 17.8 SL @ 20 g a.i./ha vis-à-vis phasalone 35% EC @ 500 g a.i./ha. Tatagar (2004) reported that among the different dosages, abamectin 1.9 EC @ 0.50ml/lit., recorded low incidence of thrips than other treatment such as profenofos 50 EC @ 2 ml/lit. Regarding the Imidacloprid 200 SL similar finding were reported by Tarage and Kurtadikar (2003).

Similarly effectiveness of Imidacloprid 0.05% was in confirmation with the findings of Jain and Ameta (2006) and Patil *et al*. (2002).

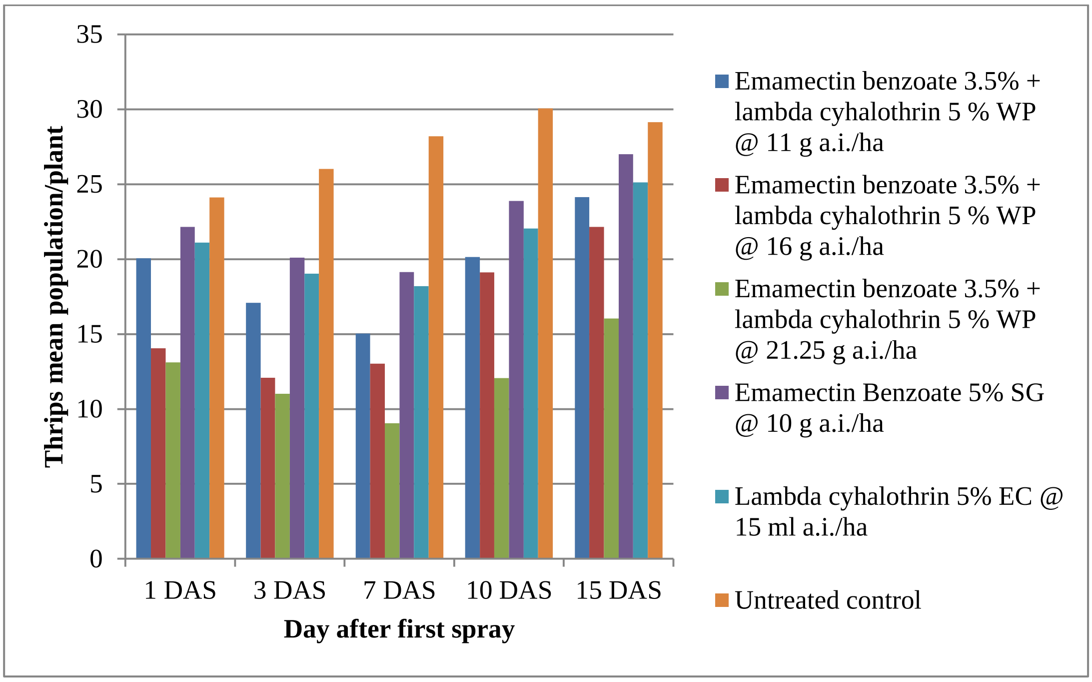


Fig. 4.16 Mean population of *Scirtothrips dorsalis* after first spray

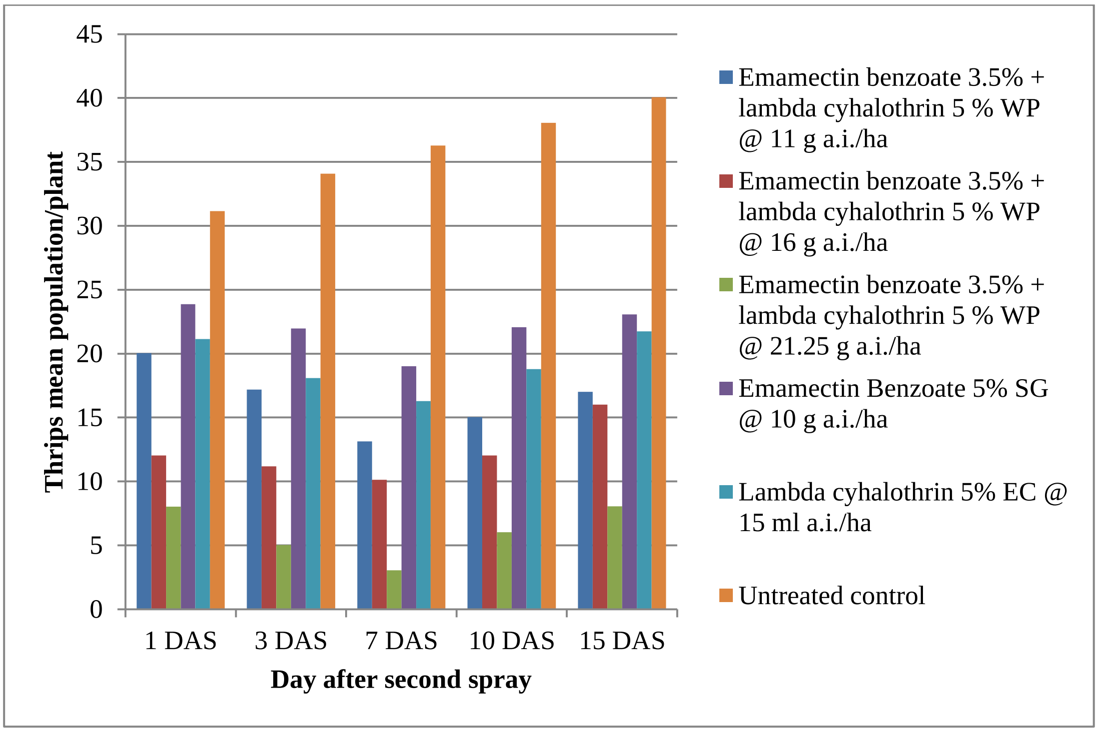


Fig. 4.17 Mean population of *Scirtothrips dorsalis* after second spray

Table 4.6 Effect of Emamectin benzoate 3.5%+Lambda cyhalothrin 5% WP against thrips on chilli during *Rabi* 2018-19

Treatment	Insecticide	Dose	Average no. of thrips/3 leaves/ plant											
			Pre treatment	I Spray					II Spray					Over all mean
				1 DAS	3 DAS	7 DAS	10 DAS	15 DAS	1 DAS	3 DAS	7 DAS	10 DAS	15 DAS	
T_1	Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP	11 g a.i./ha	25.07 (6.01)	20.05 (5.37)	17.09 (5.13)	15.03 (4.87)	20.14 (5.47)	24.14 (5.91)	20.04 (5.36)	17.19 (5.14)	13.14 (4.62)	15.03 (4.87)	17.02 (5.12)	**18.36**
T_2	Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP	16 g a.i./ha	24.40 (5.96)	14.05 (4.74)	12.09 (4.32)	13.03 (4.60)	19.12 (5.37)	22.14 (5.70)	12.04 (4.46)	11.19 (4.34)	10.14 (4.18)	12.03 (4.46)	16.02 (5.00)	**14.99**
T_3	Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP	21.25 g a.i./ha	22.48 (4.98)	13.10 (4.75)	11.02 (4.22)	9.04 (4.00)	12.06 (4.47)	16.03 (5.01)	8.04 (3.83)	5.02 (3.23)	3.06 (2.74)	6.04 (3.45)	8.06 (3.83)	**10.69**
T_4	Emamectin Benzoate 5% SG	10 g a.i./ha	23.96 (5.91)	22.14 (5.70)	20.09 (5.48)	19.13 (5.37)	23.89 (5.88)	26.99 (6.19)	23.88 (5.88)	21.96 (5.68)	19.02 (5.36)	22.07 (5.69)	23.06 (5.80)	**22.14**
T_5	Lambda cyhalothrin 5% EC	15 ml a.i./ha	24.87 (5.99)	21.11 (5.80)	19.02 (5.36)	18.19 (5.26)	22.05 (4.78)	25.13 (6.04)	21.15 (5.59)	18.08 (5.25)	16.29 (5.03)	18.78 (5.33)	21.74 (5.66)	**21.34**
T_6	Control (Untreated)	-	23.37 (5.03)	24.11 (5.91)	26.02 (6.11)	28.19 (6.30)	30.05 (5.69)	29.13 (6.39)	31.15 (6.58)	34.08 (6.83)	36.29 (7.02)	38.07 (7.17)	40.06 (7.33)	**30.93**
	SEm±		**0.004**	**0.046**	**0.016**	**0.013**	**0.026**	**0.013**	**0.013**	**0.017**	**0.015**	**0.013**	**0.018**	
	CD at 5%		**NS**	**0.246**	**0.216**	**0.209**	**0.214**	**0.217**	**0.210**	**0.213**	**0.214**	**0.208**	**0.211**	

DAS= days after spray, ( ) figures in parentheses are square root transformed, NS= Non-significant

4.3.2 Efficacy of insecticide molecules against mite, *Polyphagotarsonemus latus* (Bank)

First spray

The data on mean population of mite recorded at one day after first spray indicated that all the insecticidal treatments recorded significantly lower number of mite per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (3.43 mite/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (3.63 mite/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (3.88 mite/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (4.04 mite/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (4.27 mite/plant). However, the maximum mite population (4.31 mite/plant) was noticed in control plot.

