"STUDIES ON THE PEST SUCCESSION IN OKRA (*Abelmoschus esculentus* (L.) Moench) AND ASSOCIATED NATURAL ENEMIES AT LORMI, MUNGELI DISTRICT OF CHHATTISGARH."

M. Sc. (Ag.) THESIS

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INDIRA GANDHI KRISHI VISHWAVIDYALAYA RAIPUR
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"STUDIES ON THE PEST SUCCESSION IN OKRA (*Abelmoschus esculentus* (L.) Moench) AND ASSOCIATED NATURAL ENEMIES AT LORMI, MUNGELI DISTRICT OF CHHATTISGARH."

Thesis

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CHANDRA PRAKASH

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CERTIFICATE - I

This is to certify that the thesis entitled **"Studies on the pest succession in okra (*Abelmoschus esculentus* (L.) Moench) and associated natural enemies at Lormi, Mungeli district of Chhattisgarh."** submitted in partial fulfillment of the requirement 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 **Chandra Prakash** under my guidance and supervision. The subject of the thesis has been approved by Student's Advisory Committee and the Director of Instructions.

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

Date....11/08/2021...

Chairman

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

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Member	**Dr. (Smt.) Sonali Deole**	
Member	**Dr. H. K. Panigrahi**	
Member	**Dr. R. R. Saxena**	

CERTIFICATE-II

This is to certify that the thesis entitled **"Studies on the pest succession in okra (*Abelmoschus esculentus* (L.) Moench) and associated natural enemies at Lormi, Mungeli district of Chhattisgarh."** submitted by **Chandra Prakash** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur, in partial fulfilment of requirement for the degree of **Master of Science** in **Agriculture 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.

Signature of Head of the Department

(Name Dr. V. K. Dubey.....)

Date: - 22/09/2021

Major Advisor .....

Faculty Dean .....

Approved/Not approved

Director of Instruction .....

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Date ..11/08/2021

CHANDRA PRAKASH

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@	At the rate of
%	Percent
/	Per
°c	Degree Celsius

LISTS OF ABBREVATIONS

a.i.	Active ingredient
Cm	Centimeter
WAS	Week after sowing
et al.	And others/co-workers
Fig.	Figure
G	Gram
Ha	Hectare
Hrs	Hours
viz.	Namely
WP	Wettable Powder
VS	Vegetative stage
FS	Fruiting stage
RS	Reproductive stage
NS	Non-significant
i.e.	That is
WAS	Week after sowing
SMW	Standard meteorological week
C.G.	Chhattisgarh
MaxT	Maximum temperature
MinT	Minimum temperature

ABSTRACT

a	Title of the Thesis	:	"Studies on the pest succession in okra (*Abelmoschus esculentus* (L.) Moench) and associated natural enemies at Lormi, Mungeli district of Chhattisgarh."
b	Name of the Student	:	Chandra Prakash
c	Major Subject	:	Entomology
d	Name and address of the major advisor	:	Dr. (Smt.) Jayalaxmi Ganguli Dept. of Entomology, C.O.A, IGKV, Raipur (C.G.)
e	Degree to be Awarded	:	Master of Science in Agriculture (Entomology)

Signature of the student

Signature of major advisor

Date---11/08/2021---

Signature of Head of Department

ABSTRACT

Okra (*Abelmoschus esculentus* (L.) Moench), generally known as bhindi or lady's finger, is a member of the Malvaceae family and grown throughout the year in India. In Chhattisgarh it is called "Ramkeria". The present investigation entitled **"Studies on the pest succession in okra (*Abelmoschus esculentus* (L.) Moench) and associated natural enemies at Lormi, Mungeli district of Chhattisgarh"** was conducted at the farmer's field in Dindori village of Lormi tehsil under Mungeli district of Chhattisgarh, during the *Kharif* season of 2020.

Under the studies on pest succession, 10 species of the insects, belong to 4 orders *viz.*, Hemiptera, Lepidoptera, Coleoptera and Odonata which included 7

insect pests and 3 natural enemies were recorded. Sucking pests like aphid (*A.gossypii)*, jassid (*A. biguttula*), and whitefly (*B. tabacii*) were observed damaging during vegetative stage of okra. The okra shoot and fruit borer (*E. vittella*) and tobacco caterpillar, *Spodoptera litura* were observed damaging mainly shoots during vegetative stage and fruit damage during the fruiting stage of the crop were caused by two insect pests *i.e.* okra shoot and fruit borer (*E. vittella*) and the fruit borer (*H. armigera*). The tobacco caterpillar (*S. litura)* was recorded throughout the vegetative stage up to the harvesting period of the crop. Red cotton bug (*D. cingulatus*) was recorded from 6 WAS onwards throughout the period of the crop.

Maximum activity of the insect pests (aphids, jassids whiteflies, okra shoot and fruit borer, (*E. vittella*) and *H.armigera*, tobacco caterpillar, (*S. litura)*and red cotton bug, (*D. cingulatus*) were found during the 2nd fortnight of the October or 9-10 WAS.

Aphid, (r=0.577**) whitefly, (r=0.580**) shoot and fruit borer, *E.vitella* (r=0.603**) showed positive significant correlation with maximum temperature while jassids depicted positive significant correlation with both maximum temperature, (r=0.610**) and minimum temperature, (r=0.604**). Lady bird beetle, (r=0.780**) showed highly positive significant correlation with aphid population. Most of the insects exhibited positive correlation with minimum temperature and morning relative humidity and negative correlation with rain fall and evening relative humidity and BSS.

शोध सारांश

(अ)	शोध का शीर्षक	:	"छत्तीसगढ़ के मुंगेली जिले के लोरमी में भिंडी *(एबेलमोस्कस एस्कुलेंटस* (एल.) मोएंच) में कीट उपक्रम तथा संबद्ध प्राकृतिक शत्रुओं पर अध्ययन"
(ब)	विद्यार्थी का पूरा नाम	:	चन्द्र प्रकाश
(स)	मुख्य विषय	:	कीट विज्ञान
(द)	मुख्य सलाहकार का नाम एवं पता	:	डॉ. (श्रीमती) जयालक्ष्मी गाँगुली , प्राध्यापक (कीट विज्ञान विभाग) कृषि महाविद्यालय, इंदिरा गाँधी कृषि विश्वविद्यालय, रायपुर (छ.ग.)
(इ)	सम्मानित किये जाने वाला उपाधि	:	एम. एस .सी. (कृषि)

विद्यार्थी का हस्ताक्षर

मुख्य सलाहकार का हस्ताक्षर

दिनांक 11/08/2021

विभागाध्यक्ष का हस्ताक्षर

शोध सारांश

ओकरा (*एबेलमोस्कस एस्कुलेंटस* (एल.) मोएंच) मालवेसी परिवार का सदस्य है, जिसे आमतौर पर भिंडी या लेडिस फिंगर कहते हैं। छत्तीसगढ़ में इसे 'रमकेरिया' के नाम से जाना जाता है। भिंडी पूरे भारत में साल भर उगाई जाती है। वर्तमान शोध कार्य छत्तीसगढ़ के मुंगेली जिले के लोरमी तहसील के डिंडोरी गांव में किसान के खेत में वर्ष २०२० के खरीफ मौसम के दौरान "छत्तीसगढ़ के मुंगेली जिले के लोरमी में भिंडी *(एबेलमोस्कस एस्कुलेंटस* (एल.) मोएंच) में कीट उपक्रम तथा संबद्ध प्राकृतिक शत्रुओं पर अध्ययन" नामक शीर्षक से संपादित की गई।

कीट उपक्रम पर अध्ययन के तहत कीड़ों की दस प्रजातियां दर्ज की गई जो कि चार वर्ग– हेमिप्टेरा, लेपिडोप्टेरा, कोलिओप्टेरा और ओडोनाटा से संबंधित थे जिसमें सात शत्रु कीट और तीन प्राकृतिक मित्र कीट शामिल थे। भिंडी की वानस्पतिक अवस्था के दौरान चूसने वाले कीट जैसे, एफिड *(एफिस गोसिपी)* जैसिड *(एमेरसका बिगुटुला)* और सफेद मक्खी *(बेमेसिया टेबेकी)* को नुकसानदायक पाया गया। भिंडी के प्ररोह और फल छेदक *(ईरियास विटेला)* और तंबाकू की इल्ली *(स्पोडोप्टेरा लिटुरा)* को वानस्पतिक अवस्था के दौरान मुख्य रूप से प्ररोहों को नुकसान पहुँचाते हुए देखा गया था और फल के लगने की अवस्था के दौरान फलों को दो कीटों जैसे भिंडी की प्ररोह और फल छेदक *(ई. विटेला)* और फल छेदक *(हेलिकोवर्पा आर्मिज़ेरा)* क्षति करते पाये गये। तंबाकू कि इल्ली *(स्पोडोप्टेरा लिटुरा)* को पूरे वानस्पतिक चरण से फसल की कटाई की अवधि तक दर्ज किया गया था। लाल कपास का मत्कुण *(डिस्करकस सिन्गुलेटस)* फसल की पूरी अवधि के दौरान फसल बोने के छः सप्ताह के बाद से दर्ज की गई।

इस रस चूसक कीटों में एफिड *(एफिस गोसिपी),* जैसिड *(एमेरसका बिगुटुला)* और सफेद मक्खी *(बेमेसिया टेबेकी)* भिंडी का प्ररोह और फल छेदक *(ई. विटेला)* और फल छेदक *(हे. आर्मिज़ेरा),* तंबाकू की इल्ली *(स्पोडोप्टेरा लिटुरा)* और लाल कपास का मत्कुण *(डिस्करकस सिन्गुलेटस)* की अधिकतम गतिविधि अक्टूबर के दूसरे सप्ताह या फसल बुवाई के नवें से दसवें सप्ताह बाद पाई गई।

एफिड, (r=0.577**) सफेद मक्खी, (r=0.580*) प्ररोह और फल छेदक, *ई. विटेला* (r=0.603**) ने अधिकतम तापमान के साथ सकारात्मक महत्वपूर्ण सहसंबंध दिखाया, जबकि जैसिड्स ने अधिकतम तापमान, (r=0.610**) और न्यूनतम तापमान, (r= 0.604**) के साथ सकारात्मक महत्वपूर्ण सहसंबंध दर्शाया, कॉक्सीनेलिड भृंग (r= 0.780**) ने एफिड की संख्या के साथ अत्यधिक सकारात्मक महत्वपूर्ण सहसंबंध दिखाया, अधिकांश कीटों ने न्यूनतम तापमान और सुबह की सापेक्ष आर्द्रता के साथ सकारात्मक सहसंबंध एवम बारिश की गिरावट, शाम की सापेक्ष आर्द्रता और बुनियादी धूप घंटे के साथ नकारात्मक सहसंबंध प्रदर्शित किया।

CHAPTER –I

INTRODUCTION

Vegetables are indispensable part of diet, providing the carbohydrates, vitamins and minerals needed for a balanced diet. Their value is particularly important in many developing countries such as India, where malnutrition is a major problem for children and adults. (Khan *et al*., 2001 and Randhawa, 1974).

Among the many vegetables grown, okra (*Abelmoschus esculentus* (L.) Moench) of the Malvaceae family, which originated in Ethiopia, is an economically important vegetable crop grown in tropical and subtropical regions around the world.

Okra (*Abelmoschus esculentus* (L.) Moench) can be grown as a kitchen garden crop as well as in large area or high-tech commercial farms. It has heat and drought tolerant varieties and can tolerate soil with heavy clay and intermittent moisture, but frost can damage okra pods. Okra (*Abelmoschus esculentus* (L.) Moench), also known as ladies' fingers or ochro in many English-speaking countries, is prized for its edible green seed pods.

In various parts of the world, okra is known by a variety of local names. It is commonly referred to as a lady's finger in England, a gumbo in the United States of America, a guino-gumbo in Spanish, a guibero in Portuguese, bhindi in India, and Ramkeriya in Chhattisgarh.

Okra (*Abelmoschus esculentus*(L.) Moench) can grow from 3- 6 feet tall. It prefers a soil temperature at least of 20 °C (68 °F) for germination. Soaked seeds can germinate within six days. Seedlings require sufficient water. Okra has many varieties with insect pest resistance, disease resistance, drought resistance and high yields.

It is commercially cultivated in India, Iran, Turkey, Ghana, Western Africa, Japan, Yugoslavia, Bangladesh, Burma, Afghanistan, Malaysia, Brazil, Ethiopia and the United States of America. The major producing states in India are West Bengal, Karnataka, Uttar Pradesh, Andhra Pradesh, Assam and Bihar (Anonymous, 2004).

In India total area of okra was 509 thousand ha and production of 6094 thousand MT with 12.0 MT /ha productivity (Anonymous, 2018). Chhattisgarh state produces about 323.24 thousand MT of okra form an area of 30.88 thousand ha with productivity of 10.47 MT/ha, contributing about 4% of the total production of okra in country. (Anonymous, 2018).

Okra seeds are roasted, ground, and used as a coffee substitute in some countries. In the paper industry, mature fruits and stems containing raw fibre are used. Okra seed extracts are used as an alternative source of edible oil. The greenish-yellow edible oil has a pleasant taste and smell, and it is high in unsaturated fats like linoleic acid and oleic acid. The oil content of the seed is quite high, at around 40%. According to a 2009 study, okra oil is suitable for use as a biofuel. (Pugazhendhi *et al.* 2020)

Vitamins, potassium, calcium, and other minerals are abundant in okra, which are frequently deficient in the diets of developing countries. It has a high nutritional value, known for its high calcium (90 mg/100g), iron (1.5 mg/100g), vitamin C (30 mg per 100 g), and other minerals such as potassium, magnesium, vitamin A and B, carbohydrates, and fats (Aykroud, 1963). Except for bitter gourd, "okra" has a higher total nutritive value than cabbage, eggplant, and most other cucurbits.

Soups and stews of okra are also common. Tender fruits, which are rich in mucilage and used in soups and gravies, have high mucilage content. It also contains crude fibre from the okra plant's stem, which is used to make ropes.

The fruits of okra have a variety of medicinal properties. Mucilaginous pod that can be used to replace plasma or expand blood volume. Okra is said to help with genito-urinary disorders, sperm production, and chronic dysentery (Nandkarni, 1927). Its medicinal properties have also been documented to aid in the healing of ulcers and the relief of hemorrhoids (Adams, 1975). In 1898, it was confirmed that unspecified parts of the okra plant had diuretic properties (Felter *et al.* 2009).

The cultivation of okra is hampered by numerous constraints. Many of the pests that attack cotton also attack the okra crop. Srinivasa and Rajendran (2003)

counted 72 species of insects on okra, with the okra shoot and fruit borer, *Earias* spp. aphids, white fly, *Bemisia tabaci* (Gennadius), *Aphis gossypii* (Glover), and leaf hopper, *Amrasca biguttula biguttula* (Ishida) causing the most damage to the crop. The most dangerous and significant limiting factor in both the quantitative and qualitative harvesting of okra fruits is the okra shoot and fruit borer, Earias spp. It is a widespread insect pest that has been found infesting safflower, hollyhock, cotton, and okra. (Khan and Verma, 1946).

The sucking pests generally attack from early stage to fruit harvesting stage of the crop. Jassid attack causes the leaves to curl upward along the tip and margins and develop necrotic areas which extend over entire surface resulting in hopper burn. (Raghuwanshi *et al*. 2019)

According to study, okra shoot and fruit borer (*Earias* spp.) on okra caused a loss of 69 percent of marketable yield (Rawat and Sahu, 1973). *Earias* spp. appeared with the start of fruiting, and the infestation observed a rate of up to 100 percent after 12 weeks of sowing, with an average larval population of 1.3 per fruit (Radke and Undirwade,1981). The spoiled fruits could not be consumed. The "Prabhani kranti" variety of okra was recorded with 58.80 percent avoidable fruit losses by shoot and fruit borer in Raipur, Chhattisgarh (Dubey and Ganguli, 1998).

To prevent losses from the okra shoot and fruit borer, large amounts or high doses of pesticides are used. Normally, vegetable cultivators spray ten to twelve times on okra, and since such fruits are harvested at such short intervals, they maintain a high level of pesticide residues, which can be extremely harmful and carcinogenic to consumers, workers, and farmers. Furthermore, the overuse of chemicals has resulted in the issue of resurgence, resistance, toxicity, and the extinction of beneficial flora and fauna.

Keeping the above points in mind, the present investigation has been taken up with the following title **"Studies on the pest succession in okra (*Abelmoschus esculentus* (L.) Moench) and associated natural enemies at Lormi, Mungeli district of Chhattisgarh."** during the kharif season of 2020, with the following objectives: -

1. **To study the pest succession in okra (*Abelmoschus esculentus* (L.) Moench) at Lormi (district – Mungeli) Chhattisgarh.**
2. **To record the associated natural enemies throughout the period of study.**

CHAPTER-II

REVIEW OF LITERATURE

The literature relating to several aspects of the present investigation entitled **"Studies on the pest succession in Okra (*Abelmoschus esculentus* (L.) Moench) and associated natural enemies at Lormi, Mungeli district of Chhattisgarh"** from Chhattisgarh, India and abroad has been reviewed and grouped under the following headings: -

2.1 To study the pest succession in Okra (*Abelmoschus esculentus* (L.) Moench) at Lormi (district – Mungeli) Chhattisgarh.

Dhamdhere *et al*. (1984) found arthropod pests in okra during the season kharif of 1980 and summer of 1981 at Gwalior, M.P. In both the seasons cicadellid, *Amrasca biguttula biguttula* Ishida was remained active. In 1980 low humidity was responsible for the population buildup of shoot and fruit infestation by *E. vittella* which was 5.5 to 23.9 and 25.93 to 40.91 % in kharif and summer season, respectively in 1980 and 4.65 to 17.15 and 16.62 to 17.5 % in 1981. Infestation by *Melanagromyza hibisci* in 1980 and 1981 was 2.56 to 22.91 and 1.27 to 16.31 %, respectively. Other pests recorded were *Bemisia tabaci, A. gossypii, N. viridula, Dysdercus koenigii, Tetranychus telarius and Sylepta derogata.*

Srinivasan *et al*. (1988) documented seasonal pattern of leafhopper (*Amrasca biguttula biguttula* Ishida*)* on okra during 1981-83 in Karnataka. The weekly seasonal incidence of okra leafhopper was calculated using time series analysis. From June to mid-January, there was a low incidence of leafhoppers. The occurrence of leafhoppers had a substantial positive connection with the MinT, according to the findings. The first week of April to the first week of June saw the highest occurrence.

Mahamood *et a*l. (1990) found pest *Amrasca biguttula biguttula* Ishida appearance on crop okra in Pakistan and recorded the leaf hopper activity till end of the crop season Furthermore, among numerous environmental parameters, the influence of maximum and MinimumTemprature on pest density was the sole significant component in both years (1986-87). The pest populations were not affected by relative humidity or rainfall.

Nii-Arku *et al*. (2001) investigated the impact of various soil amendment procedures and neem products on the management of okra insect pests. at At the University of Ghana's Ashaiman irrigation project site. Insect pests were found in seven orders, which were divided into twenty-three families. *Bemesia tabaci* (Genn.*), A. gossypii* (Glov.), *Dysdercus* spp. *Heliothis armigera* (Hb.) synonym *H. armigera* (Hb,), *Anthonomus grandis* (Boh.), *Podagrica uniformis* (Jac.), *Sylepta derogata* (Fab.) and *Calidea* spp. *Empoasca* spp. *Riptortus* and *Pachnoda* spp. were also found important in attacking the okra fruits in the Ashaiman. *Coccinella* spp., *Cheilomenes vicinia* (Muls.), *Odonata* spp. and *Rhinocoris rapax* (L.) were included *under* beneficial insects.

Anitha *et al.* (2007) recorded that the seasonal incidence and management of okra sucking pests at Main Agricultural Research Station, Dharwad, Karnataka during 2006-07. Seasonal incidence studies on okra sucking pests and their natural enemies revealed that the activity of leafhopper, aphid and coccinellid was more during kharif while, the activity of whitefly, mite, and Chrysoperla was high during summer crop. Leafhopper, aphid, and whitefly infestations were seen throughout the cropping period in all three seasons, with three peaks (June-July, October-November, and January-February), three peaks (June-July, September-October, and December-January), and two peaks (April and February-March). In all three seasons, mite emergence was delayed by 2-4 weeks, with three peaks (May-June, October-November and February-March). Throughout the cropping season, the population of coccinellid and Chrysoperla was low. However, the coccinellid population was observed peak in October.

Netam *et al*. (2007) studied on the insect pest succession on okra at Raipur, Chhattisgarh, India during Kharif and Rabi seasons of 2002 and 2003, respectively. Twenty-four and Twenty cultivars were screened during the years 2002 and 2003, respectively. During Kharif 2002, 9 insect pests *viz*. shoot and fruit borer (*E. vittella*), whitefly, (*B. tabaci*), Jassid (*A. biguttula biguttula*), aphid (*A. gossypii*), red cotton bug (*D. koenigii*), semilooper (*Anomis flava*), Red hairy caterpillar (*Amsacta moorei*), green stink bug (*Nezara viridula*) and gram pod borer (*Heliothis armigera*) were noticed. During Rabi season in the year 2003, 5 insect pests *viz*. shoot and fruit

borer, whitefly, jassid, leaf miner and semi looper were observed. Shoot and fruit borer and jassid populations was observed during the whole cropping season while, aphid, whitefly and leaf miner was observed only during vegetative stages.

Singh *et al.* (2008) conducted an field experiment from 2005 to 2007 and evaluated different insecticidal modules against major pests *viz*. *Amrasca biguttula biguttula* (Ishida) and fruit borer *Earias* spp. (Boisd) in okra. Each test module consisted of three treatments with different pesticide combinations at fortnightly intervals, starting from the appearance of pests after sowing. All of the modules were shown to be significantly better than the untreated control. Module-1, which included imidacloprid 100 ml/ha, acephate 1000g/ha, and indoxacarb 500ml/ha, had the lowest fruit damage (13.08 percent) and maximum fruit yield (80.72 q/ha) with the highest net return (Rs. 40070/-), which was comparable to module-2 (three sprays of acephate 1000g/ha) in terms of fruit damage and yield. Module-3, which consisted of two imidacloprid 100 ml/ha sprays and one endosulfan 1250 ml/ha spray, provided the best protection against jassid (83.05 percent), which was comparable to Module-I. Module 3 failed to provide fruit borer protection and produced much lower fruit yields and economic returns than module 1.

Sharma *et al*. (2009) experimented at I.A.R.I. New Delhi, and explained that in both sprays, endosulfan @700 g a.i./ha was the most effective treatment against leafhoppers, followed by alphamethrin @ 40 g a.i./ha and Polytrin (440 & 880 g a.i./ha). Both alphamethrin and endosulfan dosages were successful in controlling whiteflies Fruit borer damage in various treatments were ranged from 11.816.4% while it was 25.3% in control on weight basis. Although all of the treatments were effective, endosulfan was the most effective against fruit borer in terms of both number and weight. All of the treatments were successful, with yields ranging from 4.171 to 5.720 MT/ha, compared to 3.035 MT/ha in control. However, Indoxacarb at 70 g a.i./ha had the highest yield.

Konar *et al*. (2013) reported that the incidence of aphids during two consecutive kharif seasons of 2010 and 2011 at Hooghly, West Bengal, started during the second week of July and population increased gradually and reached its peak during the first week of September (39.28 aphids/3 leaves) when minimum and

MaxT reached 26.1 and 33.5^{0}C and 33.5^{0}C, minimum and maximum relative humidity 72.57%, respectively with 1.6mm rainfall which persisted throughout the crop period with low incide

Sabyasachi *et al*. (2013) studied on the infestation of insect pests infesting the crop okra (cv. Indam-9) in Sriniketan, West Bengal, India, during the summer season (March-June) of 2009, in which following insects were recorded: leaf miner nce. (*Liriomyza trifolii*), jassid (*A. biguttula biguttula*), flea beetle (*Phyllotreta downsei*), mealy bug (*F. virgata*), white fly (*B. tabaci*), aphid (*A. gossypii*), shoot and fruit borer (*E. vittella*), red cotton bug (*D. cingulatus*), painted bug (*Bagrada cruciferarum* [*B. hilaris*]), green stink bug (*Acrosternum hilare*) and a grasshopper. Pest population incidence varied significantly depending on the stage of crop development. Leaf miner and flea beetle were more common in the early stages of the crop, whereas jassid (*A. biguttula biguttula*), white fly (*B. tabaci*), aphid (*A. gossypii*), and mealy bugs were more common as the crop progressed. Red cotton bug and lepidopteran borer infestations were most common during the reproductive stage. The incidence of leaf miners and flea beetles was negatively correlated with maximum and Minimum Temprature, rain, relative humidity and sunshine hours, but was negatively correlated with the incidence of other insect pests.

Shukla *et al*. (2014) explained the seasonal incidence of various sucking pests on okra during the crop season which was significantly different at crop growth period. The aphid population peaked (27.17 aphids/3 leaves) during the 14th week after seeding, according to the period mean (first week of July). During the months of June and July 2011, the aphid population on the crop was at its peak. The correlation studies between the incidence of major sucking insect pests and selected weather parameters revealed that maximum activity was recorded in July, and aphids showed a positive correlation with rainfall (r = 0.261) and a negative correlation with both maximum and MinT, but aphids showed a positive correlation with relative humidity.

Akbar and Khan, (2015) explained population dynamics of insect pests on 6 okra varieties in Peshawar. *B. tabaci* and *A. gossypii* were found to be the primary pests of all okra cultivars in Peshawar, according to the findings. Both pest

populations peaked in June and July. *B. tabaci* and *A. gossypii* had significantly greater mean densities (2.27 and 2.13 individuals per leaf) on Malay than on the other cultivars.

Wagon *et al*. (2015) studied the okra crop was infested by a various number of insect pests, among these *Amrasca devastans* was the most notorious and major insect pest. This hazardous pest was controlled by a variety of insect and non-insect predators. After 25 days of germination, the crop was monitored at 10-day intervals. The Jassid population began to grow after the second week of observation and lasted until the last picking. Many species of spiders, ladybird beetles, ants, and green lacewings were among the natural enemies observed at various times. Jassid populations appeared after germination and infested the crop until the end, according to this study. The rise in plant vegetative growth led to a considerable increase in Jassid numbers. Natural enemies developed at different times, and populations increased as the quantity of jassid per plant increased. Natural enemies were also found to lower jassid populations, making them a good source of pest control in the field.

Huggi *et al.* (2016) investigated the population dynamics of natural enemies on lepidopteran pests, toxicity of insecticides on natural enemies and the management of fruit borers in okra at the Main Agricultural Research Station, UAS, Dharwad during the year 2015-16. In comparison to the first fortnight of August, natural enemies were more active on crops sown during the first and second fortnights of July. *Cheilomenes sexmaculata* populations were at their peak during the first week of September. The occurrence of *Bracon* spp. parasitizing fruit borers was highest during the third week of September, while fungus *Nomuraea rileyi* parasitizing *H. armigera* was highest during the first week of September. Laboratory studies on the toxicity of insecticides to *C. zastrowisillemi* and *T. chilonis* revealed that chlorpyriphos and cypermethrin caused the highest mortality (100 %) of *Chrysoperla* 2nd instar larvae, while azadirachtin and emamectin benzoate treatments caused relatively lower mortality (78.83 %). Monocrotophos and spinosad, on the other hand, caused 95.83 % death and drastically reduced adult survival, making them the most dangerous insecticides for *T. chilonis*. Emamectin

benzoate and lufenuron, which caused 80.83 and 81.67 % mortality, respectively, were shown to be relatively harmless to the parasitoid. Chlorantraniliprole, flubendiamide, and emamectin benzoate were found to be effective in the field at reducing the population of fruit borers *(Helicoverpa armigera)* with B:C ratios of 2.99, 2.57, and 2.49, respectively. Azadirachtin (0.81 grub/plant and 0.67 grub and adult/plant, respectively) and emamectin benzoate (0.73 grub/plant and 0.59 grub and adults/plant) had the highest mean population of predators, namely C. sexmaculata and *C. zastrowisillemi*, showing their safety from natural enemies.

Aarwe *et al*. (2016) observed the effect of the weather factors on incidence of major insect pests on okra during the kharif season 2014 at JNKV, Jabalpur. The population of *A. biguttula biguttula* had a significant positive association with maxT (r=0.58) and *B. tabaci* had a substantial positive correlation with minT (r=0.67), while *A. gossypii* and *E. vittella* had a non-significant link with meteorological parameters.

Khating et al. (2016) undertook studies on seasonal incidence of sucking pests of okra along with natural enemies at research farm of Department of Agricultural Entomology, College of Agriculture, Dhule during Kharif 2015, revealed that Leafhopper activity peaked in the second week of September (23 leafhoppers/3 leaves/plant), while aphid activity peaked in the first week of September (43.3 aphids/3 leaves/plant). When the population of sucking pests was at its peak, the second week of September had the highest incidence of whiteflies (21 whiteflies/3 leaves/plant), whereas the second week of September saw the highest activity of the predator lady bird beetle (26 lady bird beetle/plant). Aphids (r=0.170), leafhoppers (r=-0.060) and whiteflies (r=0.287) had no significant relationship with MaxT. The MinT had a non-significant positive link with leafhoppers (r=0.131) and a significant positive correlation with aphids (r=0.644). The presence of whiteflies (r=0.313), leafhoppers (r=0.454) and aphids (r=0.458) was positively correlated and non-significant to morning relative humidity. Similarly, during the Kharif 2015 season, the evening relative humidity had a negative non-significant link with pests such as leafhoppers (r=-0.100), whiteflies (r=-0.339) and aphids (r=-0.223). With leafhopper, whitefly and aphid rainfall had

no significant influence at the 5% and 1% levels.

Pathan *et al*. (2016) observed that the incidence of whitefly remained low throughout season during summer, 2015. The population aphid showed highly significant negative association with Bright Sunshine Hours (BSS) (r=-0.72). Higher activity of mite was recorded during 4th week of May. Temperature (MinT and MaxT), BSS and Wind Speed (WS) were the important abiotic factors which affected the fluctuation of mite population. The activity of *Earias vittella* Fab. as fruit borer was highly correlated with BSS (0.83), WS (0.74), MaxT (0.79) and MinT (0.85). Spiders, as universal predator showed significant positive association with MaxT (0.59) and MinT (0.72). Correlation study between/among various insect pests indicated that aphid had significant association with the activity of leafhopper (r= 0.60), whereas, *E. vittella* showed highly significant positive association with mite (0.74).

Kaushik *et al*. (2016) reported that the relative impact of insecticidal applications on population of natural enemies in okra at G.B. Pant University of Agriculture and Technology Pantnagar, which revealed that the thiamethoxam - 25 WG @ 25g a.i/ha (1.00) was recorded with maximum jassid mortality, while lambda cyhalothrin - 5 EC @ 25ml a.i/ha (3.42) showed maximum mean population count i.e. lowest mortality up to seven days after application. The second spray 10 days after first application also showed similar results as follows; thiamethoxam - 25 WG @ 25ga.i/ha (0.87) maximum jassid mortality while triazophos - 40 EC @ 750ml a.i/ha (3.13) showed minimum mortality up to 7 days after application. The effectiveness of these treatments was reflected in terms of reduction in population of jassid and green fruit yield. The results were reflected in terms of % increase over control are as follows; thiamethoxam 25 WG @ 25g a.i/ha plot gave maximum increased fruit yield 66.3% while lambda cyhalothrin - 5 EC @ 25ml ai/ha showed 26.1% with minimum increase in fruit yield.

Siddaratha *et al.* (2017) stated that the MaxT and average temperature had a significant positive effect on leafhoppers, aphids and whiteflies but on mites, negative effect was observed.

Pandey and Kosta, (2017) studied the effect of abiotic factors on major insect pests in okra cultivar Parbhani Kranti at the experimental field of Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh during Rabi season 2014. 5 insect species *viz*, shoot and fruit borer (*E. vittella*), jassid (*A. biguttula biguttula*), aphid (*A. gossypii*) and red cotton bug (*Dysdercus koenigii*) were observed as major insect pests on the okra variety Parbhani Kranti and causing damage at all growth stages of crop from vegetative to maturation of crop.

Bhatt *et al*. (2018) investigatied the population dynamics of sucking pests and their predators on okra agroecosystem during the kharif, 2016. The major sucking pests recorded in the experimental field were whitefly (*Bemisia tabaci* Gennadius), leaf hopper (*Amrasca bigutulla bigutulla* Ishida) and aphids (*Aphis gossypii* Glover). Ladybird beetle (*Coccinella* spp.), green lacewing (*Chrysoperla carnea*), *Eocanthecona* spp., spiders, syrphid fly and ants were some of the predators observed in the bhindi ecosystem. Among them *Coccinella* spp. and spiders were most commonly occurring predators in the field. The peak densities of insect pests and their predators were attained in September-October. *A.bigutulla bigutulla* and *Bemisia tabaci* attained the peak (11.13 leafhoppers /3 leaves and 12.11 whiteflies/3 leaves) in the 40th standard meteorological week while *Aphis gossypii* attained its highest density (23.08 aphids/3 leaves) the in 39th standard meteorological week. The predator population also attained its peak (3.16 spiders/plant and 3.01 coccinellids/plant) in the 39th standard meteorological week.

Potai and Chandrakar, (2018) recorded the seasonal incidence of major insect pests and natural enemies of okra and their correlation with weather parameters during Kharif 2016-17 at Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur, Chhatisgarh. The main activity period of aphids and jassid were found August to October 2016 Or 39th standard meteorological week were peak population of aphids observed 39.24 aphid/plant and *B. tabaci* noted during 1st fortnight of August (1st week of August) to 2nd fortnight of August (last week of August) 2016 with population of 4.89 whitefly/plant. During the third week of September the activity of the bird beetle lady (*Coccinella* spp.) peaked with maximum temperature (32.2°C) and lowest temperature (24.9°C), and the relatively high humidity of morning (94%)

and evening (69%), respectively. There was a substantial good association with maximum temperature and the populations of aphids, whiteflies, jassids and red cotton bugs, whereas the shoot and fruit borer population showed a negligible positive correlation.