The data on mean population of mite recorded at three days after first spray indicated that all the insecticidal treatments recorded significantly lower number of mite per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (2.39 mite/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (2.76 mite/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (2.98 mite/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (3.84 mite/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (4.01 mite/plant). However, the maximum mite population (5.34 mite/plant) was noticed in control plot.

The data on mean population of mite recorded at seventh days after first spray indicated that all the insecticidal treatments recorded significantly lower number of mite per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (2.29 mite/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (2.59 mite/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (2.79 mite/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (3.71 mite/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (3.89 mite/plant). However, the maximum mite population (7.38 mite/plant) was noticed in control plot.

The data on mean population of mite recorded at tenth days after first spray indicated that all the insecticidal treatments recorded significantly lower number of mite per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (2.43 mite/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (2.74 mite/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (2.92 mite/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (3.81 mite/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (4.15 mite/plant). However, the maximum mite population (6.40 mite/plant) was noticed in control plot.

The data on mean population of mite recorded at fifteenth days after first spray indicated that all the insecticidal treatments recorded significantly lower number of mite per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (2.93 mite/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (3.04 mite/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (4.01 mite/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (3.91 mite/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (4.32 mite/plant). However, the maximum mite population (8.42 mite/plant) was noticed in control plot.

Second spray

The data on mean population of mite recorded at one day after second spray indicated that all the insecticidal treatments recorded significantly lower number of mite per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (2.73 mite/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (2.88 mite/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (3.62 mite/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (3.65 mite/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (4.15 mite/plant). However, the maximum mite population (7.44 mite/plant) was noticed in control plot.

The data on mean population of mite recorded at three days after second spray indicated that all the insecticidal treatments recorded significantly lower number of mite per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (2.60 mite/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (2.80 mite/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (3.49 mite/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (3.53 mite/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (4.06 mite/plant). However, the maximum mite population (9.46 mite/plant) was noticed in control plot.

The data on mean population of mite recorded at seventh days after second spray indicated that all the insecticidal treatments recorded significantly lower number of mite per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (2.50 mite/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate

3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (2.70 mite/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (2.99 mite/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (3.38 mite/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (3.96 mite/plant). However, the maximum mite population (8.48 mite/plant) was noticed in control plot.

The data on mean population of mite recorded at tenth days after second spray indicated that all the insecticidal treatments recorded significantly lower number of mite per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (2.96 mite/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (3.00 mite/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (3.49 mite/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (3.62 mite/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (4.25 mite/plant). However, the maximum mite population (7.50 mite/plant) was noticed in control plot.

The data on mean population of mite recorded at fifteenth days after second spray indicated that all the insecticidal treatments recorded significantly lower number of mite per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (3.10 mite/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (3.17 mite/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (3.72 mite/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (3.69 mite/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (4.33 mite/plant). However, the maximum mite population (8.52 mite/plant) was noticed in control plot.

Overall mean population of mite after first and second spray

The overall minimum corrected mean population was recorded in (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (2.74 mite/plant) followed by (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (2.93 mite/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (3.39 mite/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (3.72 mite/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (4.14 mite/plant). However, the maximum mite population (7.05 mite/plant) was noticed in control plot (Table 4.2).

More or less, similar findings were recorded by the Samanta *et al.* (2017) stated that the treatments, spiromesifen 24 SC @ 120 g a.i./ha were observed to be very much effective against yellow mite. Shahaji (2007) stated that the abamectin 0.0009% was significantly superior in reducing mite population with 2.66 mites/plant.