Kaushal *et al.* (2019) reported the activity of two sucking pests *viz*, *Amrasca biguttula biguttula* and *Aphis gossypii* on okra at Palampur and was initiated during 2nd and 3rd week of July, respectively and the pests were remained associated with the crop till harvest *i.e.* 3rd week of October. During the second and fourth weeks of October, respectively, peak populations of *A. gossypii* (101.3 aphids/plant) and *A. biguttula biguttula* (7.2 jassids/plant) were recorded. whereas, at Samloti the population of *A. biguttula biguttula*, *A. gossypii* and *Tetranychus urticae* were started appearing during the 1st week of June. The peak population of aphids (64.4/plant) was recorded during the 3rd week of September. Maximum jassids number (18.6/plant) were observed during the last week of August.

2.2 To record the associated natural enemies throughout the period of study.

Ahmad *et al.* (2003) noted that population of ladybird beetle increased during 1st to 4th week intervals but gradually decreased during 4th to 8th week intervals. The population of green lacewing gradually increased during 1st to 4th week intervals but gradually decreased during 4th to 8th week intervals. No syrphid fly was found during 1st and 8th week intervals, the population of syrphid fly increased during 1st to 4th week intervals but gradually decreased during 4th to 8th week intervals in okra field.

Arno *et al*. (2009) reported that the predators and Arthropod parasitoids were ubiquitous and operated continuously on all the life stages of the whiteflies, functioning as control factors in the process. The purpose of biological control is to better utilise this behaviour so that pests may be managed more efficiently and insecticides can be used less frequently. Observation and use of natural enemy activities have been used to achieve biological control of whiteflies and other pests.

Suresh and Patel, (2010) recorded the population of *Cheilomenes sexmaculata* commenced from the second week of January and increased gradually to peak in the third week of February in the okra.

Seathre et al. (2011) undertook studies to provide new information on the biodiversity of aphids and their complex of natural enemies in vegetable agro-ecosystems in Benin. During a 2-year survey (2007/2008 to 2008/2009), aphid species, their host plants and natural enemies were identified from samples collected from 29 vegetables and 22 weed species at 30 vegetables production sites across Benin. Aphids affected 82 % of vegetable species and 12 % of weed species. *Aphis gossypii* (Glover) infested a wide range of the vegetables and occurred on 62% of the species, while *Aphis spiraecola* Patch, *Aphis craccivora* Koch, *Myzus persicae* (Sulzer), *Lipaphis erysimi* (Kalt.) and *Toxoptera odinae* (Van de Goot) were collected from a limited number of vegetables, each with a frequency occurrence ranging from 3 to 28%. Alternative weed hosts for aphids included *Euphorbia hirta* L. and *Commelina benghalensis* L. Common natural enemies were the predators *Cheilomenes propinqua* (Mulsant), *Cheilomenes sulphurea* (Olivier) and *Ischiodon aegyptius* (Wiedemann), the obligate entomopathogen *Neozygites* sp., and the parasitoids *Lysiphlebus testaceipes* (Cresson), *Aphelinus ficusae* Prinsloo and *Neser. Lysiphlebus* testaceipes was usually the only primary parasitoid on aphids across the sites and its common host was *A. gossypii*. Five species of hyper parasitoids were discovered in parasitized mummies, the most prevalent of which was *Syrphophagus africanus* (Gahan). This is the first time *A. Spiraecola*, L. Testaceipes and *S. africanus* have been found in West Africa.

Abdalla *et al.* (2012) observed that chrysopids and spiders were the predominant predators in autumn and summer seasons, whereas syrphids, chrysopids and coccinellids were the abundant groups during winter. However, *Chrysoperla carnea*was the most prevalent species in okra fields all the year round.

Singh *et al*. (2013) found that okra crop was infested with sucking insect pests, such as, whitefly (*Bemisia tabaci*), leafhopper (*Amrasca bigutulla bigutulla*) and aphid (*A. gossypii*) during 2008 at Satna, (M.P). Aphid population correlated negatively with MaxT and mean temperature, rainfall, and maximum and minimum

relative humidity, but positively with MaxT and coccinellids. With aphid populations, aphidophagous predators like coccinellids seemed more or less. The coccinellids were negative for maximum, lowest and average temperature, maximum and minimum relative humidity and rainfall.

Venkanna, (2014) in studied on *kharif* crop of okra genotype Arka Anamika. Coccinellid population was first noticed during last week of July and during first week of October with a population or 4.8 grubs/plant.

Imtiaz, (2015) reported that the population densities of *Coccinella septumpunctata* appeared on the okra cultivars from June 10th and was continuously prevalent till August 12th, where its maximum mean density of 3.00 individuals/leaf was recorded on July 15th on Arizona and Malay. The beetle density was significantly affected by disappearance of pests with rainfall and crop maturity.

Zala *et al*. (2015) an experiment was conducted at Anand Agricultural University, Anand to study the impact of insecticides on the activity of coccinellids and spiders, a potential predator of sucking pests during two consecutive seasons summer and kharif, 2012-13. Two insecticides *i.e.* thiamethoxam 25 WG and dimethoate 30 EC were evaluated on two different application strategies *i.e.* schedule based and need ETL based with two different doses concentration for their adverse impact on natural enemies *i.e.* spiders and coccinellids. Among the insecticidal application strategies, the schedule based application of thiamethoxam 25 WG@ 0.0125% was relatively safer to the activity of these two predators in okra ecosystem by recording the highest population.

Nagar *et al.* (2017) recorded the predatory lady bird beetle, *Menochilus sexmaculatus* Fab. during the crop season. The population of lady bird beetle was first recorded in the third week of August which gradually increased and reached to peak (4.70 beetles/five plants) in the third week of September, thereafter, their population started to decline. The correlation studies showed a nonsignificant correlation with MaxT, MinTs and rainfall, while, significant correlation with relative humidity was noticed. Lady bird beetles showed a significant effect on the pest species.

Lal *et al.* (2019) observed Coccinellid beetles from fourth week of August (34th SMW) with population 0.2 beetles/plant and reached its peak population synchronizes with the peak of aphid in both the years at Gwalior Madhya Pradesh. Among the natural enemies, coccinellid beetle had significant positive correlation with MaxT and evaporation, respectively and Coccinellid beetle was associated significantly positive with aphid population.

Raghuwanshi *et al.* (2019) assessed the succession and incidence of insect pests and their natural enemies on okra, which revealed three orders (Hemiptera, Lepidoptera and Coleoptera) and six families (Cicadellidae, Aphididae, Aleyrodidae, Pyrrhocoridae, Noctuidae and Coccinellidae). Natural enemies *viz*., lady bird beetle and predatory mites were noticed during the 36th SMW *i.e.* 2nd and 35th SMW *i.e.* 1st week of September, respectively, during 2015-16 and 2016-17. The data revealed maximum activity in September.

Khan *et al.* (2019) worked on the diversity and occurrence of insect pests, predators and pollinators associated with okra, *Abelmoschus esculentus* (L.) at Gazipur Bangladesh from May to September 2016. Insects in the okra agro-ecosystem belonged to 29 species, in 24 families under 10 different taxonomic orders. The pest, predator and pollinator insect species revealed the highest occurrence in the order Hemiptera, Coleoptera and Lepidoptera, respectively. The relative abundance of the insect pest varied from 0.9 to 35.7%, predator from 1.7 to 26.0% and pollinator from 2.7 to 34.8%. Among the pests, aphids, whiteflies, and okra shoot and fruit borer were found as major. The aphid, ant and lemon butterfly depicted maximum abundance as pest, predators and pollinators, respectively.

Bisen *et al.* (2020) reported that natural enemies *viz*., coccinellids, and spiders remained in good numbers at initial stage and fluctuated depending upon availability food in the okra field. The spider mites and fruit damage due to shoot and fruit borer were not affected significantly by any of the weather parameters.

Gaikwad *et al.* (2020) experimented at Parbhani, Maharashtra, India to assess the population of coccinellids (grub and adult). The peak population of coccinellids (grub and adult) was observed during 40th SMW (01-07 Oct.), The peak activity of larvae of green lacewing was observed during 40th SMW (01-07

Oct.) in 2017-18 and 37th SMW (10-16 Sept) in 2018-19 and the peak population of spider was noticed in 40th SMW (01-07 Oct.) in 2017-18 and 2018-19, respectively.

CHAPTER –III
MATERIALS AND METHODS

This chapter deals with the concise description of materials used and methods adopted during the course of the present investigation conducted during the kharif season of 2020, entitled **"Studies on the pest succession in okra (*Abelmoschus esculentus* (L.) Moench) and associated natural enemies at Lormi, Mungeli district of Chhattisgarh."**

3.1 Location of the experimental site:

The field experiment was carried out at the farmer's field in Dindori village of Lormi tehsil under Mungeli district of Chhattisgarh, during the Kharif season of 2020-21.

3.2 Geographical situation: -

The district Mungeli is situated in north-east part of Chhattisgarh and situated 21°48′35″ To 22°40′30″ North Latitude and 81°29′45″ to 82 °02′10″ East Longitude with an altitude of 288 meters above the mean sea level. This place falls under dry sub humid region of the country and the climate is ideal with a beautiful monsoon, a mild summer and a bearable winter.

3.2.1 Climate:

Mungeli is located in India's tropical area. Mungeli's climate is dry sub-humid to semi-arid, with an average annual rainfall of 1071 mm, primarily concentrated from mid-June to September, with rare showers in winter. During the summer, the temperature may reach 46°C. The weather data were acquired from the Meteorological Observatory at the BRSM College of Agriculture, Engineering, and Technology and Research Station in Mungeli, Indonesia (C.G.)

3.3 Cultural Operation: -

3.3.1 Field preparation

Cross ploughing with a tractor-drawn cultivator was used to prepare the field. To obtain a weed-free and stubble-free field, the weeds and agricultural residues were eliminated.

3.3.2 Sowing:

Seeds were sown on 5th of August, 2020 with a planting distance of row to row 30cm and plant to plant 30cm.

3.3.3 Fertilizer:

The crop received the recommended fertiliser dose of 60:35:35 kg N, P, K per acre. Urea, Single Super Phosphate (SSP), and Muriate of Potash (MOP) were used to apply N, P, and K, respectively. Half of the N, as well as the full amounts of P and K, were administered as a basal dosage in the furrows at the time of sowing, and the remaining half was applied as a top treatment 35-40 DAS.

3.3.4 Weed control

Two manual hand weeding were done to keep the experimental plots weed-free.

3.3.5 Irrigation

The first irrigation was given just after seed sowing and subsequent irrigations were given by plot to plot system wherein the intervals between two irrigations were adjusted accordingly as per crop requirement.

3.3.6 Harvesting

The fruits were harvested after 45-60 DAS. Pods were picked when they were still immature, tender and green and attained edible size. Picking was done on every alternate day.

3.4 Technical programme of work: -

3.4.1 Experimental Details

Experimental site: - The field experiment was conducted at the farmer's field **at Dindori Village, Lormi tehsil under Mungeli district of Chhattisgarh,** during the kharif season of 2020-21.

Crop	**Okra (*Abelmoschus esculentus*(L.) Moench)**
Variety:-	Namdhari-864
Spacing :-	30cm x 30cm (R×P)
Plot size :-	25m x 6m = (150) m^2
Number of plot -	5

3.5 Following observation were undertaken: -

3.5.1 To study the pest succession in okra (*Abelmoschus esculentus*(L.) Moench) at Lormi (district – Mungeli) Chhattisgarh.

- Population of major insect pests were recorded at weekly intervals on 10 randomly selected plants per plot.
- The population of aphid (*Aphis gossypii)*, jassid (*Amrasca biguttula*), whiteflies (*Bemisia tabaci*) were recorded on three leaves (upper, middle and lower) of 10 randomly selected plants per plot.
- The incidence of shoot and fruit borer (*Earias vittella* Fab.*)* was recorded by counting infested plants and damaged fruits on 10 randomly selected plants throughout the period of study.

3.5.1.1 Method of observation: -

- **For white flies -** Observations were recorded on three leaves per plant, by placing a hand mirror under the leaf, without disturbing the plant. (Taggar and Gill, 2012), The total number of adults and nymphs of whiteflies per plants had been counted at weekly interval on 10 randomly selected plants per plot.
- **For aphids -** Observations were recorded on three leaves per plant on 10 randomly selected plants per plot and the total number of adults and nymphs of aphids per plant were counted at weekly intervals.

- **For leaf hoppers** - Observations were recorded on three leaves per plant on 10 randomly selected plants per plot and the total number of adults and nymphs of leaf hoppers per plant were counted at weekly intervals.
- **For shoot and fruit borer** –

(A) For shoot infestation: - Number of wilted plants were counted on 10 randomly selected plants after confirming the attack at the apical portion (part) of the plant.

(B) For fruit infestation: - Number of infected fruits and total number of fruits per plant were counted on 10 randomly selected plant per plot at every picking.

(C) Fruit infestation (%) $\frac{\textbf{Number of damaged fruit}}{\textbf{Total number of fruit}}\textbf{X100}$

3.5.2 To record the associated natural enemies throughout the period of study.

The number of various natural enemies associated with the insect pests were recorded throughout the period of study.

3.5.2.1 Method of observation: -

Number of natural enemies present (predators and parasitoids along with infected insects etc.) were counted on the plants on which the insect pests had been noted.

3.6 Statistical Analysis:

3.6.1 Karl Pearson correlation coefficient:

Correlation and regression in between abiotic factors and okra major insect pest population were worked out by using the formula as suggested by Snedecor and Cochran (1967). The correlation coefficient between two variable *X* and *Y* is usually denoted by t is a numerical measure of liner relationship of two variable and is given by the ratio of covariance between two variables *X* and *Y* to product of standard deviation of both the variable *X* and *Y*. Symbolically,

$$r = \frac{Cov(X,Y)}{\sigma x \times \sigma y} = \frac{\frac{1}{N}\sum(X-\bar{X})\,(Y-\bar{Y})}{\sqrt{\frac{1}{N}\sum(X-\bar{X})^2} * \sqrt{\frac{1}{N}\sum(Y-\bar{Y})^2}}$$

Where,

Covariance of series / variable X and Y is= $\frac{1}{N}\sum(X-\bar{X})\,(Y-\bar{Y})$,

$\bar{X}$is the A.M. of a variable X

$\bar{Y}$ is the A.M. of a variable Y

Standard deviation of a variable X = $\sigma_X\sqrt{\frac{1}{N}\sum(X-\bar{X})^2}$

Standard deviation of a variable Y=$\sigma_X\sqrt{\frac{1}{N}\sum(Y-\bar{Y})^2}$

r =$\frac{\frac{1}{N}\sum(X-\bar{X})\,(Y-\bar{Y})}{\sqrt{\frac{1}{N}\sum(X-\bar{X})^2} * \sqrt{\frac{1}{N}\sum(Y-\bar{Y})^2}}$ or r =$\frac{\sum XY-\frac{\sum X*\sum Y}{N}}{\sqrt{X^2\frac{(\sum X^2)}{N}} * \sqrt{Y^2\frac{(\sum Y^2)}{N}}}$

Test of significance of correlation coefficient:

The test of significance of correlation coefficient means to test the hypothesis, whether or not the correlation coefficient is zero in the population *i.e.*, we test,

H₀: **= 0 vs.** ***H₁:*** **≠ 0**

Test Statistics t= $\frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$

3.6.2 Regression Coefficient:

In the regression equation of *Y* on *X*, *b* is known as regression coefficient of *Y* on *X* and is denoted by *byx*. While in the regression equation of *X* on *Y*, the

regression coefficient of *X* on *Y* is denoted by b*xy*.

These two regression equations can be written as Regression equation of *Y*on *X*

$Y = a + byx$X

Regression equation of *X* on*Y*

X = $a + bxy$Y

Both the regression coefficient can be obtained directly by the formula

byx= $r\frac{\sigma y}{\sigma x}$;bxy=r $\frac{\sigma x}{\sigma y}$

Where,

byx= Regression coefficient of Y onX.

bxy= Regression coefficient of X onY.

y = Standard deviation of Y

x = Standard deviation of X.

r= Correlation coefficient between X and Y

Table 3.1-Weekly meteorological data recorded during the experimental period (2020) at Mungeli.

S.N.	Standard Meteorological Week	Period	Temperature (^{0}C)			Relative Humidity (%)			Rainfall (mm)	Sun shine (hrs)
			Max.	Min.	Avg.	RH I	RH II	Avg. RH		
1	35	27.08.2020-02.09.2020	30.17	22.7	26.43	90.71	82.28	86.495	16.4	3.21
2	36	03.09.2020-09.09.2020	32.97	24.05	28.51	91	72.57	81.785	0.34	6.51
3	37	10.09.2020-16.09.2020	33.78	23.82	28.8	89	67.78	78.39	0.2	6.32
4	38	17.09.2020-23.09.2020	33.37	22.81	28.09	92.71	76.42	84.565	16.28	1.65
5	39	24.09.2020-30.09.2020	33	22.62	27.81	90.85	64.57	77.71	0	4.87
6	40	01.10.2020-07.10.2020	32.71	22.14	27.425	90	66.71	78.355	5.62	4.57
7	41	08.10.2020-14.10.2020	32.87	22.92	27.895	89.85	66.28	78.065	0.14	4.15
8	42	15.10.2020-21.10.2020	32.88	21.98	27.43	87.85	59.85	73.85	0	8
9	43	22.10.2020-28.10.2020	32.67	17.84	25.255	83.71	49	66.355	0	8.31
10	44	29.10.2020-04.11.2020	31.74	15.84	23.79	81.71	47.71	64.71	0	8.88
11	45	05.11.2020-11.11.2020	30.62	11.41	21.015	76.42	46.14	61.28	0	8.92
12	46	12.11.2020-18.11.2020	32.6	16.98	24.79	85.42	50.14	67.78	0	8.72

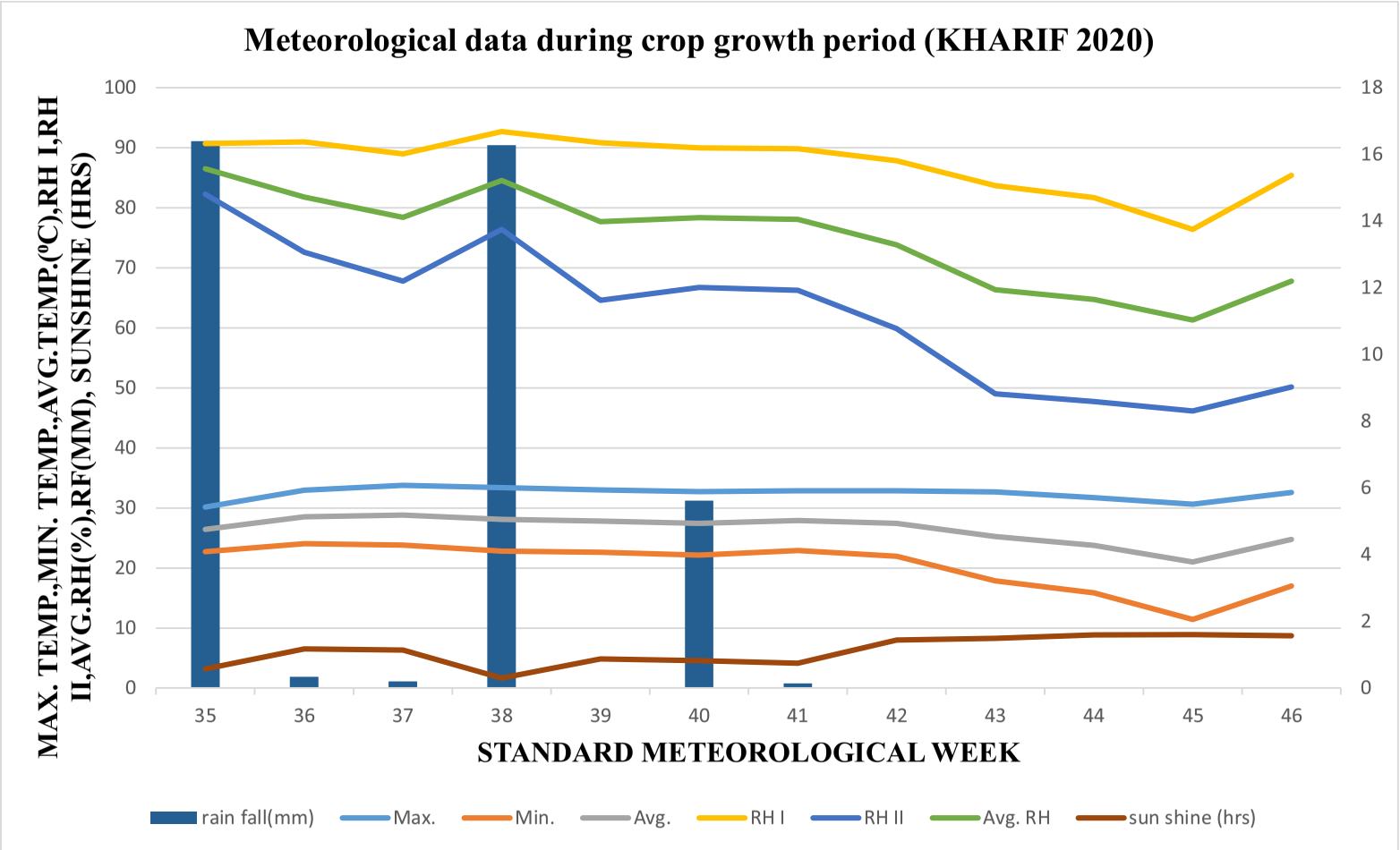

Fig. 3.1 Meteorological data during crop growth period (KHARIF 2020)

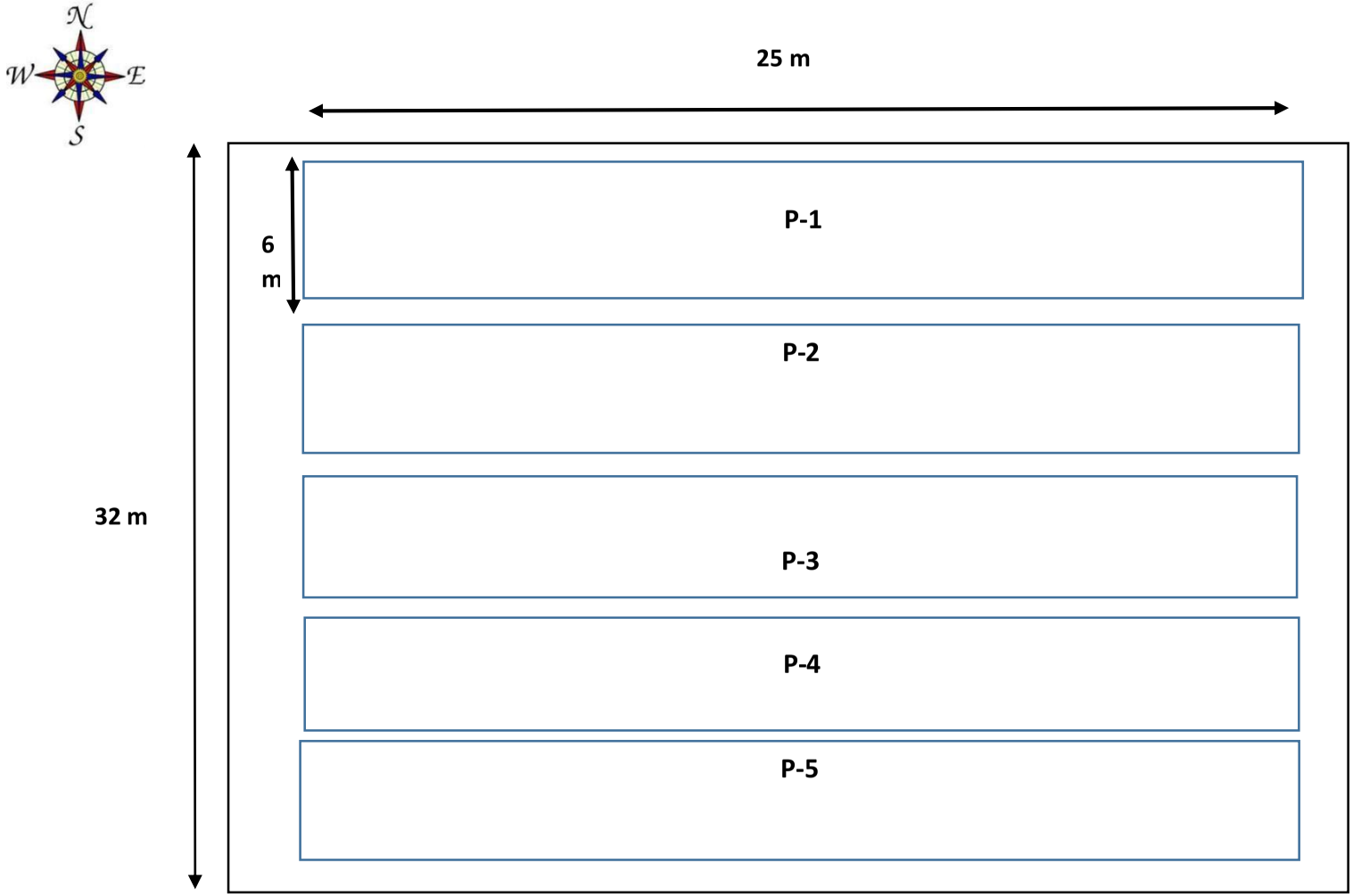

Fig.3.2 Layout of the experimental field (farmer field) at Village- Dindori.

CHAPTER –IV
RESULTS AND DISCUSSION

This chapter deals with the brief explanation of results under different objectives of the experiment entitled **"Studies on the pest succession in okra (*Abelmoschus esculentus* (L.) Moench) and associated natural enemies at Lormi, Mungeli district of Chhattisgarh."**. The results of the current study are presented objective wise as under: -

- **To study the pest succession in okra (*Abelmoschus esculentus* (L.) Moench) at Lormi (district – Mungeli) Chhattisgarh.**
- **To record the associated natural enemies throughout the period of study**

4.1 To study the pest succession in okra (*Abelmoschus esculentus*(L.) Moench) at Lormi (district – Mungeli) Chhattisgarh.

The insect pests on okra plants were recorded along with their natural enemies at weekly intervals from September first week, at the time of vegetative stage of crop (3 WAS) to the last week of November 2020 up to the last picking of fruits.

4.1.1 Succession of different insect-pests on okra, *Abelmoschus esculentus* (L.) Moench.

Under the study of insect pest succession on okra,10 species of the insects, belong to four orders *i.e.* Hemiptera, Lepidoptera, Coleoptera and Odonata (Table No 4.1) which included seven insect pests and three natural enemies were recorded. Sucking pests like aphid (*Aphis gossypii)*, jassid (*Amrasca biguttula biguttula* Ishida), and whitefly (*Bemisia tabacii* Gennadius) were observed damaging during the vegetative stage of okra.

The okra shoot and fruit borer *(E. vittela)* were observed damaging mainly shoots during vegetative stage and fruit damage during the fruiting stage of the crop. Infestation of the fruit borer (*Helicoverpa armigera*) was also noticed at the fruiting

stage of the crop. Tobacco caterpillar (*Spodoptera litura)* was recorded throughout the vegetative stage to the harvesting period of the crop. The red cotton bug (*Dysdercus cingulatus* Fabricus) were recorded from 6 WAS on wards throughout the period of the crop.

Table 4.1 Insect pests recorded on okra crop during the experimental period of Kharif 2020

S.N.	**Order- Hemiptera**		
	Insect- pests	**Scientific Name**	**Family**
1	Aphid	*Aphis gossypii Glover*	Aphididae
2	Jassid	*Amrasca biguttula biguttula* Ishida	Cicadellidae
3	Whitefly	*Bemisia tabacii* Gennadius	Aleyrodidae
4	Red cotton bug	*Dysdercus cingulatus* Fabricius	Pyrrhocoridae
	Order- Lepidoptera		
5	Okra shoot and fruit borer	*Earias vitella* Fabricius	Noctuidae
6	Fruit borer	*Helicoverpa armigera* Hubner	Noctuidae
7	Tobacco caterpillar	*Spodoptera litura*	Noctuidae

Table - 4.2 Activity period of various insect pests on okra crop during kharif 2020.

Name of insect	Scientific Name	Range of Population	Period of maximum insect population	Period of Activity	Crop stage during infestation
Aphid	*Aphis gossypii* Glover	2.21-32.22	3rd week of October /10 WAS	2nd week of September to 3rdweek of November	All stage
Jassid	*Amrasca biguttula biguttula* Ishida	0.33-5.68	2nd week of October / 9WAS	1stweek of September to 3rd week of November	All stage
White fly	*Bemisia tabacii* Gennadius	2.60-18.75	2nd week of October / 9WAS	2nd week of September to 3rd week of November	All stage
Shoot and fruit borer (S)	*Earias vitella*	0.02-.67	1st week of October / 8 WAS	2nd week of September to last week of October	VS & RS
Shoot and fruit borer(F)	*Earias vitella*	1.45-14.63	2nd week of October / 9WAS	**4th** week of September to 3rdweek of November	FS
Fruit borer	*Helicoverpa armigera*	0.50-4.30	3rd week of October /10 WAS	1st week of October to 3rd week of November	FS
Red cotton bug	*Dysdercus cingulatus*	0.72-4.23	3rd week of October /10 WAS	3rd week of September to 3rd week of November	After vegetative stage
Tobacco caterpillar	*Spodoptera litura*	0.12-15.27	3rd week of October /10 WAS	1st week of September to 3rd week of November	All stage

VS- Vegetative stage, FS- Fruiting stage, RS- Reproductive stage

4.1.2 Insect pest succession on okra: -

4.1.2.1 Aphid, *Aphis gossypii* Glover (Hemiptera: Aphididae)

The population of aphids initiated during the vegetative stage of the crop in the 2nd week of September *i.e.* (36 SMW, 4 WAS) with an average population level of 5.31 aphids/ three leaves. The mean maximum and minimum temperature during the initiation period of aphids were 32.97˚C and 24.05˚C and the average morning and evening relative humidity was 91.00% and 72.57% respectively with an average rain fall of 0.34 mm. The aphids remained active till the last picking of okra fruits. The lowest aphid population (2.12 /three leaves) was recorded in the 3rd week of November 2020. The average maximum and minimum temperature during lowest population period of aphid were 32.6˚C and 16.98˚C and the average morning and evening relative humidity was 85.42% and 50.14% respectively with no rain fall (0.00 mm). Peak population of 32.22 aphids / three leaves during the third week of October (42 SMW *i.e.* 10 WAS), was observed after this, the population of aphids showed a decreasing trend till the last picking of fruits. The average maximum and minimum temperature during the peak period aphids were 32.88˚C and 21.98˚C and the average morning and evening relative humidity was 87.85% and 59.85% respectively with no rainfall.

Singh and Jha (2013), Bhatt and Karnataka (2018) and Thara *et al.* (2019) also reported initiation of aphids 4 WAS or during the month of September, Thara *et al.* (2019) also recorded peak population of aphids 10 WAS. Patel and Rote (1995) also reported about the peak of aphid population in the second fortnight of October. Similar, findings were reported by Preetha and Nadarajan (2007), Hegde *et al.* (2004), Gulati (2004) and Anita and Nandihalli (2008).

Aphid showed positive significant correlation with MaxT (r = 0.577**), and positive non-significant correlation with minimum temperature (r = 0.402), morning and evening relative humidity (r =0.366), (r =0.107), negative non-significant correlation with rainfall and BSS (r = -0.083), (r = -0.291), where as a highly positive significant correlation (r=0.780*) with coccinellids was depicted. (Table No.4.4)

Singh and Jha (2013) and Thara *et al.* (2019) also reported positive significant correlation with MaxT and coccinellids, and negative correlation with

rain fall which is in agreement with the present findings. Similarly, Ghuges *et al.* (2020) recorded positive correlation with minimum temperature and negative correlation with rain fall which again matches with the present results.

Nature of Damage: Both nymphs and adults of aphids cause damage by sucking cell sap from leaves, twigs, and other delicate plant components. Aphids also secrete honey dew, which leads to the growth of black sooty mould and the sugary compounds are responsible for attracting the red ant (*Oecophylla smaragdina*).

4.1.2.2 Jassid, *Amrasca biguttula biguttula* Ishida (Hemiptera: - Cicadellidae)

Jassid population initiated during the vegetative stage of the crop in the 1stweek of September (35th SMW *i.e.* at 3 WAS) with an average population of 0.33 jassid/ three leaves, the average maximum and minimum temperature during the initiation period of jassids was 30.17˚C and 22.70˚C and the average morning and evening relative humidity was 90.71% and 82.28% respectively. The average rain fall was recorded to be 16.4 mm. Jassids remained active till the last picking of okra fruits. Lowest jassid population (0.33 / three leaves) was recorded in the 1st week of September 2020, and the average maximum and minimum temperature during that period was 30.17˚C and 22.70˚C and the average morning and evening relative humidity was 90.71% and 82.28% respectively, with an average rain fall of 16.4 mm. Highest population (5.68 / three leaves) was recorded during the 2nd week of October (41st SMW *i.e.* at 9 WAS) thereafter, a decreasing trend of jassid population was observed till the last picking of fruits. The average maximum and minimum temperature during the peak period of jassids were 32.87˚C and 22.92˚C with an average morning and evening relative humidity of 89.85% and 66.28% respectively. The average rain fall during the period was recorded to be 0.14 mm.

Thara *et al.* (2019) also reported that the incidence of jassids initiated during the 35th SMW and the peak population was reported to be similar (9- 10 WAS) which is in line with the present findings. Similarly, Bhatt and Karnataka (2018) and Kumar *et al.* (2017) recorded the incidence of Jassids, three weeks after sowing and also the peak period of jassids were recorded during the 1st fortnight of October, *i.e.* 9 Week after sowing which is also in match with the present results. The present findings are

also in accordance with Board *et al.* (1993) and Anitha *et al.* (2008) who also recorded that the peak period of jassids during 1st fortnight of October.