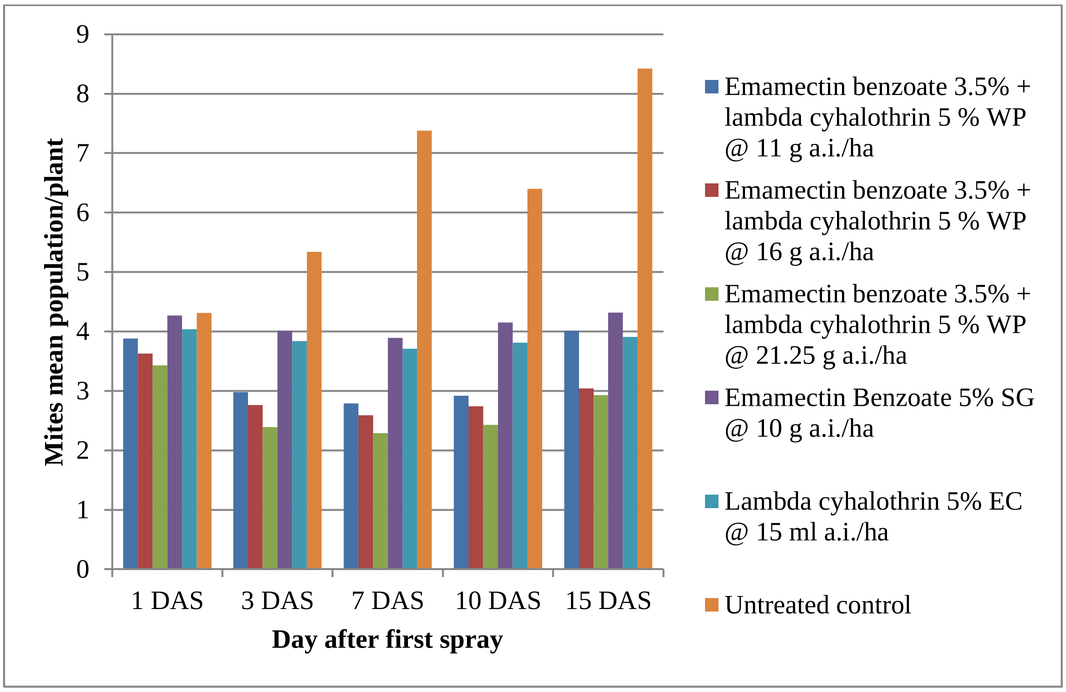


Fig. 4.18 Mean population of *Polyphagotarsonemus latus* after first spray

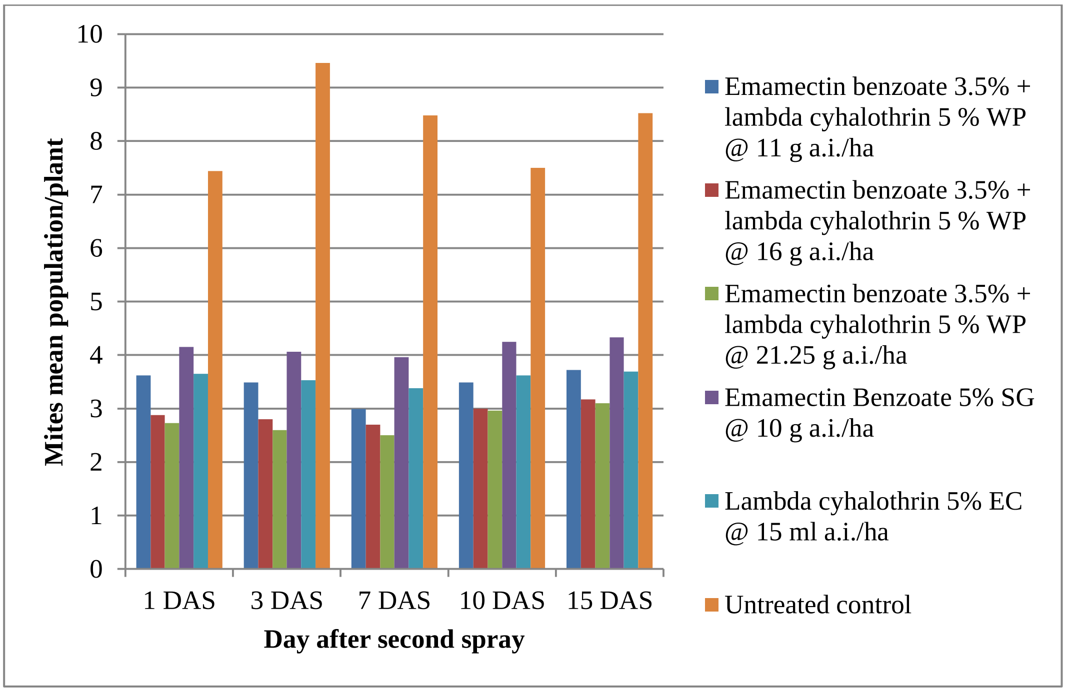


Fig. 4.19 Mean population of *Polyphagotarsonemus latus* after second spray

Table 4.7 Effect of Emamectin benzoate 3.5%+Lambda cyhalothrin 5% WP against mites on chilli during *Rabi* 2018-19

Treatment	Insecticide	Dose	Average no. of mites/plant											
			Pre treatment	I Spray					II Spray					Over all mean
				1 DAS	3 DAS	7 DAS	10 DAS	15 DAS	1 DAS	3 DAS	7 DAS	10 DAS	15 DAS	
T_1	Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP	11 g a.i./ha	4.89 (2.21)	3.88 (1.96)	2.98 (1.72)	2.79 (1.67)	2.92 (1.70)	4.01 (2.00)	3.62 (1.90)	3.49 (1.86)	2.99 (1.72)	3.49 (1.86)	3.72 (1.92)	**3.39**
T_2	Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP	16 g a.i./ha	5.19 (2.27)	3.63 (1.90)	2.76 (1.66)	2.59 (1.60)	2.74 (1.65)	3.04 (1.74)	2.88 (1.69)	2.80 (1.67)	2.70 (1.64)	3.00 (1.73)	3.17 (1.78)	**2.93**
T_3	Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP	21.25 g a.i./ha	4.99 (2.23)	3.43 (1.85)	2.39 (1.54)	2.29 (1.51)	2.43 (1.55)	2.93 (1.71)	2.73 (1.65)	2.60 (1.61)	2.50 (1.58)	2.96 (1.72)	3.10 (1.76)	**2.74**
T_4	Emamectin Benzoate 5% SG	10 g a.i./ha	5.21 (2.28)	4.27 (2.06)	4.01 (2.00)	3.89 (1.97)	4.15 (2.03)	4.32 (2.07)	4.15 (2.03)	4.06 (2.01)	3.96 (1.98)	4.25 (2.06)	4.33 (2.08)	**4.14**
T_5	Lambda cyhalothrin 5% EC	15 ml a.i./ ha	4.49 (2.11)	4.04 (2.02)	3.84 (1.95)	3.71 (1.92)	3.81 (1.95)	3.91 (1.97)	3.65 (1.91)	3.53 (1.87)	3.38 (1.83)	3.62 (1.90)	3.69 (1.92)	**3.72**
T_6	Control (Untreated)	-	4.94 (2.22)	4.31 (2.07)	5.34 (2.31)	7.38 (2.71)	6.40 (2.52)	8.42 (2.90)	7.44 (2.72)	9.46 (3.07)	8.48 (2.91)	7.50 (2.73)	8.52 (2.91)	**7.05**
	SEm±		**0.29**	**0.58**	**0.57**	**0.58**	**0.59**	**0.55**	**0.58**	**0.59**	**0.55**	**0.58**	**0.59**	
	CD at 5%		**NS**	**1.15**	**1.14**	**1.15**	**1.17**	**1.09**	**1.15**	**1.17**	**1.09**	**1.15**	**1.17**	

DAS= days after spray, ( ) figures in parentheses are square root transformed, NS= Non- significant

4.3.3 Efficacy of insecticide molecules against aphid, *Aphis gossypii*

First spray

The data on mean population of aphid recorded at one day after first spray indicated that all the insecticidal treatments recorded significantly lower number of aphid per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (1.64 aphid/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (2.65 aphid/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (3.78 aphid/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (4.66 aphid/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (5.79 aphid/plant). However, the maximum aphid population (6.13 aphid/plant) was noticed in control plot.

The data on mean population of aphid recorded at three days after first spray indicated that all the insecticidal treatments recorded significantly lower number of aphid per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (2.42 aphid/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (3.32 aphid/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (4.29 aphid/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (5.49 aphid/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (5.83 aphid/plant). However, the maximum aphid population (6.46 aphid/plant) was noticed in control plot.

The data on mean population of aphid recorded at seventh days after first spray indicated that all the insecticidal treatments recorded significantly lower number of aphid per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (3.45 aphid/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (4.35 aphid/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (5.12 thrips/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (5.96 aphid/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (5.99 aphid/plant). However, the maximum aphid population (7.49 aphid/plant) was noticed in control plot.

The data on mean population of aphid recorded at tenth days after first spray indicated that all the insecticidal treatments recorded significantly lower number of aphid per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (4.02 aphid/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (5.02 aphid/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (6.09 aphid/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (6.03 aphid/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (6.19 aphid/plant). However, the maximum aphid population (8.16 aphid/plant) was noticed in control plot.

The data on mean population of aphid recorded at fifteenth days after first spray indicated that all the insecticidal treatments recorded significantly lower number of aphid per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (5.02 aphid/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (5.88 aphid/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (5.02 aphid/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (6.72 aphid/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (6.86 aphid/plant). However, the maximum aphid population (8.93 aphid/plant) was noticed in control plot.

Second spray

The data on mean population of aphid recorded at one day after second spray indicated that all the insecticidal treatments recorded significantly lower number of aphid per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (1.52 aphid/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (2.72 aphid/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (3.22 aphid/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (3.82 aphid/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (4.86 aphid/plant). However, the maximum aphid population (9.36 aphid/plant) was noticed in control plot.

The data on mean population of thrips recorded at three days after second spray indicated that all the insecticidal treatments recorded significantly lower number of thrips per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (1.72 aphid/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (2.92 aphid/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (3.42 aphid/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (4.02 aphid/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (5.06 aphid/plant). However, the maximum aphid population (10.03 aphid/plant) was noticed in control plot.

The data on mean population of aphid recorded at seventh days after second spray indicated that all the insecticidal treatments recorded significantly lower number of aphid per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (2.02 aphid/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate

3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (3.22 aphid/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (3.72 aphid/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (4.32 aphid/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (5.36 aphid/plant). However, the maximum aphid population (10.86 aphid/plant) was noticed in control plot.

The data on mean population of aphid recorded at tenth days after second spray indicated that all the insecticidal treatments recorded significantly lower number of aphid per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (2.42 aphid/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (3.62 aphid/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (4.12 aphid/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (4.72 aphid/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (5.76 aphid/plant). However, the maximum aphid population (11.03 aphid/plant) was noticed in control plot.

The data on mean population of aphid recorded at fifteenth days after second spray indicated that all the insecticidal treatments recorded significantly lower number of aphid per plant as compared to control. The treatment (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (2.92 aphid/plant) was found to be the most effective treatment as compare to other treatment and it was on at par with the treatment of (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (4.12 aphid/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (4.62 aphid/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (5.22 aphid/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (6.26 aphid/plant). However, the maximum aphid population (11.76 aphid/plant) was noticed in control plot.

Overall mean population of aphid after first and second spray

The overall minimum corrected mean population was recorded in (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (3.01 aphid/plant) followed by (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (3.98 aphid/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (4.61 aphid/plant), (T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (5.20 aphid/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (5.81 aphid/plant).However, the maximum mite population (8.74 aphid/plant) was noticed in control plot (Table 4.3).

Ditya *et al*. (2010) stated that chlorfenapyr belongs to pyrrole group of insecticides and is used as a broad spectrum insecticide cum acaricide for the control of whiteflies, thrips, caterpillar, mites, leaf miners, aphids etc. Furthermore, effectiveness of imidacloprid was reported by various workers against aphid on chilli. Kumar *et al*. (2001) stated that imidacloprid (70 g/ha) was the best treatment in controlling aphids (99.76% reduction) against the major pest complex aphids, thrips, gram pod borer, tobacco caterpillar of chilli. Das (2013) concluded that imidacloprid had good knock down effect on aphids population in chilli. Sujay *et al*. (2015) noted lesser effectiveness of imidacloprid against chilli pests. Viz. green peach aphid (*Myzus persicae* Sulzer, *Aphis gosspyi* Glover) and other sucking pests.

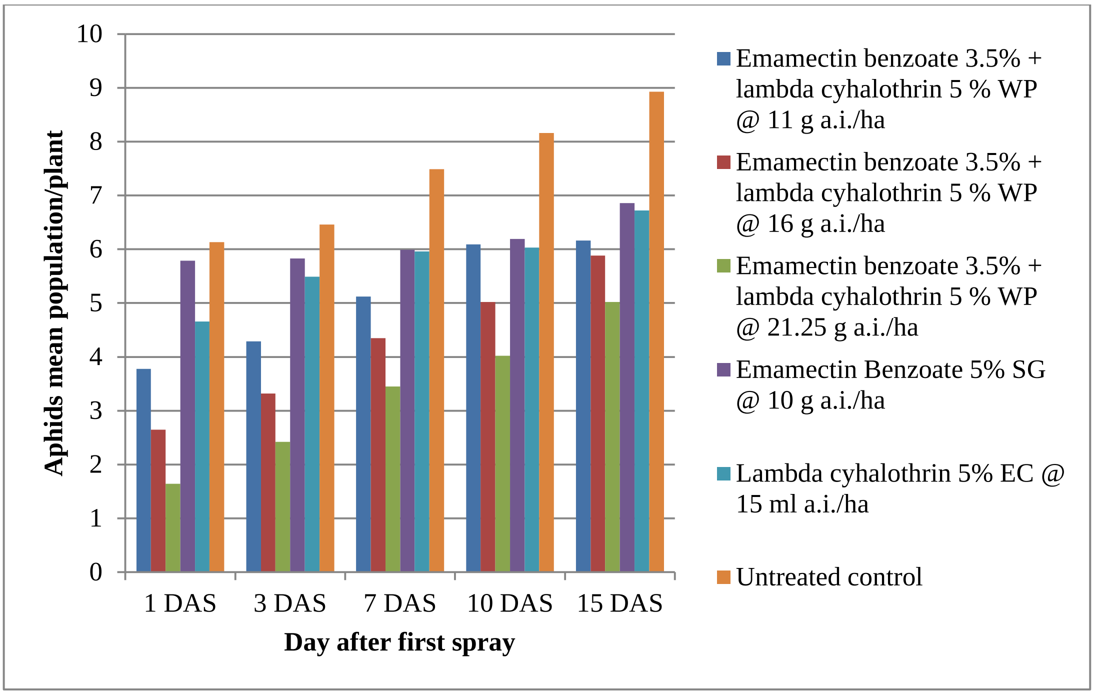


Fig. 4.20 Mean population of *Aphis gossypii* after first spray

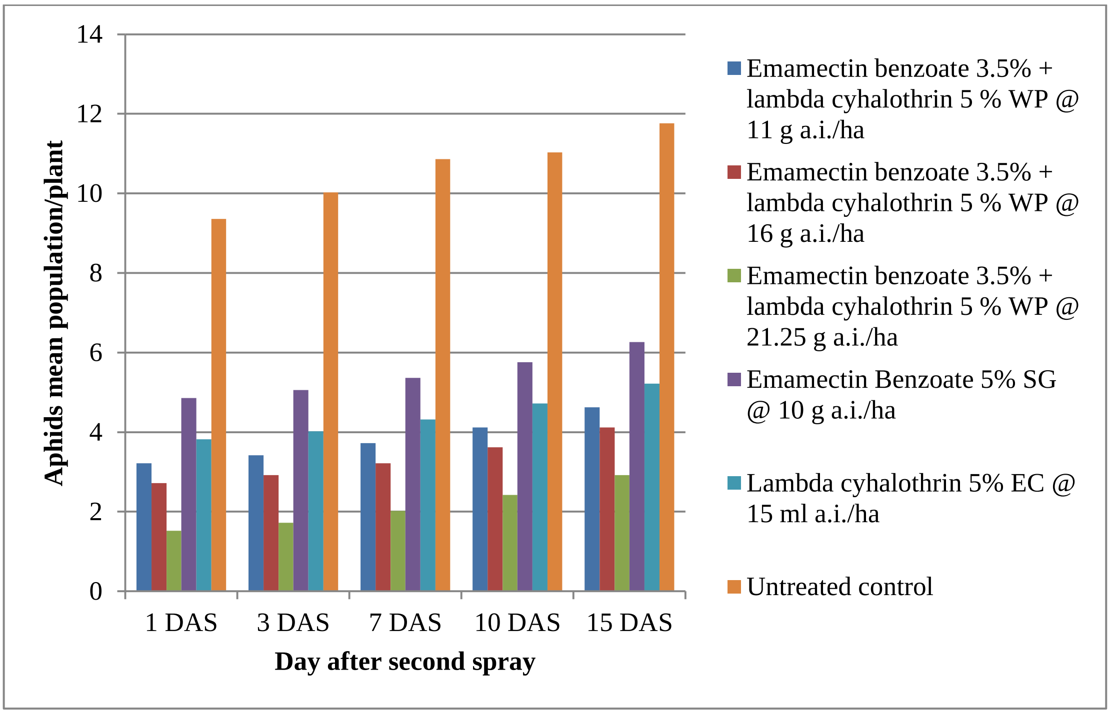


Fig. 4.21 Mean population of *Aphis gossypii* after second spray

Table 4.8 Effect of Emamectin benzoate 3.5%+Lambda cyhalothrin 5% WP against aphids on chilli crop during *Rabi* 2018-19

Treatment	Insecticide	Dose	Average no. of aphid/plant											
			Pre treatment	1st Spray					2nd Spray					Overall Mean
				1DAS	3DAS	7DAS	10DAS	15DAS	1DAS	3DAS	7DAS	10DAS	15DAS	
T1	Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP	11 g a.i./ha	6.19 (2.68)	3.78 (2.18)	4.29 (2.30)	5.12 (2.47)	6.09 (2.66)	6.16 (2.67)	3.22 (2.05)	3.42 (2.10)	3.72 (2.17)	4.12 (2.26)	4.62 (2.37)	**4.61**
T2	Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP	16 g a.i./ha	5.93 (2.62)	2.65 (1.91)	3.32 (2.07)	4.35 (2.31)	5.02 (2.45)	5.88 (2.62)	2.72 (1.92)	2.92 (1.97)	3.22 (2.05)	3.62 (2.14)	4.12 (2.26)	**3.98**
T3	Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP	21.25 g a.i./ha	5.97 (2.63)	1.64 (1.62)	2.42 (1.82)	3.45 (2.10)	4.02 (2.23)	5.02 (2.45)	1.52 (1.58)	1.72 (1.64)	2.02 (1.73)	2.42 (1.84)	2.92 (1.97)	**3.01**
T4	Emamectin Benzoate 5% SG	10 g a.i./ha	6.12 (2.67)	5.79 (2.60)	5.83 (2.61)	5.99 (2.64)	6.19 (2.68)	6.86 (2.80)	4.86 (2.42)	5.06 (2.46)	5.36 (2.52)	5.76 (2.60)	6.26 (2.69)	**5.81**
T5	Lambda cyhalothrin 5% EC	15 ml a.i./ha	6.09 (2.66)	4.66 (2.37)	5.49 (2.54)	5.96 (2.62)	6.03 (2.65)	6.72 (2.78)	3.82 (2.19)	4.02 (2.24)	4.32 (2.30)	4.72 (2.39)	5.22 (2.49)	**5.20**
T6	Control (Untreated)	-	5.99 (2.64)	6.13 (2.66)	6.46 (2.73)	7.49 (2.91)	8.16 (3.02)	8.93 (3.15)	9.36 (3.21)	10.03 (3.32)	10.86 (3.44)	11.03 (3.46)	11.76 (3.57)	**8.74**
	SEm±		**0.029**	**0.032**	**0.026**	**0.033**	**0.040**	**0.041**	**0.032**	**0.023**	**0.018**	**0.036**	**0.018**	
	CD at 5%		**NS**	**0.102**	**0.082**	**0.106**	**0.127**	**0.132**	**0.103**	**0.073**	**0.058**	**0.114**	**0.058**	

DAS= days after spray, ( ) figures in parentheses are square root transformed, NS= Non-significant

4.3.4 Effect on natural enemies

4.3.4.1 Impact of Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP on the population of coccinellid

Both the grubs and adults of coccinellids were found to predate on the thrips, aphids etc. The data on the mean population of coccinellid beetles per plant has been recorded and the impact of different doses of Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP at different days after spray has been presented in table 4.4 and the same for 2^{nd} round of application has been presented in table 4.4. It was observed that no adverse effect was found on coccinellid population during experimental period.