The data present in Table No. 4.4, clearly indicates that jassids showed significant positive correlation with maximum (r = 0.610**), and minimum temperature (r = 0.604**) and positive but non-significant correlation with morning (r =0.545) and evening relative humidity (r = 0.324), negative non–significant correlation with rainfall (r = -0.110) and BSS (r = -0.415).

Similar findings were reported by Ghuges *et al.* (2020) who also recorded positive correlation with minimum temperature and negative correlation with rain fall. Pathan *et al.* (2016), Potai and Chandrakar (2018) and Raghuwanshi *et al.* (2019) also recorded positive correlation with maximum and minimum temperature and negative correlation with rain fall which is also in concurrence with the present findings.

Nature of Damage:

Both nymphs and adults of jassids damage the plant by sucking of the cell sap from under surface of the leaves, twigs and other tender parts of the whole plant, and are responsible for the curling of the leaves, leading to stunting growth of the plants. Jassids also responsible for the formation of sooty mould due to secretion of honey dew which causes adverse effect on photosynthesis of the plants.

4.1.2.3 Whitefly, *Bemisia tabaci* Gennadius (Hemiptera:- Aleyrodidae)

The whitefly population initiated during the vegetative stage of the crop in the 2nd week of September, (36th SMW *i.e.* 4 WAS) with an average population level of 11.71 whiteflies / three leaves, The average maximum and minimum temperature during initiation period of whiteflies were 32.97˚C and 24.05˚C and the average morning and evening relative humidity were 91.00% and 72.57% respectively, with a mean rain fall of 034 mm. The whiteflies remained active till the last picking of okra fruits. Highest population (18.75 nymphs and adult of whiteflies/three leaves) were recorded during the 2nd week of October (41st SMW, *i.e.* 9 WAS) After this, decrease in the population of whiteflies till the last picking of fruits was observed. The average maximum and minimum temperature during peak period of whiteflies

were 32.87˚C and 22.92˚C and the average morning and evening relative humidity was 89.85% and 66.28% respectively with an average rain fall of 0.14 mm. The lowest whitefly population (2.60/ three leaves) was recorded in the 1st week of November 2020 (44th SMW *i.e.* 12WAS). The average maximum and minimum temperature during the lowest population period of whitefly was 31.74˚C and 15.84˚C and the average morning and evening relative humidity were81.71% and 47.71% respectively with an average rain fall of 0.00 mm.

Singh and Jha (2013) also reported initiation of white flies during the 1st fortnight of September (36th SMW) which is in agreement with the present studies. Similarly, Board *et al.* (1993), Anitha *et al.* (2008) and Kumar *et al.* (2017) also recorded that the peak period of white flies during the 1st fortnight of October, *i.e.* 9th week after sowing, matches with the current findings.

The data presented in Table No. 4.4, clearly indicates that the whiteflies showed a positive significant correlation with MaxT (r = 0.58**), and positive but non-significant correlation with minimum temperature (r = 0.214), morning (r =0.206) and evening relative humidity (r = 0.060), negative non-significant correlation with rainfall (r = -0.274), and (BSS = r -0.171),

Similar results stating positive correlation with minimum temperature and negative correlation with rain fall were given by Pandey and Kostha (2017), Potai and Chandrakar (2018) and Ghuges *et al.* (2020) is in accordance with the present findings.

Nature of Damage:

Whiteflies damage the plants by sucking the cell sap from the under surface of the leaves and also act as a vector for the cause and spread of the yellow vein mosaic viral disease of okra.

4.1.2.4 Okra shoot and fruit borer, *Earias vittella* Fabricius Lepidoptera (Noctuidae)

4.1.2.4.1 Shoot Infestation by shoot and fruit borer, *Earias vittella* Fabricius.

The shoot damage by shoot and fruit borer, *E.vittella* was noticed in

The vegetative stage of the crop *i.e.* in the 2nd week of September (37th SMW, 5 WAS) with an average population of 0.20 larvae per plant. The average maximum and minimum temperature during initiation period was 33.78˚C and 23.82˚C and the average morning and evening relative humidity was 89% and 67.78% respectively, with an average rain fall of 02 mm. *E.vittella* continued up to the fruit formation stage thereafter, gradual decrease in infestation on shoot, with its highest infestation of 0.67 larvae / plant during the 1st week of October (40th SMW *i.e.* 8 WAS). After this the population of *E. vittella* depicted a decreasing trend. The average maximum and minimum temperature during the peak period of okra shoot and fruit borer, *E vittella* was 32.71˚C and 22.14˚C and the average morning and evening relative humidity was 90% and 66.71% respectively with the an average rain fall of 5.62 mm. Lowest infestation of *E. vittella* on shoot was recorded to be 0.20 infested shoots per plant was recorded in the 2nd week of September, (37th SMW *i.e.* 5 WAS) with an average population level of 0.20 infestation on shoots per plant, The average maximum and minimum temperature the during lowest infestation period was 33.78˚C and 23.82˚C and the average morning and evening relative humidity was 89% and 67.78% respectively with an average rain fall of 0.2 mm.

Similar results about the peak infestation on okra shoots by *E.vitella* during 40 SMW or 1st fortnight of October, were reported by Lal *et al.* (2020), Nirmal *et al.* (2018,) Selvaraj *et al.* (2020), Aarwe *et al.* (2016) and Singh and Saini (2005) which is in support to the present findings.

Okra shoot and fruit borer, *E. vittella* showed positive significant correlation with MaxT (r = 0.603**), and positive but non-significant correlation with minimum temperature (r = 0.514), morning (r =0.471) and evening relative humidity (r = 0.221), negative and non-significant correlation with rainfall (r = -0.039 and BSS (r = -0.221) with shoot infestation. (Table 4.4)

The findings of Bhareat *et al.* (2020), Raghuwanshi *et al.* (2019) and Pandey and Koshta (2017) stating positive significant correlation with MaxT and negative correlation with rainfall are in agreement with the present studies.

Nature of Damage:

Larvae of *E.vitella* are brownish in colour and an internal feeder. After hatching it immediately bores into a nearest tender shoot and plugs the entrance hole with its excreta. Due to infestation in twigs, the fruit dries up and drops off.

4.1.2.4.2 Fruit damage by shoot and fruit borer, *Earias vittella* Fabricius

The shoot damage was first observed on fruits during the 4th week of September (38thSMW, *i.e.* 6 WAS) with an average fruit damage level of 5.14%. The average maximum and minimum temperature during initiation period on fruit damage by Okra shoot and fruit borer, *E. vittella* was 33.37˚C and 22.81˚C and the average morning and evening relative humidity was 92.71% and 76.42% respectively, with an average rain fall of 16.28 mm. The activity of okra shoot and fruit borer, *E. vittella* continued up to the fruiting stage of the crop with highest fruit damage 14.63% during the 2nd week of October (40th SMW *i.e.* 8 WAS). After this a decrease in the rate of *E.vittella* on fruit infestation was seen. The average maximum and minimum temperature during the peak period of okra shoot and fruit borer, *E. vittella* were 32.71˚C and 22.14˚C and the average morning and evening relative humidity was 90% and 66.71% respectively, with an average rain fall of 5.62 mm.

The lowest infestation of *E. vittella* on fruit infestation (1.45%) was recorded in the last week of November, (46th SMW *i.e.* 14 WAS). The average maximum and minimum temperature during lowest fruit infestation period was 32.6˚C and 16.98˚C and the average morning and evening relative humidity was 85.45% and 50.14% respectively with no rain fall (0.00 mm).

Lal *et al.* (2020) and Raghuwanshi *et al.* (2019) also recorded infestation of *E.vittella* on fruits in month of September or 6 WAS and maximum infestation was also recorded in the month of October, which matches with the present studies. Balpande *et al.* (2019) also recorded the maximum fruit infestation on fruit by shoot and fruit borer in the month of October which is again supportive to the present studies.

Infestation on fruits by okra shoot and fruit borer, *E. vittella* showed positive but non-significant correlation with maximum(r=0.296), minimum temperature

(r=0.174) morning relative humidity (r =0.191); negative and non-significant correlation with evening relative humidity (r =-0.065), rainfall (r = -0.126) and BSS (r = -0.221). (Table No.4.4).

Lal *et al.* (2020), Raghuwanshi *et al. (*2019), Pandey and Koshta (2017) and Pathan *et al.* (2016) also showed positive correlation with MaxT, and negative correlation with evening relative humidity and rain fall.

4.1.2.5 Okra fruit Borer, *Helicoverpa armigera* Hubner (Lepidoptera: Noctuidae)

The population of okra fruit borer, initiated during the fruiting stage of the crop *i.e.* during the 4nd week of September, (39th SMW *i.e.* 7 WAS) with an average population level of 0.90 larvae per plant, The average maximum and minimum temperature during the initiation period of was 33˚C and 22.62˚C and the average morning and evening relative humidity was 90.85% and 64.57% respectively, with no rain fall (0.00 mm). The okra fruit borers, remained active till the last picking of okra fruits. The lowest population 0.50 larvae / plant was recorded in the last week of November 2020. The average maximum and minimum temperature during that period was 32.6˚C and 16.98˚C and the average morning and evening relative humidity was 85.42% and 50.14% respectively with no (0.00 mm.) rainfall. Maximum population of 4.30 larvae / plant were recorded during the third week of October (42nd SMW.*i.e* 10 WAS), thereafter a decreasing trend of *H.armigera* was seen till the last picking of fruits. The average maximum and minimum temperature during the peak period okra fruit borer, *H. armigera* was 32.88˚C and 21.98˚C and the average morning and evening relative humidity was 87.85% and 59.85% respectively with no rainfall.

Ray *et al.* (2018) and Siddartha *et al.* (2017) reported similar results stating that the initiation of okra fruit borer, *H armigera* during fruiting stage of the crop to last picking of the crop. Similarly, Ghuges *et al.* (2020) also recorded negative correlation with rain fall which matches with the present findings.

The data present in Table No. 4.4 indicates that, *H. armigera* showed positive non-significant correlation with maximum (r =0.143) and minimum temperature (r =0.027) and BSS (r = 0.238), non-significant negative correlation with morning

relative humidity (r = -0.069) evening relative humidity (r = -0.252) and rainfall (r = -0.366).

Siddartha *et al.* (2017) also reported that fruit borer infestation had a non-significant positive correlation with evening relative humidity which is also in line with the present results.

Ray *et al.* (2018) stated that the okra fruit borer population showed a non-significant relationship with all meteorological parameters, which also is in agreement with the present studies.

Nature of Damage:

After hatching of the young larvae fed on the foliage for some time, and later bore in to the fruits with half of its body hanging outside.

4.1.2.6 Red cotton bug, (*Dysdercus cingulatus* Fabricius) (Order-Hemiptera-: Family-Pyrrhocoridae)

The population of the red cotton bug, (*Dysdercus cingulatus* Fabricius**)** was initiated during the vegetative stage of the crop in the 4thweek of September, (38th SMW *i.e.* 6 WAS) with an average population level of 2.24 nymphs and adults /plant. The average maximum and minimum temperature during the initiation period of were 33.37˚C and 22.81˚C and the average morning and evening relative humidity were 92.71% and 76.42% with an average rain fall of 16.28 mm. The bugs remained active till the last picking of okra fruits. Highest population of 4.23 nymphs and adults per plant were recorded during the 3rd week of October (42nd SMW, 10 WAS), thereafter a decreasing rate of population was noticed till the last picking of fruits. The average maximum and minimum temperature during the peak period were 32.88˚C and 21.98˚C and the average morning and evening relative humidity was 87.85% and 59.85% respectively with no rainfall. Lowest population of 0.72 nymphs and adults / plant was recorded in the 1st week of November (44th SMW, *i.e.* 12 WAS) The average maximum and minimum temperature during lowest population period of the red cotton bug were 31.74˚C and 15.84˚C and the average morning and evening relative humidity were 81.71% and 47.71% with no rain fall (0.00 mm).

Pandey and Kostha (2017) also reported the initiation of red cotton bug at 6 WAS and the peak population was also reported 10 WAS which is concurrent with the present findings. Netam *et al.* (2003) also recorded the incidence of red cotton bugs during vegetative stage of crop to last picking of crop which again is in agreement with the present studies.

The data presented in Table No.4.4, indicates that the red cotton bug, showed positive non-significant correlation with maximum (r =0.339) and minimum temperature (r =0.172), morning relative humidity (r = 0.222), and negatively non-significant correlation with evening relative humidity (r = -0.041) rainfall (r = -0.093) and BSS (r = -0.141).

Pandey and Kostha (2017) also recorded positive correlation with maximum and minimum temperature, and negative non-significant correlation with BSS. Similarly, Pal *et al.* (2020) also recorded positive non-significant correlation with MaxT and negative correlation with rainfall and relative humidity which matches with the present findings.

Nature of Damage:

Both nymphs and adults cause damage by sucking of cell sap that weakens and stunts growth of the plant and fruit curls up.

4.1.2.7 Tobacco caterpillar, *Spodoptera litura* (Lepidoptera: - Noctuidae)

The population of tobacco caterpillar *S. litura* initiated during the vegetative stage of the crop, in the 1st week of September, (35th SMW, *i.e.* 3 WAS) with an average population level of 0.8 larvae per plant. The average maximum and minimum temperature during initiation period of *S. litura* was 30.17˚C and 22.70˚C and the average morning and evening relative humidity were 90.71% and 82.28% respectively with an average rain fall of 16.4 mm. *S. litura* remained active till the last picking of okra fruits, with its highest population (15.27 larvae / plant) during the 4th week of October (42nd SMW *i.e.*10 WAS) Thereafter, the population decreased till the last picking of fruits.

The average maximum and minimum temperature during the peak period of *S.litura* was 32.88˚C and 21.98˚C and the average morning and evening relative humidity was 87.85% and 59.85% respectively with no rain fall (0.00 mm.) The lowest population of *S.litura* (0.10 larvae / plant) was recorded in the last week of November 2020, (46thSMW *i.e.*14 WAS). The average maximum and minimum temperature during lowest population period of *S.litura* was, 32.6˚C and 16.98˚C respectively and the average morning and evening relative humidity was 85.45% and 50.14% respectively with no rain fall (0.00mm).

The data presented in Table No. 4.4, clearly indicates that *S.litura* showed a positive but non-significant correlation with maximum (r =0.144) minimum temperature (r =0.075) and BSS (r = -0.141) negative and non-significant correlation with morning relative humidity (r = 0.038), evening relative humidity (r = -0.196) and rainfall (r = -0.307).

Duraimurugan *et al.* (2018), Meena *et al.* (2017) and Ahir *et al.* (2017) also recorded similar results that the larval population of *S.litura* was observed throughout the crop period *i.e.* from August to November which is in accordance with the present studies.

Similar findings stating positive correlation with minimum temperature were reported by Reddy *et al.* (2016), Duraimurugan *et al.* (2018) and Singh *et al.* (2021) which is congruent with the present findings.

Nature of Damage:

The young larvae of *S. litura* first feed gregariously and scrape the leaves. Older larvae spread out and completely defoliates the leaves resulting in poor growth of plants.

Table 4.3 Succession of different insect pests recorded on okra during *Kharif* 2020.

WAS	SMW	Mean population of different insects							
		Aphids/ 3 leaves	**Jassids/ 3 leaves**	**White flies / 3 leaves**	**Shoot damage due to *E. vittella* / plant**	**Fruit damage due to *E. vittella* (%)/ plant**	***H. armigera***	**Tobacco caterpillar *(S.litura)* / plant**	**Nymphs and adults of Red cotton bug/ plant**
3	35	0	0.33	0.00	0	0	0.00	0.80	0.00
4	36	5.31	2.36	11.71	0	0	0.00	2.41	0.00
5	37	12.25	2.55	14.33	0.40	0	0.00	1.70	0.00
6	38	22.91	3.23	15.52	0.41	5.14	0.00	1.50	2.34
7	39	23.15	3.56	14.10	0.58	8.91	0.90	1.72	3.50
8	40	23.21	4.12	9.50	0.67	14.63	1.23	8.02	1.90
9	41	25.54	5.68	18.75	0.50	12.3	2.31	12.52	2.11
10	42	32.22	4.81	13.17	0.61	8.32	4.30	15.27	4.23
11	43	16.53	1.33	4.61	0.32	7.51	1.21	4.91	0.91
12	44	7.9	0.69	2.60	0	5.21	0.81	11.70	0.72
13	45	5.21	0.64	13.75	0	1.58	0.72	0.90	0.91
14	46	2.12	0.61	12.15	0	1.45	0.50	0.12	1.22
Over all mean		**14.69**	**2.49**	**10.833**	**0.29**	**5.42**	**5.42**	**5.12**	**1.48**

Table 4.4 Correlation of the population of different insect pests of Okra in relation to weather parameters during *kharif* 2020.