4.3.4.2 Impact of Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP on the population of spider

The data on the mean population of spiders per plant has been recorded and the impact of different doses of Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP at different days after spray has been presented in table 4.5 and the same for 2^{nd} round of application has been presented in table 4.5. It was observed that no adverse effect was found on spiders population during experimental period.

4.3.5 Yield

The yield of chilli fruits of different treatments have been presented in table-4.7 which revealed that the highest healthy fruit yield (94.66 qt/ha) were registered by Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha, followed by Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i/ha (92.72 qt /ha), Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i/ha (91.12 qt /ha). The lowest yield was harvested from untreated check plots (88.11 qt /ha) (Table 4.7).

Table 4.9 Effect of different combination of insecticides on coccinellids during R*abi* 2018-19

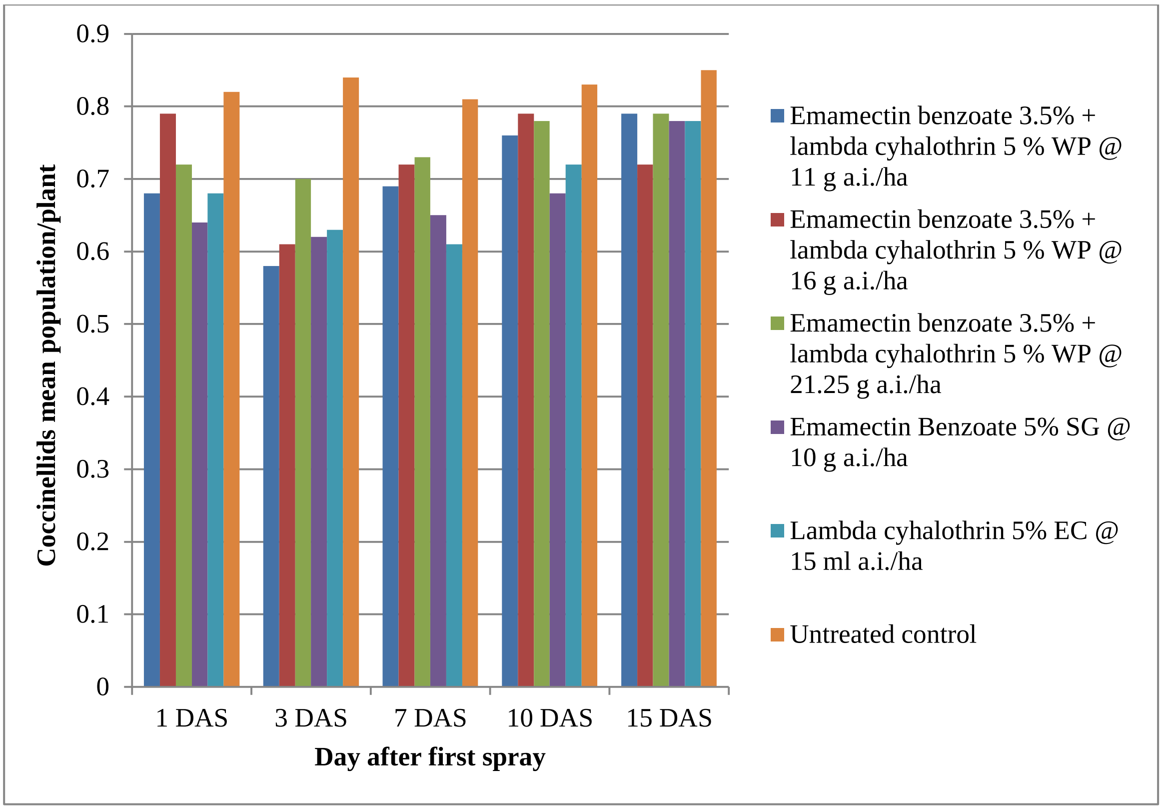
Treatment	Insecticides	Dose	Average no. of coccinellids/plant											
			Pre treatment	I Spray					II Spray					Over all mean
				1 DAS	3 DAS	7 DAS	10 DAS	15 DAS	1 DAS	3 DAS	7 DAS	10 DAS	15 DAS	
T_1	Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP	11 g a.i./ha	0.82 (1.72)	0.68 (1.58)	0.58 (1.48)	0.69 (1.59)	0.76 (1.66)	0.79 (1.69)	0.68 (1.58)	0.65 (1.55)	0.68 (1.58)	0.78 (1.68)	0.79 (1.69)	0.71
T_2	Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP	16 g a.i./ha	0.80 (1.70)	0.79 (1.69)	0.61 (1.51)	0.72 (1.62)	0.79 (1.69)	0.72 (1.62)	0.71 (1.61)	0.70 (1.60)	0.71 (1.61)	0.81 (1.71)	0.76 (1.66)	0.72
T_3	Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP	21.25 g a.i./ha	0.88 (1.78)	0.72 (1.62)	0.70 (1.60)	0.73 (1.63)	0.78 (1.68)	0.79 (1.69)	0.72 (1.62)	0.68 (1.58)	0.61 (1.51)	0.72 (1.62)	0.68 (1.58)	0.73
T_4	Emamectin Benzoate 5% SG	10 g a.i./ha	0.80 (1.70)	0.64 (1.54)	0.62 (1.52)	0.65 (1.55)	0.68 (1.58)	0.78 (1.68)	0.68 (1.58)	0.65 (1.55)	0.74 (1.64)	0.77 (1.67)	0.79 (1.69)	0.69
T_5	Lambda cyhalothrin 5% EC	15 ml a.i./ha	0.83 (1.73)	0.68 (1.58)	0.63 (1.53)	0.61 (1.51)	0.72 (1.62)	0.78 (1.68)	0.68 (1.58)	0.62 (1.52)	0.59 (1.49)	0.65 (1.55)	0.67 (1.57)	0.66
T_6	Control (Untreated)	-	0.81 (1.71)	0.82 (1.73)	0.84 (1.74)	0.81 (1.71)	0.83 (1.74)	0.85 (1.75)	0.83 (1.74)	0.81 (1.71)	0.82 (1.72)	0.80 (1.65)	0.79 (1.69)	0.81
	SEm±		0.043	0.045	0.043	0.044	0.042	0.043	0.042	0.041	0.043	0.042	0.043	
	CD at 5%		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	

DAS= days after spray, ( ) figures in parentheses are square root transformed, NS= Non-significant

Table 4.10 Effect of different combination of insecticides on spiders during *Rabi* 2018-19

Treatment	Insecticide	Dose	Average no. of spiders/plant											
			Pre treatment	I Spray					II Spray					Over all mean
				1DAS	3DAS	7DAS	10DAS	15DAS	1DAS	3DAS	7DAS	10DAS	15DAS	
T_1	Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP	11 g a.i./ha	0.36 (1.26)	0.15 (1.03)	0.26 (1.16)	0.28 (1.18)	0.23 (1.13)	0.24 (1.14)	0.31 (1.21)	0.20 (1.10)	0.24 (1.14)	0.26 (1.16)	0.20 (1.10)	**0.23**
T_2	Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP	16g a.i./ha	0.39 (1.29)	0.18 (1.07)	0.29 (1.19)	0.18 (1.07)	0.27 (1.17)	0.25 (1.15)	0.23 (1.13)	0.27 (1.17)	0.31 (1.21)	0.23 (1.13)	0.27 (1.17)	**0.25**
T_3	Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP	21.25 g a.i./ha	0.38 (1.28)	0.17 (1.06)	0.26 (1.16)	0.22 (1.12)	0.28 (1.18)	0.26 (1.16)	0.28 (1.18)	0.24 (1.14)	0.23 (1.13)	0.22 (1.12)	0.24 (1.14)	**0.24**
T_4	Emamectin Benzoate 5% SG	10 g a.i./ha	0.40 (1.39)	0.18 (1.07)	0.29 (1.19)	0.18 (1.07)	0.27 (1.17)	0.25 (1.15)	0.23 (1.13)	0.27 (1.17)	0.31 (1.21)	0.23 (1.13)	0.25 (1.15)	**0.26**
T_5	Lambda cyhalothrin 5% EC	15 ml a.i./ha	0.32 (1.22)	0.13 (1.01)	0.26 (1.16)	0.15 (1.03)	0.22 (1.12)	0.24 (1.14)	0.26 (1.16)	0.20 (1.10)	0.24 (1.14)	0.18 (1.07)	0.22 (1.12)	**0.22**
T_6	Control (Untreated)	-	0.37 (1.26)	0.25 (1.15)	0.26 (1.16)	0.28 (1.18)	0.30 (1.20)	0.31 (1.21)	0.30 (1.20)	0.32 (1.22)	0.34 (1.24)	0.35 (1.25)	0.36 (1.26)	**0.30**
	SEm±		**0.010**	**0.015**	**0.013**	**0.012**	**0.013**	**0.014**	**0.015**	**0.012**	**0.013**	**0.011**	**0.010**	
	CD at 5%		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	

DAS= days after spray, ( ) figures in parentheses are square root transformed, NS= Non-significant



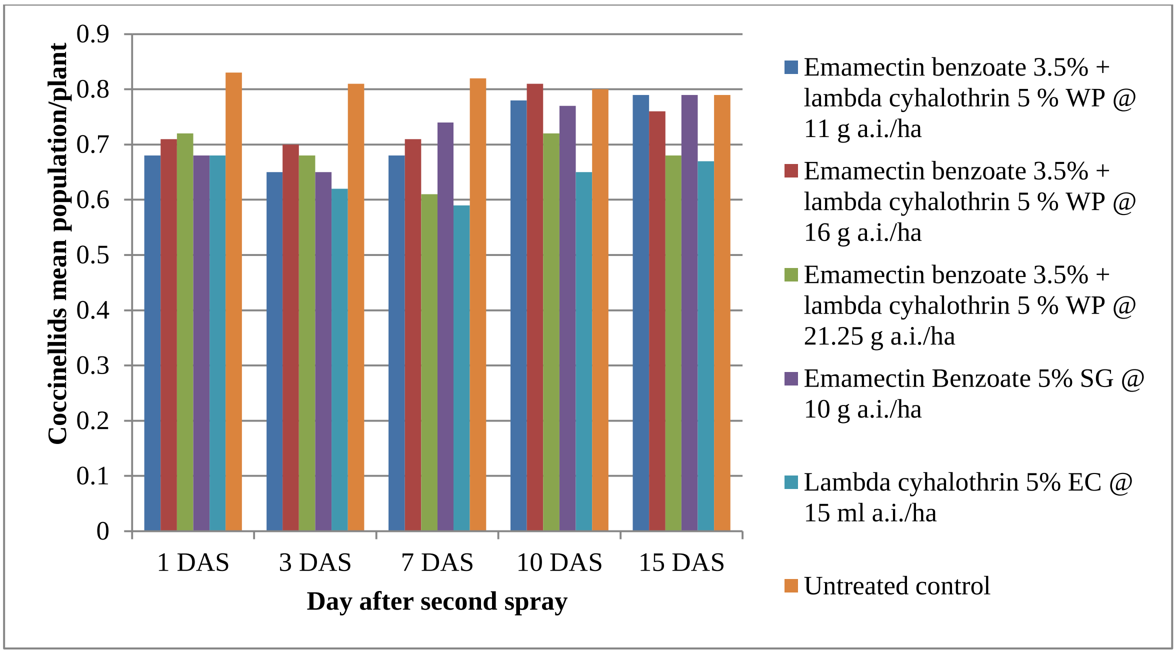
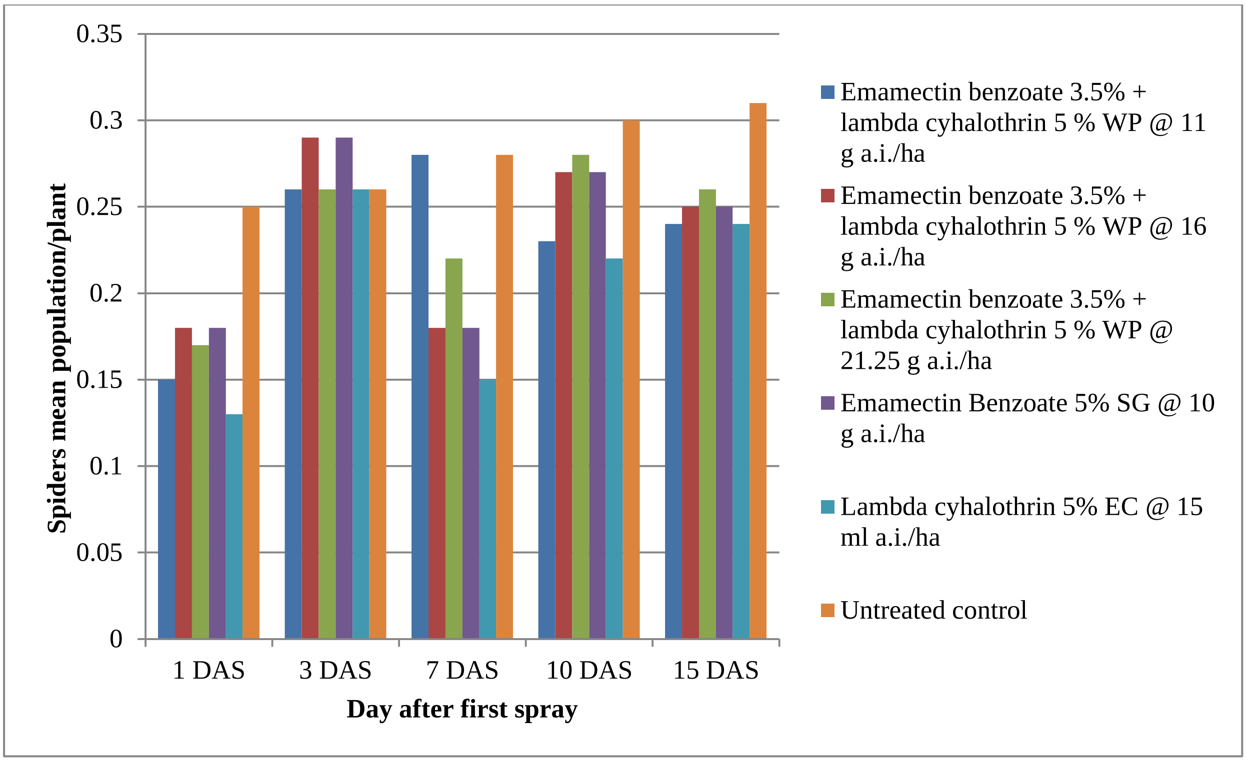


Fig. 4.22 Mean population of coccinellids per plant at different days after spray (DAS) during 1st and 2nd spray of insecticides