SN	Pests	Weather Parameters						
		Max. Temp. (°C)	Min. Temp. (°C)	Rainfall (MM)	Morning RH(%)	Evening RH(%)	BSS	Aphid
1	Aphid	0.77**	0.402	-0.083	0.366	0.107	-0.291	
2	Jassids	0.610**	0.604**	-0.110	0.545	0.324	-0.415	--
3	Whiteflies	0.58**	0.214	-0.274	0.206	0.060	-0.171	---
4 (a)	Shoot & fruit borer (S)	0.603**	0.514	-0.039	0.471	0.221	-0.383	---
4 (b)	Shoot & fruit borer (F)	0.296	0.174	-0.126	0.191	-0.065	-0.221	---
5	Tobacco caterpillar	0.144	0.075	-0.31	-0.04	-0.19	0.166	---
6	Red cotton bug	0.339	0.172	-0.093	0.222	-0.041	-0.141	---
7	Fruit borer	0.143	0.027	-0.366	-0.069	-0.252	0.238	---
8	Coccinellids	0.280	0.234	-0.025	0.184	0.026	-0.030	0.780**
9	Damselfly	0.136	-0.022	-0190	-0.023	-0.176	0.143	---
10	Dragonfly	0.145	--0.185	-0.036	-0.061	-0.219	-0.008	---

**Significant at 5% level of significance.

Table 4.5 Order wise population of major insect pests in okra during kharif, 2020.

SN	ORDER		INSECT	MEAN POPULATION (whole crop period)	MEAN POPULATION (%)	
					Insects + natural enemies	Insects
	Pests	**SN**				
		i	Aphids (/three leaves)	14.69	63	64
1	Hemiptera	ii	Jassids (/three leaves)	2.49		
		iii	White flies (/three leaves)	10.83		
		iv	Red cotton bug	1.48		
		i	Fruit and shoot borer	5.71	35	36
		ii	Fruit borer	5.42		
2	Lepidoptera	iii	Tobacco caterpillar	5.12		
	Natural enemies					
3	Coleoptera	i	Lady bird beetle	0.16	1	-
4	Odonata	i	Dragonfly	0.15	1	-
		ii	Damselfly	0.18		
Total					100	100

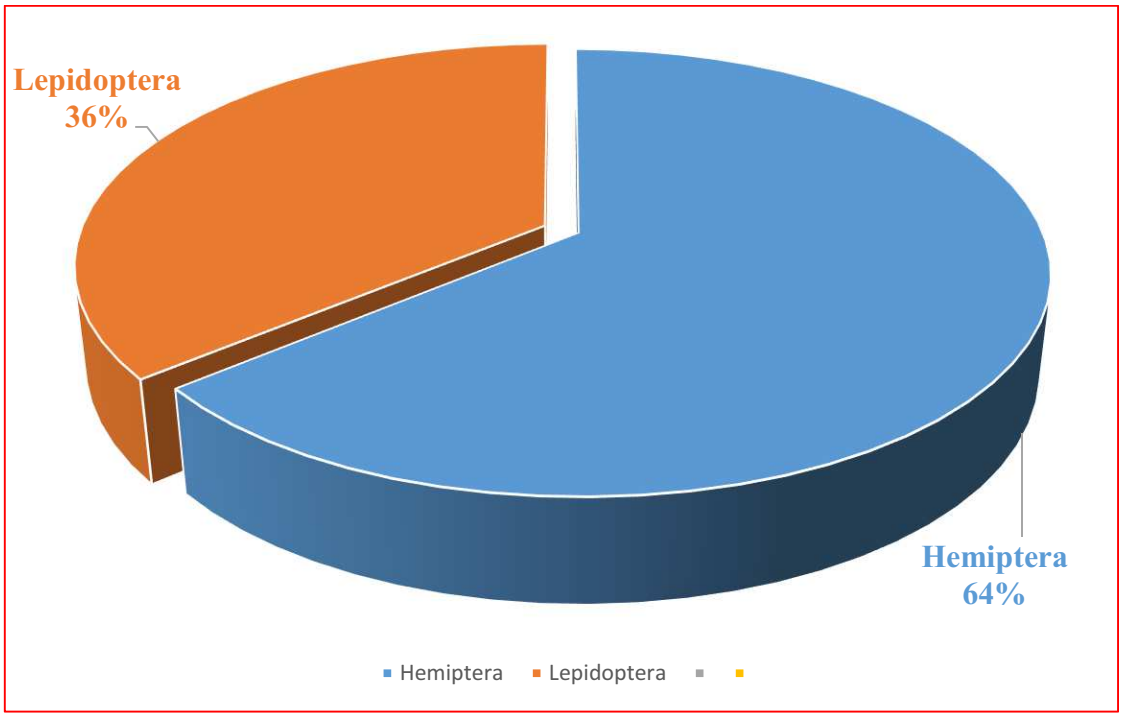

Fig. 4.1 Order wise population of major insect pests in okra during kharif, 2020.

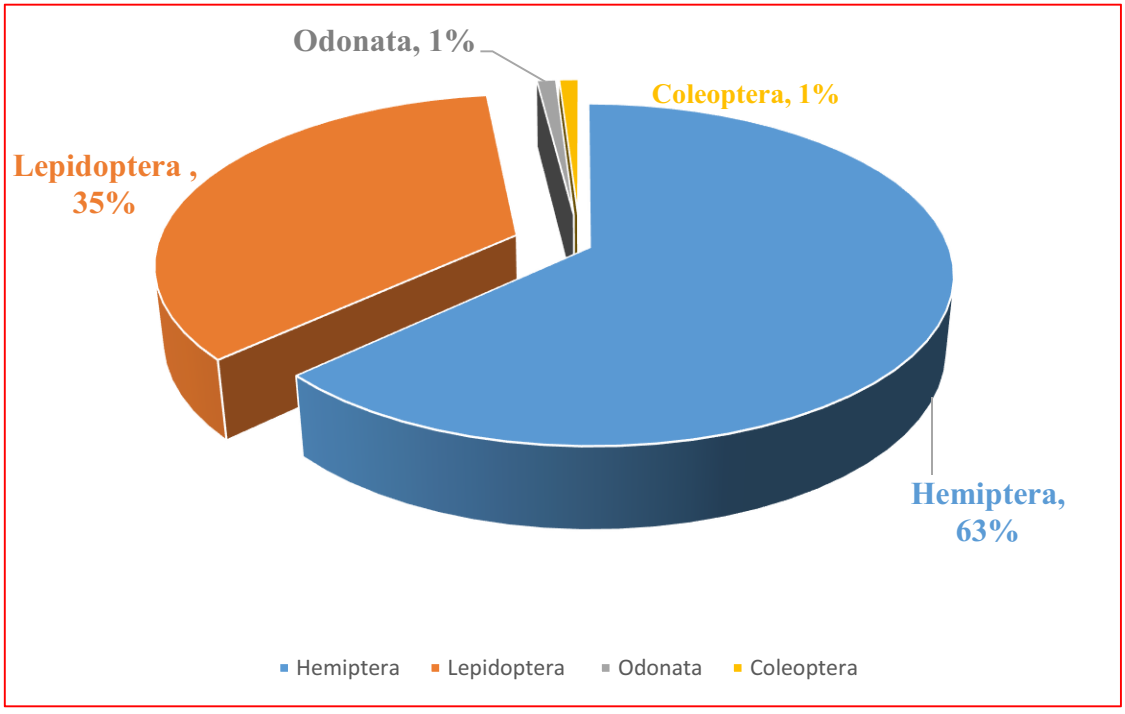

Fig. 4.2 Insect pests and natural enemies in okra during kharif, 2020.

Table No.: -4.6 Weekly meteorological data recorded during the experimental period (2020) at Mungeli.

S.N.	Standard Meteorological Week	Period	Temperature (^{0}C)			Relative Humidity (%)			Rainfall (mm)	n shine (hrs)
			Max.	Min.	Avg.	RH I	RH II	Avg. RH		
1	35	27.08.2020-02.09.2020	30.17	22.7	26.43	90.71	82.28	86.495	16.4	3.21
2	36	03.09.2020-09.09.2020	32.97	24.05	28.51	91	72.57	81.785	0.34	6.51
3	37	10.09.2020-16.09.2020	33.78	23.82	28.8	89	67.78	78.39	0.2	6.32
4	38	17.09.2020-23.09.2020	33.37	22.81	28.09	92.71	76.42	84.565	16.28	1.65
5	39	24.09.2020-30.09.2020	33	22.62	27.81	90.85	64.57	77.71	0	4.87
6	40	01.10.2020-07.10.2020	32.71	22.14	27.425	90	66.71	78.355	5.62	4.57
7	41	08.10.2020-14.10.2020	32.87	22.92	27.895	89.85	66.28	78.065	0.14	4.15
8	42	15.10.2020-21.10.2020	32.88	21.98	27.43	87.85	59.85	73.85	0	8
9	43	22.10.2020-28.10.2020	32.67	17.84	25.255	83.71	49	66.355	0	8.31
10	44	29.10.2020-04.11.2020	31.74	15.84	23.79	81.71	47.71	64.71	0	8.88
11	45	05.11.2020-11.11.2020	30.62	11.41	21.015	76.42	46.14	61.28	0	8.92
12	46	12.11.2020-18.11.2020	32.6	16.98	24.79	85.42	50.14	67.78	0	8.72

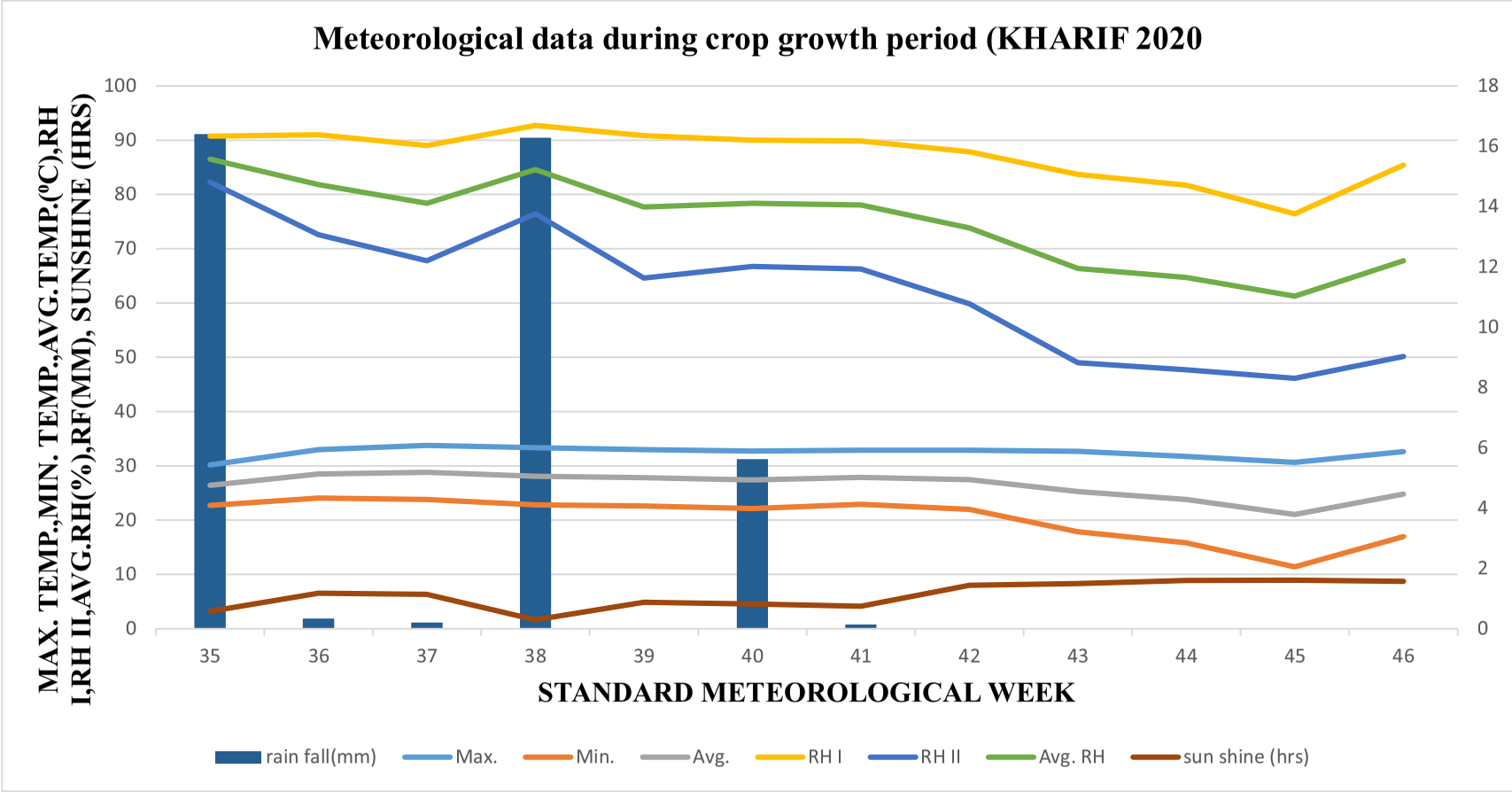

Fig. 4.3 Meteorological data during crop growth period (KHARIF 2020)

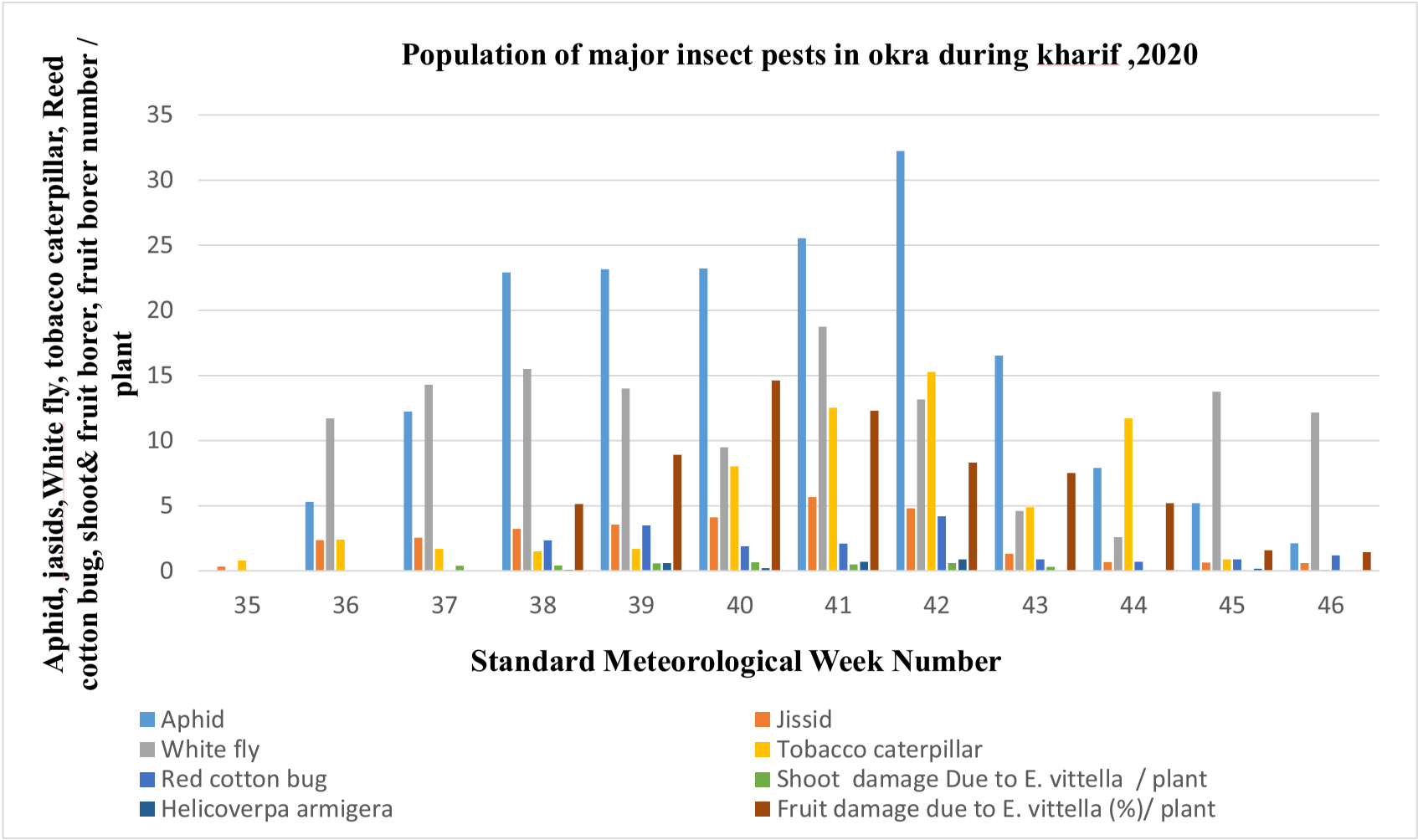

Fig. 4.4 Population of major insect pests in okra during kharif,2020

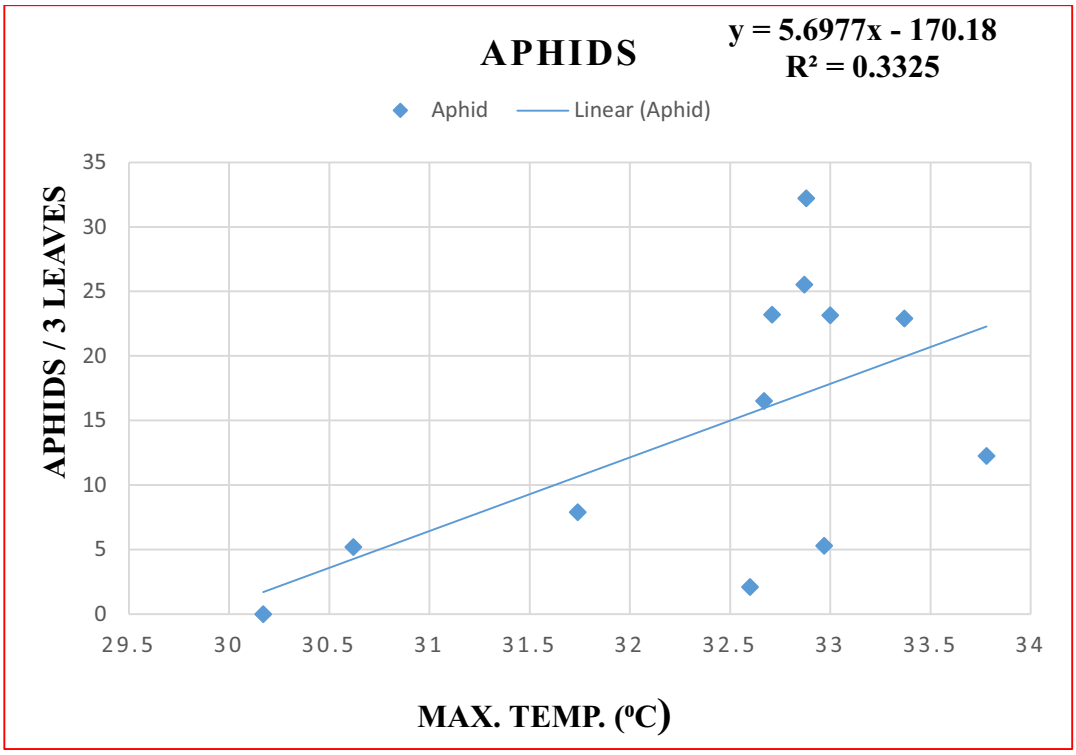

Fig. 4.5 Regression of Aphid infestation with Max. Temp.(°C)

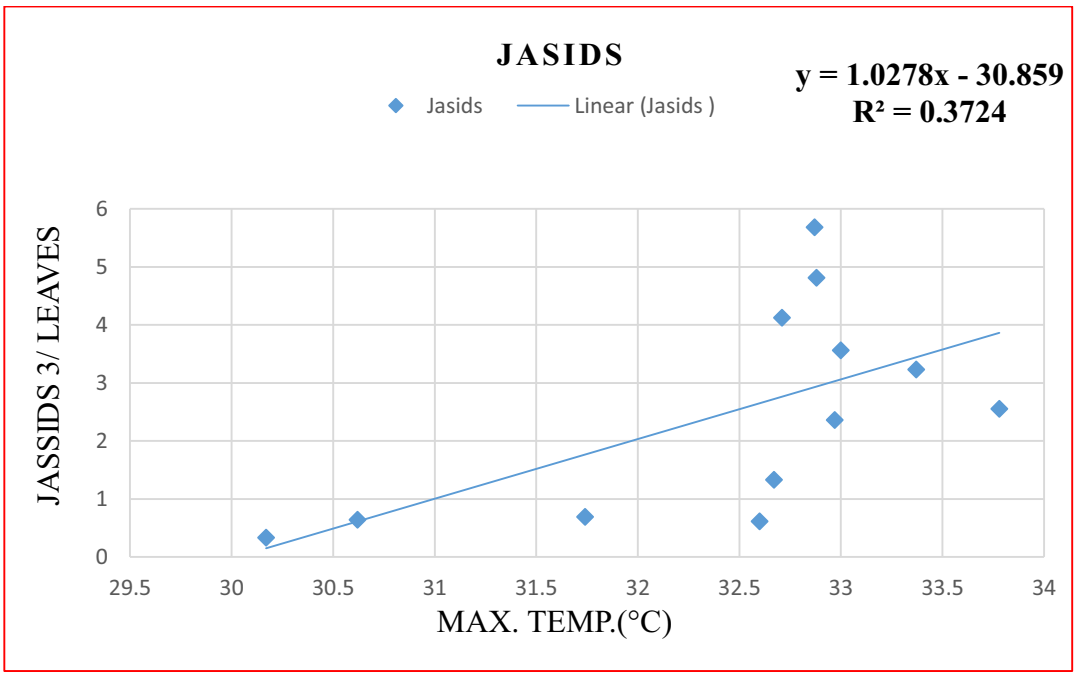

Fig. 4.6 Regression of jasid infestation with Max. Temp.(°C)

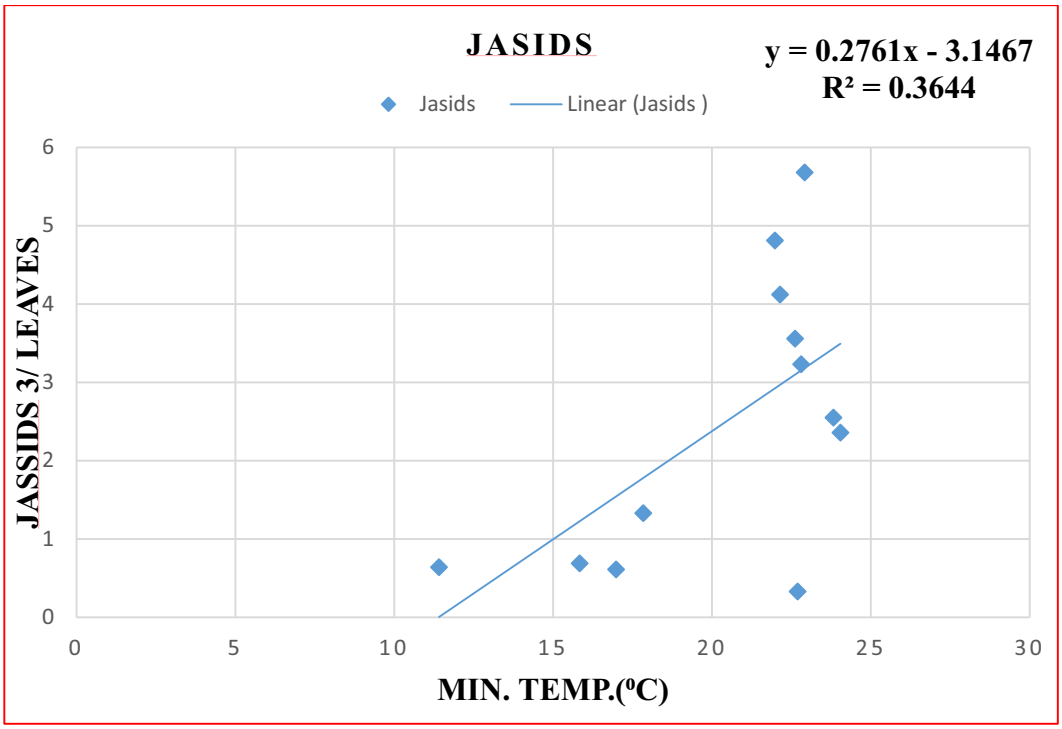

Fig. 4.7 Regression of jassid infestation with Min. Temp.(°C)

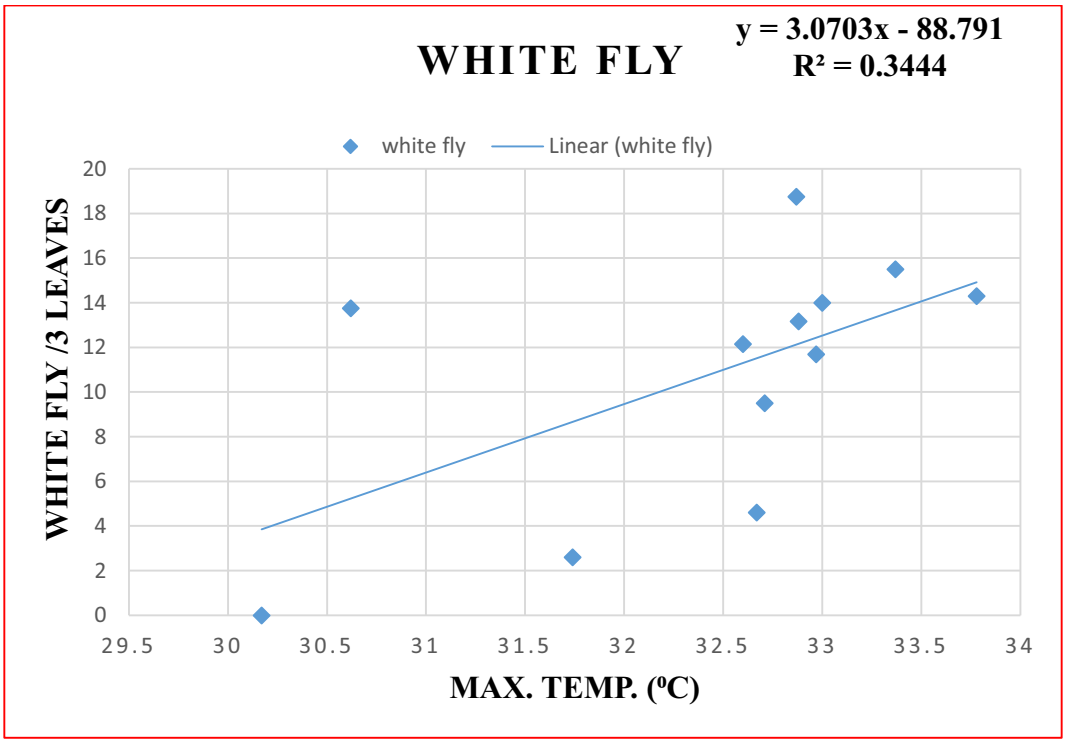

Fig.4.8 Regression of White fly infestation with Max. Temp.(° C)

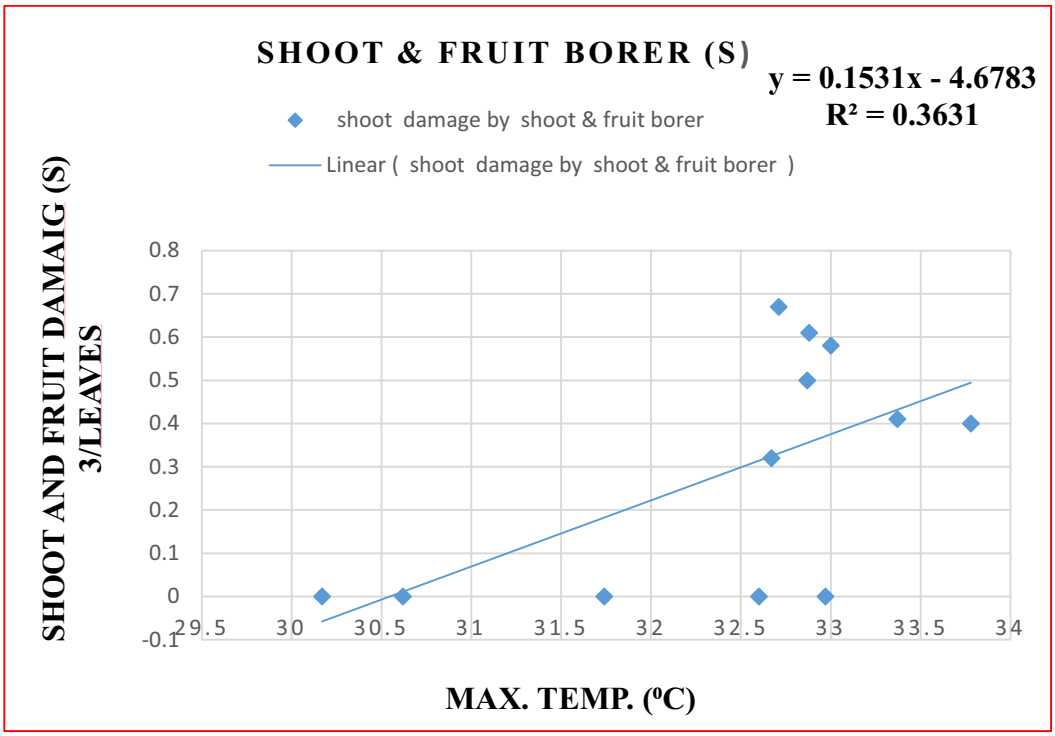

Fig. 4.9 Regression of Shoot fruit borer (S) infestation with Max.Temp.(°C)

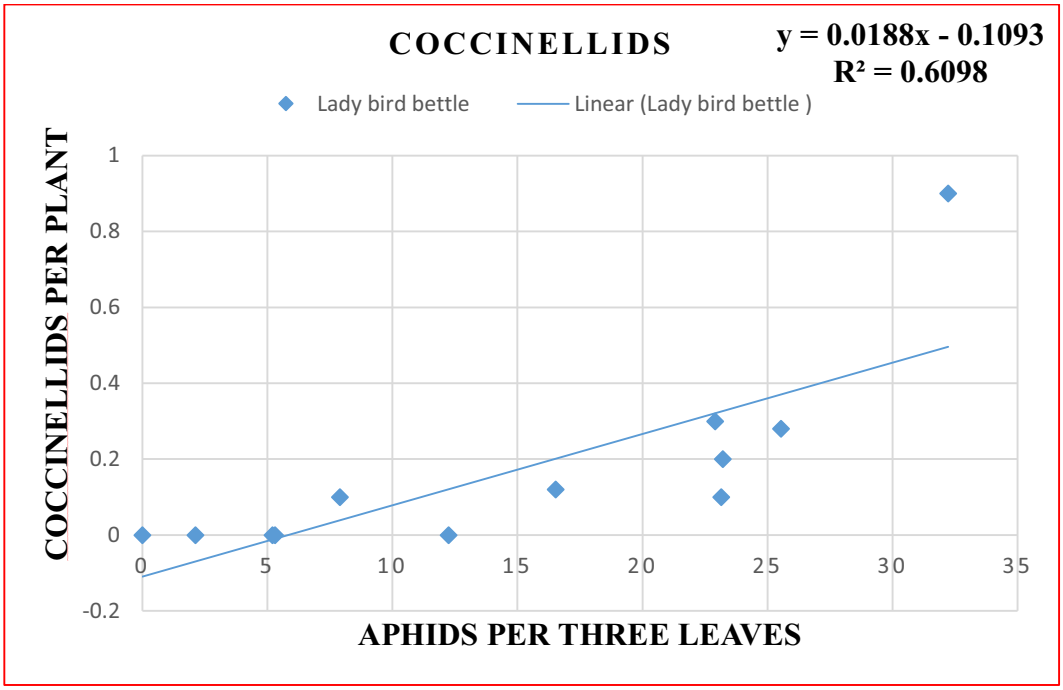

Fig. 4.10 Regression of Coccinellids with population of aphids/ three leaves.

4.2To record the associated natural enemies throughout the period of study.

Table 4.7 Natural enemies recorded on okra during experimental period, 2020.

S.No.	Insect pests	Scientific Name	Order	Family
1	Lady bird beetle	*Cheilomenes sexmaculata* Fabricius	Coleoptera	Coccinellidae
2	Damselfly	*Oristicta* sp.	Odonata	Isosticitidae
3	Dragonfly	*Orthetrum* sp.	Odonata	Ashnidae

Table 4.8 Activity of natural enemies in okra during experimental period, 2020.