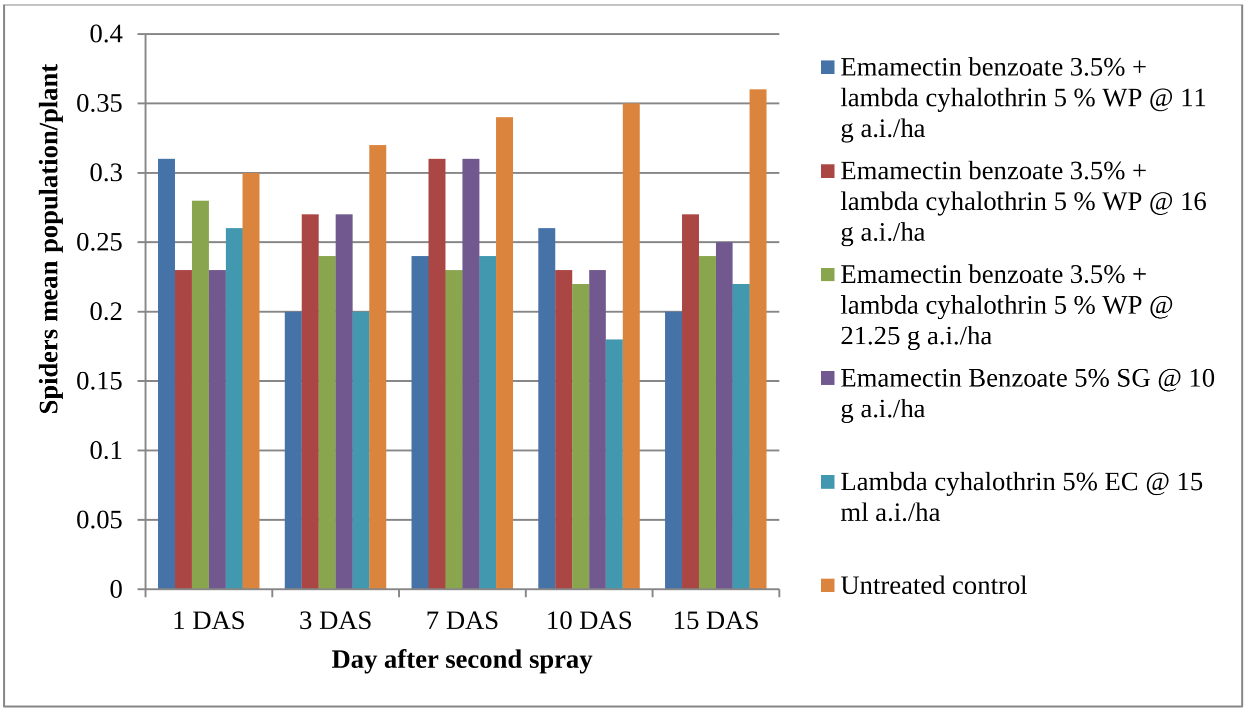


Fig. 4.23 Mean population of spiders per plant at different days after spray (DAS) during 1st and 2nd spray of insecticides

Table 4.11 Cost benefit ratio assessment of different treatments on chilli crop

S.No.	Treatments	Healthy Fruit yield (q./ha)	Increased healthy yield over Control (q./ha)	Price of increased healthy Yield over control (Rs./ha)	Cost of Treatment (Rs./ha)	Net profit (Rs./ha)	Cost Benefit Ratio
T1	Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP	91.12	3.01	7525	1581.84	5943.16	1:3.75
T2	Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP	92.72	4.61	11525	1756.48	9768.52	1:5.56
T3	Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP	94.66	6.55	16375	1940	14435	1:7.44
T4	Emamectin Benzoate 5% SG	90.26	2.15	5375	3684	1691	1:0.45
T5	Lambda cyhalothrin 5% EC	90.59	2.48	6200	2802	3398	1:1.21
T6	Control (Untreated)	88.11	-	-	-	-	-

Labour rate per day = Rs. 300 per labourer (2 labourer required for spraying in one hectare per day), Price of chilli 2500 Rs per quintal

The cost benefit ratio of different insecticidal treatments applied for the management of sucking pest has been calculated. The highest cost benefit ratio was found in treatment (T3) Emamectin Benzoate 3.5% + Lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (1:7.44) followed by (T2) Emamectin Benzoate 3.5% + Lambda cyhalothrin 5% WP @ 16 g a.i./ha (1:5.56) (Table 4.7).

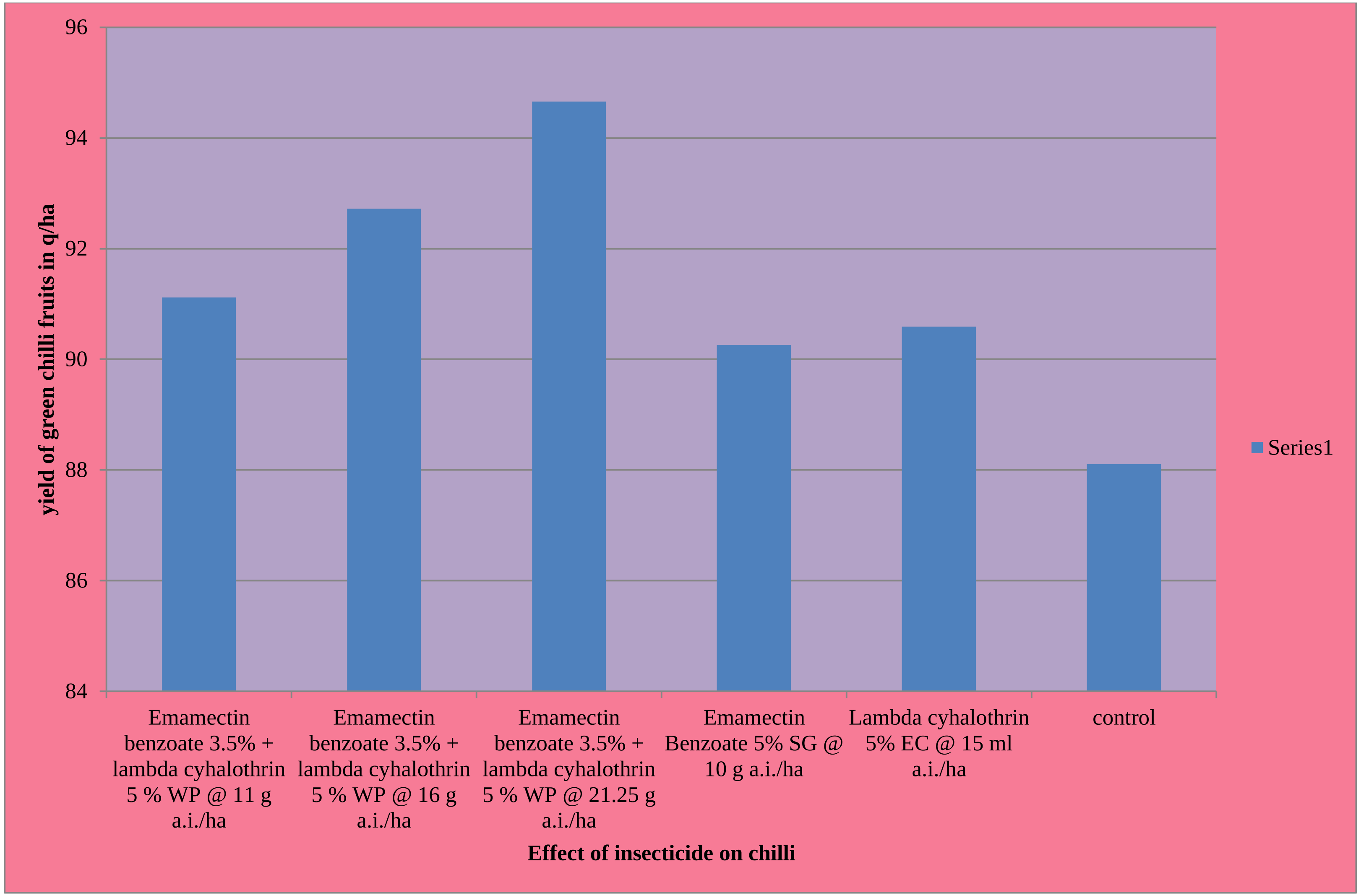


Fig. 4.24 Yield of healthy green chilli fruits

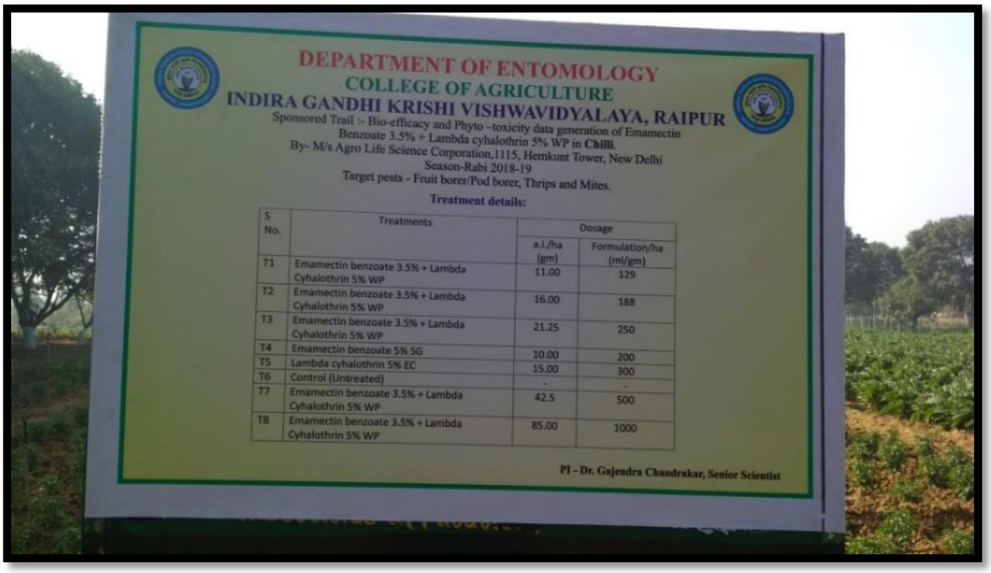


Plate: 4.3 Research field of bio-efficacy of insecticides on chilli

CHAPTER- V
SUMMARY AND CONCLUSION

The investigation entitled **"Seasonal incidence, population dynamics and efficacy of different combination of insecticide against sucking pests of Chilli (*Capsicum annum* L.)''** was undertaken with following objectives:

5.1 Studies on the seasonal incidence of major insect pests on chilli.

5.2 Studies on the population dynamics of major insect pests on chilli.

5.3 Studies on the bio-efficacy of different combination of insecticides against sucking pests on chilli.

The experiments were conducted at the experimental field of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C. G.). The experiments were carried out during *Rabi* season 2018-19. The findings are summarized below:

5.1 Studies on the seasonal incidence of major insect pests on chilli crop

Studies on the seasonal incidence of insect pests of chilli and their natural enemies revealed that thrips (*Scirtothrips dorsalis*), mite (*Polyphagotarsonemus latus* Bank) and aphid (*Aphis gossypii*) as sucking pests and another pest tobacco caterpillar (*Spodoptera litura*) was recorded. Lady bird beetle and spider as natural enemies on sucking pests of chilli were also recorded.

The population of thrips started from 26th November to 27th May. Its ranged from 0.74 to 22.2 thrips per plant and it was reached at peak point 22.2 thrips per plant during the period of first week of March. Activity of mite was recorded from 29th January to 20th May and its population ranged 0.09 to 1.44 mite per plant which was reached in peak point 1.44 per plant during the second week of April. Population of aphid ranged 0.31 to 18.97 per plant was observed during the active period from 26th November to 6th April and 18.97 aphid per plant was recorded as peak point during the first week of February. The seasonal incidence of tobacco caterpillar was started in first week of January on vegetative stage and it to be continued on flowering and fruiting stage. Active period of tobacco caterpillar of chilli was recorded from 1st January to 20th May, ranged from 0.12 to 2.30 per plant and it was reached in peak at 2.30 larvae per plant during the period of last week of January. Lady bird beetle population ranged from 0.3 to 4.9 per plant was recorded during the active period from 12th November to 27th May and it was reached in peak 4.9 per plant during third week of April. Spider population ranged from 0.21 to 3.21 per plant was recorded during the active period from 19th November to 27th May and it was reached in peak 3.21 per plant during the first week of January of active period.

5.2 Studies on the population dynamics of major insect pests on chilli crop

The population of thrips had positive and significant correlation with maximum temperature (r = 0.396*) and wind velocity (r = 0.543*) and negative significant correlation with relative humidity (r = -0.398*) in the morning. It showed non- significant positive correlation with minimum temperature and bright sunshine hours, while non-significant negative correlation with rainfall and evening relative humidity.

The population of mite had positive and significant correlation with maximum temperature (r=0.393*). Mite population also showed significant positive correlation with wind velocity (r =0.516*). It showed non- significant positive correlation with minimum temperature and sunshine hours, while non- significant negative correlation with rainfall, morning and evening relative humidity.

The population of aphid had positive and significant with morning relative humidity (r=0.410*). The aphid population also showed significant negative correlation with maximum temperature (r= -0.456*) and highly significant negative correlation with minimum temperature (r= -0.494**). The population of aphid in chilli had non-significant positive correlation with rainfall and evening relative humidity, while non- significant negative correlation with wind velocity and sunshine.

The population of *S. litura* in chilli had non-significant positive correlation with morning, evening relative humidity, sunshine and wind velocity. While non- significant negative correlation with maximum, minimum temperature and rainfall.

Thrips and mite population showed non-significant negative correlation with lady bird beetle and spider.

Aphid population showed significant negative correlation with lady bird beetle (r= -0.464*). The regression equation with lady bird beetle [y = -1.7025x + 7.887; R^2 =0.216] and non- significant negative correlation with spider.

5.3 Studies on the bio-efficacy of newer insecticides against sucking pests on chilli crop

Efficacy of Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP at three different doses *viz.*, 11, 16 and 21.25 g a.i./ha respectively has been tested against sucking insect pests along with single dose of Emamectin Benzoate 5% SG market sample (10 g a.i./ha) and Lambda cyhalothrin 5% EC (15 ml a.i./ha) were sprayed with an untreated control check.

The results of the experiment revealed that lowest mean population of thrips, was recorded in (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (10.69 thrips/plant) followed by (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (14.99 thrips/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (18.36 thrips/plant),(T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (21.34 thrips/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (22.14 thrips/plant). However, the maximum thrips population (30.93 thrips/plant) was noticed in control plot.

The results of the experiment revealed that lowest mean population of mite, was recorded in (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (2.74 mite/plant) followed by (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (2.93 mite/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (3.39 mite/plant),(T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (3.72 mite/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (4.14 mite/plant). However, the maximum mite population (7.05 mite/plant) was noticed in control plot.

The results of the experiment revealed that lowest mean population was recorded in (T3) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha (3.01 aphid/plant) followed by (T2) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha (3.98 aphid/plant), (T1) Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 11 g a.i./ha (4.61 aphid/plant),(T5) Lambda cyhalothrin 5% EC @ 15 ml a.i./ha (5.20 aphid/plant) and it was on at par with the treatment of (T4) Emamectin Benzoate 5% SG @ 10 g a.i./ha (5.81 aphid/plant).However, the maximum mite population (8.74 aphid/plant) was noticed in control plot.

Impact of different doses of Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP at different days after spray was observed and no adverse effect was found on natural enemies (coccinellid and spider) during experimental period.

CONCLUSIONS

The peak population of thrips was observed in first week of March (22.2 thrips per plant) while, the highest activity of mite and aphid was observed in second week of April (1.44 mite per plant) and the first week of February (18.97 aphid per plant), respectively. The peak population of tobacco caterpillar 2.30 larvae per plant during the period of last week of January. The peak population of Lady bird beetle was recorded 4.9 per plant during third week of April. The peak population of spider was observed in first week of January (3.21 per plant).

The population of thrips had positive and significant correlation with maximum temperature (r = 0.396*) and wind velocity (r = 0.543*). The negative and significant correlation with morning relative humidity (r = -0.398*). The population of mite also showed positive significant correlation with maximum temperature (r =0.393*) and significant positive correlation with wind velocity (r =0.516*). The population of aphid had positive significant correlation with morning relative humidity (r =0.410*). The aphid population also showed significant negative correlation with maximum temperature (r= -0.456*) and highly significant negative correlation with minimum temperature (r= -0.49**). Aphid population showed significant negative correlation with lady bird beetle (r= -0.464*).

Efficacy of Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 21.25 g a.i./ha against thrips, mite and aphid was found to be most effective chemical because it recorded the lowest insect mean population. The second best treatment was Emamectin Benzoate 3.5% + lambda cyhalothrin 5% WP @ 16 g a.i./ha.

SUGGESTIONS FOR FUTURE RESEARCH WORK

- The study should be repeated for two or more years to verify result and the conclusions.
- Behaviour and biology should be studied in detail as it helps in detailed study of beneficial insects and natural enemies.
- The observations of insect pests and natural enemies were taken very carefully from the field for proper forecast of incidence of insect pests.
- Looking onto high cost of insecticide and hazards to environment, different suitable integrated insect pest management strategies for the region are needed to be practiced.

- Further studies on the residual periods of insecticides on the crop and development of insecticide resistance in insect pests should be carried out.
- Apart from bio- rationals, bio- pesticides can also be used for the purpose of managing the insect pests.

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