WAS	SMW	Mean population of natural enemies /plant		
		Lady bird beetle	Dragonfly	Damselfly
3	35	0	0.00	0.00
4	36	0	0.00	0.00
5	37	0	0.00	0.00
6	38	0.3	0.30	0.20
7	39	0.1	0.23	0.35
8	40	0.2	0.17	0.18
9	41	0.28	0.21	0.16
10	42	0.9	0.36	0.75
11	43	0.12	0.027	0.025
12	44	0.1	0.08	0.075
13	45	0	0.25	0.25
14	46	0	0.28	0.19
Over all mean		**0.16**	**0.15**	**0.18**

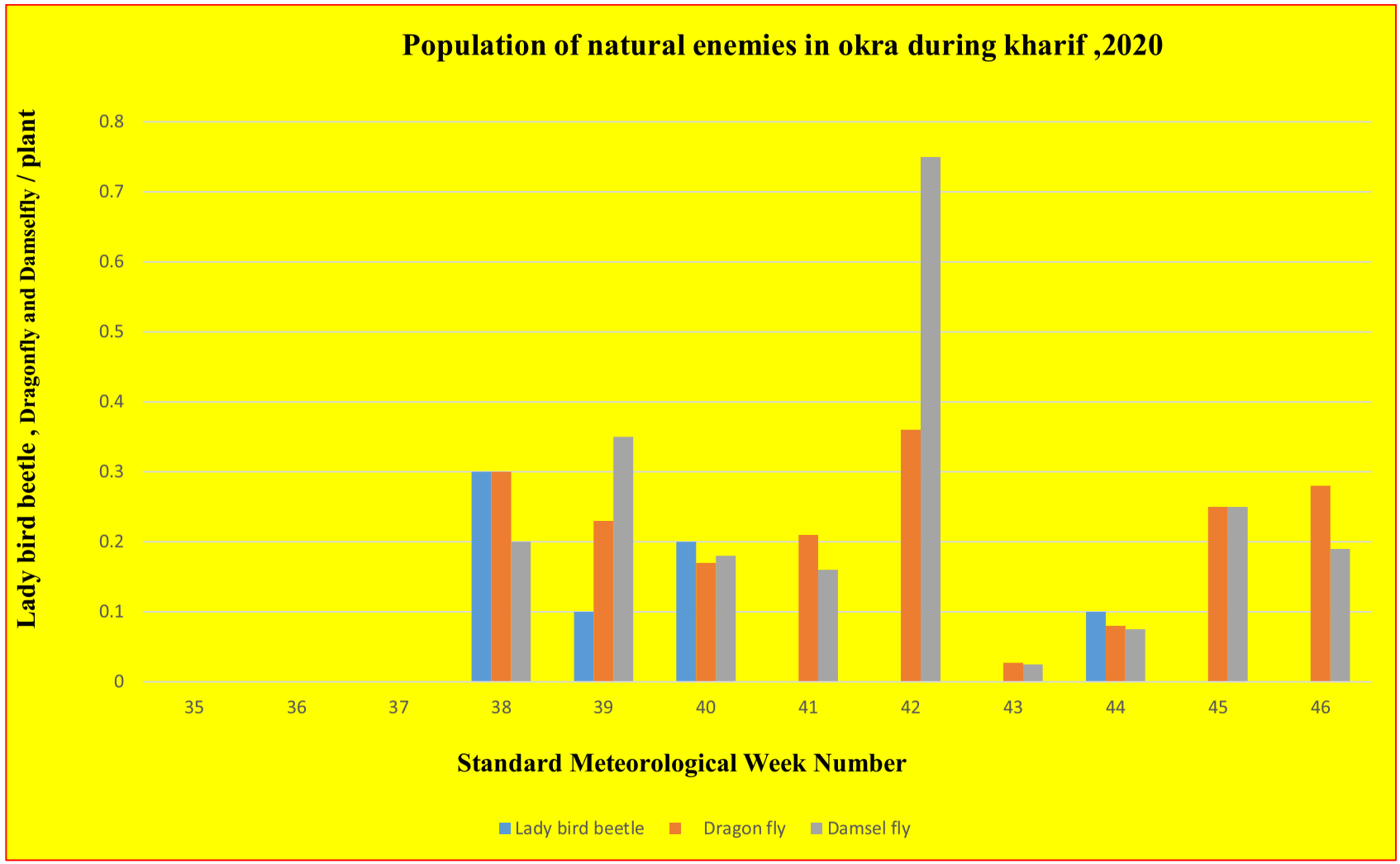

Fig 4.11 Population of natural enemies in okra during kharif,2020

4.2.1 The results on succession of natural enemies on okra, *Abelmoschus esculentus* (L.) Moench.is described below-

4.2.1.1 Lady bird beetle, *Cheilomenes sexmaculata* (Coleoptera: Coccinellidae)

Three species of lady bird beetles *viz.*, *Coccinella septempunctata*, *Menochilus sexmaculatus* and *Micraspis vineta* were recorded in the present studies. Their population initiated during the vegetative stage of the crop in the 4th week of September, (38thSMW *i.e.* 6 WAS) with an average population level of 0.30 beetles per plant.

The average maximum and minimum temperature during the initiation period of lady bird beetles were 33.71˚C and 22.81˚C and the average morning and evening relative humidity was 92.71% and 76.42% respectively with an average rain fall recorded of 16.28 mm. The lady bird beetles remained active till the 2nd week of November. Their lowest population (0.10 per plant) was recorded in 2nd week of November 2020.The average maximum and minimum temperature during 31.74˚C and 15.84˚C and the average morning and evening relative humidity were 81.71% and 47.71% respectively with no rain fall (0.00 mm) recorded highest population (0.91beetles per plant) during the 3rd week of October (42nd SMW, *i.e.* 10 WAS). The average maximum and minimum temperature during the peak period were 32.88˚C and 21.98˚C and the average morning and evening relative humidity were 87.85% and 59.85% respectively with no rain fall during the period.

Singh and Jha (2013) and Bhatt *et al.* (2018) also reported initiation of coccinellids from the 2nd fortnight of September, Bhatt *et al.* (2018) recorded peak population of lady bird beetles 9 WAS which is more or less similar to the present findings. Gaikwad *et al.* (2020) and Singh and Jha (2013) also recorded the peak population of coccinellids on month of October which is in line with the present studies.

The data presented in Table No.4.4 clearly indicates that the lady bird beetles (grub and adult) showed a highly positive significant correlation with aphid population (r=0.780**) and depicted positive but non-significant correlation with

maximum (r = 0.280), and minimum temperature (r = 0.234) and positive correlation with morning (r =0.184), and evening relative humidity (r = 0.026) but it was negative and non-significantly correlated with rainfall and (r = -0.025), BSS (r = -0.030).

Singh and Jha (2013), Lal *et al.* (2020) and Raghuwanshi *et al.* (2019) also reported negative correlation with rain fall and positive correlation with minimum temperature morning and evening relative humidity which is similar to the present findings.

Feeding Habits:

Grubs and adults of lady bird beetle are predators. They feed on nymph and adult stages of soft bodied insect *viz*., aphids, jassids, and whiteflies

4.2.1.2 Dragonfly, *Orthetrum* spp. (Odonata:- Aeshnidae)

The dragonfly, population was initiated during vegetative stage of the crop in the 4th of September, (38th SMW *i.e.* 6 WAS) with an average population level of 0.30 dragonflies per plant., The average maximum and minimum temperature during the initiation period of dragonfly, were 33.71˚C and 22.81˚C and the average morning and evening relative humidity was 92.71% and 76.42% respectively with an average rain fall of 16.28 mm. Dragonflies, remained active till the last week of November. The lowest population of dragonflies, (0.027 per plant) was recorded in the 1st week of October 2020, with an average maximum and minimum temperature during 32.67˚C and 17.84˚C and the average morning and evening relative humidity were 83.71% and 49% respectively with no rain fall (0.00 mm). Highest population (0.36 dragonflies per plant) during the 4th week of October (42nd SMW *i.e.*10 WAS). The average maximum and minimum temperature during peak period, dragonflies were 32.88˚C and 21.98˚C and the average morning and evening relative humidity were 87.85% and 59.85% respectively with no rainfall during the period.

Ray *et al.* (2017) also reported that the initiation of dragonflies was noticed 6 WAS and their findings are similar to the present findings and the peak period of damselfly population was observed 9 WAS which is more or less similar to the present findings. Netam *et al.* (2003) also recorded more activity period in the month

of October which is also in line with the present results.

The data presented in Table No. 4.4. clearly indicated non-significant positive correlation with maximum (r = 0.145), negative but non-significant correlation with and minimum temperature (r = -0.185) and morning (r =-0.061), and evening relative humidity (r =-0.219) rainfall and (r = -0.036), BSS (r = -0.008).

4.2.1.3 Damselfly, *Oristicta* spp. (Odonata:- Isostictidae)

The population of damselflies initiated during the vegetative stage of the crop in the 4th week of September, (38th-SMW *i.e.* 6 WAS) with an average population level of 0.20 damselflies, per plant, with an average maximum and minimum temperature during the initiation period of damselflies, were 33.71˚C and 22.81˚C and the average morning and evening relative humidity were 92.71% and 76.42% respectively with an average rain fall of 16.28 mm. The damselflies, remained active till the last week of November. The lowest population of damselflies 0.025 per plant was recorded in the 1st week of November 2020. Lowest population period of damselflies, were associated with average maximum and minimum temperature during 32.67˚C and 17.84˚C and the average morning and evening relative humidity were 83.71% and 49% respectively with no rain fall (0.00mm). Highest population 0.75 per plant was observed during the 4th week of October (42ndSMW *i.e.*10 WAS). The average maximum and minimum temperature during the peak period of damselflies, was 32.88˚C and 21.98˚C and the average morning and evening relative humidity was 87.85% and 59.85% respectively with 0.00mm rain fall.

The data presented in Table No. 4.4clearly indicates that the population of damselflies showed non-significant positive correlation with MaxT (r = 0.136), and BSS (r = 0.143), negative and non-significant correlation with and minimum temperature (r = -0.022) and morning (r =-0.023), and evening relative humidity (r =- 0.176) rainfall and (r = -0.190).

Ray *et al.* (2017) also reported the initiation of damselflies at 6 WAS and more or less similar peak period of damselflies population at 9 WAS is very close to the present findings.

Plate no:- 4.1 Experimental field at Dindori Village, under Lormi Block, Dist. Mungeli.

Plate no:- 4.2 Recording data in the experimental field

Plate no:- 4.3 Okra fruit infested by okra shoot and fruit borer, *E. vittella*

Plate no:- 4.4 Okra Shoot infested by okra shoot and fruit borer, *Earias vittella* Fabricius

Plate no:- 4.5 Infestation of tobacco caterpillar, *Spodoptera litura*

Plate no:-4. 6 Okra leaf infested by aphid, *Aphis gossypii* Glover

Plate no:- 4.7 Fruit damage by Okra fruit Borer, *Helicoverpa armigera*

Plate no:- 4.8 Jassid, *Amrasca biguttula*

Plate no:- 4.9 Whitefly, *Bemisia tabacii*

Plate no:- 4.10 Lady bird beetle, *Micraspis vineta*

Plate no:- 4.11 Lady bird beetle, *Cheilomenes sexmaculata* Fabricius

Plate no:- 4.12 Adult and grub of lady bird beetle, *Coccinella transversalis*

Plate no:- 4.13 Damselfly, *Oristicta* sp. **Plate no:- 4.14 Dragonfly, *Orthetrum* sp.**

Plate no:- 4.15 Red cotton bug, (*Dysdercus cingulatus* Fabricius)

CHAPTER–V

SUMMARY AND CONCLUSION

The objective wise summary and conclusion of the work done under the investigation entitled **"Studies on the pest succession in okra (*Abelmoschus esculentus*(L.) Moench) and associated natural enemies at Lormi, Mungeli district of Chhattisgarh."** is as presented below: -

- **To study the pest succession in okra *Abelmoschus esculentus* (L.) Moench) at Lormi (district – Mungeli) Chhattisgarh**.

- **To record the associated natural enemies throughout the period of study.**

The field experiment was carried out at the farmer's field in Dindori village of Lormi tehsil under Mungeli district of Chhattisgarh. The experiment was conducted during the *Kharif* season of 2020-21. The results are summarized and concluded below: -

5.1 To study the pest succession in okra (*Abelmoschus esculentus* (L.) Moench) at Lormi (district – Mungeli) Chhattisgarh.

- Under the study on insect pest succession of okra during the kharif season of 2020, observations were recorded on 10 randomly selected plants, in which 10 species of the insects were observed, belonging to 4 orders namely, Hemiptera, Lepidoptera, Coleoptera and Odonata which included 7 insect pests and 3 natural enemies.

- Sucking pests like aphid (*A. gossypii)*, jassid (*A biguttula biguttula* Ishida), and whitefly (*B. tabacii* Gennadius) were observed damaging during vegetative stage of okra.

- The okra shoot and fruit borer (*E. vittella*) were observed damaging mainly shoots during vegetative stage and fruit damage during the fruiting stage of the crop.

- Infestation of the fruit borer (*Helicoverpa armigera*) was noticed at the fruiting stage of the crop.
- Tobacco caterpillar (*Spodoptera litura)* was recorded throughout the vegetative stage up to the harvesting period of the crop.
- The red cotton bug (*Dysdercus cingulatus* Fabricus) was recorded from 6 WAS onwards throughout the period of the crop.
- Aphids were recorded from the 2nd week of September to the 3rdweek of November with maximum aphid population (32.22/ three leaves) during 3rd week of October (10 WAS).
- Positive significant correlation of maximum temperature (r=0.577**) with aphids was recorded.
- The incidence of jassid was recorded from 1stweek of September to 3rdweek of November maximum jassid population (5.68 / three leaves) during the 2nd week of October (9 WAS).
- Positive significant correlation of MaxT and (r=0.610**), MinT (r=0.604**), was found with population of jassids.
- Whiteflies were recorded from the 2ndweek of September to the 3rdweek of November with maximum whitefly population (18.75 nymphs and adults / three leaves) during 2nd week of October (9 WAS).
- Population of whiteflies depicted positive significant correlation with maximum temperature (r=0.580**).
- Infestation of *E.vitella* on shoot was observed from the2nd week of September to the last week of October.
- Maximum shoot damage was recorded (0.67/ plant) during 1st week of October (8 WAS).
- Positive significant correlation of maximum temperature (r=0.603**) with *E.vitella* on shoot.

- Maximum damage to shoots due to *E. vitella* was recorded from 4thweek of September to 3rdweek of November.
- Maximum fruit damage due to *E. vitella* were observed (14.63 %) during the 2nd week of October / 9WAS with range of 1.45 to 14.63 % fruit damage.
- The incidence of *Helicoverpa armigera* was recorded from 1st week of October to 3rd week of November.
- Maximum population of *H. armigera* was observed (4.30 larvae per plant) during the 3rd week of October (10WAS).
- Infestation of *Spodoptera litura* was observed at all stages of the crop, from the 1st week of September to the 3rd week of November with maximum larvae recorded (15.27 larvae per plant) during the 3rd week of October (10WAS)
- Red cotton bug was observed at all stages of the crop from the 3rd week of September to the 3rd week of November with a maximum population (4.23 per plant) recorded during the 3rd week of October (10WAS).

5.2 To record the associated natural enemies throughout the period of study.

Under the studies on natural enemies, three natural enemies were recorded throughout the period of study, *viz.,* lady bird beetles, dragonflies and damselflies.

- Three species of lady bird beetles *viz.*, *Coccinella septempunctata*, *Menochilus sexmaculatus* and *Micraspis vineta* were recorded in the present studies.
- Population of natural enemies (lady bird beetles, dragonflies and damselflies) initiated during the vegetative stage of the crop in the 4th week of September at the time of aphid infestation.
- Maximum population of lady bird beetles (0.9 per plant) dragonflies (0.36 per plant) damseflies (0.75 per plant) were observed during the 3rd week of October (10WAS).

- Highly positive significant correlation of aphid population (r=0.780**) with population of lady bird beetle was exhibited.

Suggestions for future work: -

1. Different hybrid and improved varieties of okra can be compared with local varieties of a particular region to study the extent of pest incidence.
2. Biocontrol agents such as *Trichogramma* spp. and larval parasitoid, *Bracon* sp. along with predator, reduviid bugs can be tested against major lepidopteran pests to reduce the use of chemicals for the production of healthy and pesticide residue free yield.
3. Coccinellid beetles can be tested against aphids and jassids.
4. Cost benefit ratio of biocontrol agents and chemical used in farmers (non-biocontrol) can be worked out.

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Appendix- A

Table 3.1-Weekly meteorological data recorded during the experimental period (2020) at Mungeli.

S.N.	Standard Meteorological Week	Period	Temperature (^{0}C)			Relative Humidity (%)			Rainfall (mm)	n shine (hrs)
			Max.	Min.	Avg.	RH I	RH II	Avg. RH		
1	35	27.08.2020-02.09.2020	30.17	22.7	26.43	90.71	82.28	86.495	16.4	3.21
2	36	03.09.2020-09.09.2020	32.97	24.05	28.51	91	72.57	81.785	0.34	6.51
3	37	10.09.2020-16.09.2020	33.78	23.82	28.8	89	67.78	78.39	0.2	6.32
4	38	17.09.2020-23.09.2020	33.37	22.81	28.09	92.71	76.42	84.565	16.28	1.65
5	39	24.09.2020-30.09.2020	33	22.62	27.81	90.85	64.57	77.71	0	4.87
6	40	01.10.2020-07.10.2020	32.71	22.14	27.425	90	66.71	78.355	5.62	4.57
7	41	08.10.2020-14.10.2020	32.87	22.92	27.895	89.85	66.28	78.065	0.14	4.15
8	42	15.10.2020-21.10.2020	32.88	21.98	27.43	87.85	59.85	73.85	0	8
9	43	22.10.2020-28.10.2020	32.67	17.84	25.255	83.71	49	66.355	0	8.31
10	44	29.10.2020-04.11.2020	31.74	15.84	23.79	81.71	47.71	64.71	0	8.88
11	45	05.11.2020-11.11.2020	30.62	11.41	21.015	76.42	46.14	61.28	0	8.92
12	46	12.11.2020-18.11.2020	32.6	16.98	24.79	85.42	50.14	67.78	0	8.72

RESUME

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Membership of professional societies: No

Awards/ Recognitions: No

Publication: No

Signature

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