“SEASONAL INCIDENCE, POPULATION DYNAMICS, GERMPLASM SCREENING AND BIO-EFFICACY STUDIES OF INSECTICIDES AGAINST INSECT PESTS OF BRINJAL”

M.Sc. (Ag.) Thesis

By

Harshal Kumar Chandrakar

DEPARTMENT OF ENTOMOLOGY
COLLEGE OF AGRICULTURE
FACULTY OF AGRICULTURE
INDIRA GANDHI KRISHI VISHWAVIDYALAYA
RAIPUR (CHHATTISGARH)

2019

“SEASONAL INCIDENCE, POPULATION DYNAMICS, GERMPLASM SCREENING AND BIO-EFFICACY STUDIES OF INSECTICIDES AGAINST INSECT PESTS OF BRINJAL”

Thesis

Submitted to the

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

By

Harshal Kumar Chandrakar

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

Master of Science

in

Agriculture

(Entomology)

U.E.ID.20131417169 **ID.No.120117127**

November, 2019

CERTIFICATE – I

This is to certify that the thesis entitled **"Seasonal incidence, population dynamics, germplasm screening and bio-efficacy studies of insecticides against insect pests of brinjal"** submitted in partial fulfillment of the requirements for the degree of **Master of Science in Agriculture** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, is a record of the bonafide research work carried out by **Harshal Kumar Chandrakar** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

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

Dr. Gajendra Chandrakar
Chairman

Date: 28/11/2019

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

Chairman	(Dr. Gajendra Chandrakar)	____________
Member	(Dr. Navneet Rana)	____________
Member	(Dr. Dhananjay Sharma)	____________
Member	(Dr. R. R. Saxena)	____________

CERTIFICATE – II

This is to certify that the thesis entitled **"Seasonal incidence, population dynamics, germplasm screening and bio-efficacy studies of insecticides against insect pests of brinjal"** submitted by **Harshal Kumar Chandrakar** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) in partial fulfilment of the requirements for the degree of **Master of Science in Agriculture** in the **Department of Entomology** has been approved by the external examiner and student's advisory committee after oral examination.

29-12-19

Date: Signature External Examiner

(Name S.N. Upadhyay --------)

Major Advisor ----------------------------------

Head of the Department/Section ----------------------------------

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

Approved/Not approved ----------------------------------

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

ACKNOWLEDGEMENT

I take this golden opportunity to express my heartfelt sense of gratitude to all those who guided and helped me to make my research possible. These words are small acknowledgement but never fully recompensed for their guidance, help and co-operation.

With great reverence I express my warmest feeling with deep sense of gratitude to my advisor and chairman of my advisory committee Dr. Gajendra Chandrakar, Senior Scientist, Department of Entomology, College of Agriculture, IGKV, Raipur (C.G.). I have no words to express my heartfelt thanks to him for illuminating guidance, unfailing encouragement, scholarly suggestions, unique supervision, construction criticism, sympathetic attitude and keeping interest during the course of my research and preparation of this manuscript.

I express my sincere and profound gratitude to Dr. D. K. Rana, Professor and Head, Department of Entomology, College of Agriculture, Raipur, for his inspiring suggestions and providing me all the necessary facilities during my study.

With extreme pleasure, I extent my heartiest thanks to the members of my Advisory Committee Dr. Navneet Rana, Scientist, Department of Entomology , Dr. Dhananjay Sharma, Sr. Scientist, Department of vegetable Science, Dr. R. R. Saxena, professor, Department of Agril. Statistics, Mathematics and Computer Science for their guidance, suggestions and encouragement during the course of investigation.

I wish to record my sincere thanks to Dr. S.K. Patil, Hon'ble Vice Chancellor, Dr. M.P. Thakur, Director of Instructions, Dr. R.K. Bajpai, Director Research Services, Dr. S.C. Mukherjee, Director of Extension Services, Dr .G. K. Shrivastava, Dean Student Welfare and Dr. S.S. Rao, Dean, College of Agriculture, Raipur for their administrative and technical help which facilitated my research work.

I am thankful to the teachers of my Department Dr. S. S. Shaw, Dr. V. K. Koshta, Dr. Rajeev Gupta, Dr. A.K. Dubey, Dr. H. K. Chandrakar, Dr. V.K. Dubey, Dr. R. N. Ganguli, Dr. Y. K. Yadu, Dr. (smt.) Jaya Laxmi Ganguli, Dr. Navneet Rana, Dr. B. P. Katlam, Dr. (smt.) Sonali Deole for their constant co-operative suggestion, encouragement and help during my investigation.

I would like to express my sincere gratitude to Dr. Madhav Pandey and Library staff for giving me their kind help during my present study.

I do express my thanks to the non-technical staff members namely, Dinesh Sahu, Devnarayan Chandrakar, Tribhuvan Sahu, Parasram Rangier, Kunjlal Sahu, who were always ready to help me during the period of study.

I am thankful to my respected seniors Manmohan Bisen sir, Mamta Paikra mam, Nagendra Bhuarya sir, Saurabh Padamshali sir, V. Sajil Kumar sir who were there to give their encouragement, help and suggestion in the present study.

I am deeply privileged to express heartfelt thanks to my best friends Beerendra Anant, Tarun Kumar Nayak, Aalok Kumar, Renuka, Ambika, santoshi, Nandita, Roshni, Manju, Hemlata, Diksha, Chetna and Aniket who provided me an inner strength and guided me during my entire academic career as to steer up my ambition in a proper way.

For the most important personalities of my life, there aren't enough words to express my gratitude to my beloved father Mr. Mahendra Kumar Chandrakar and mother Smt. Madhu Chandrakar, my Uncle Mr. Tarun Chandrakar and my brother Mr. Vinay Chandrakar for their constant encouragement, sincere prayers and blessings which have always been the most vital source of inspiration and motivation in my life.

I would like to convey my cordial thanks to all those unmentioned persons who helped me directly and indirectly to fulfill my dream come true.

Harshal

Department of Entomology *Harshal Kumar Chandrakar*

College of Agriculture, IGKV, Raipur

Date: 28/11/2019

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LIST OF ABBREVIATIONS

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

THESIS ABSTRACT

a)	Title of Thesis	:	"Seasonal incidence, population dynamics, germplasm screening and bio-efficacy studies of insecticides against insect pests of brinjal"
b)	Full Name of the Student	:	Harshal Kumar Chandrakar
c)	Major Subject	:	Entomology
d)	Name and Address of the Major Advisor	:	Dr. Gajendra Chandrakar (Senior Scientist) Department of Entomology, College of Agriculture, Raipur-492012
e)	Degree to be Awarded	:	Master of Science in Agriculture (Entomology)

Signature of the Student

Signature of Major Advisor

Date: 28/11/2019

Signature of Head of the Department

ABSTRACT

The present investigation entitled **"Seasonal incidence, population dynamics, germplasm screening and bio-efficacy studies of insecticides against insect pests of brinjal"** was carried out in the research field of Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh) during season *rabi* 2018-19.

Incidence of jassids (*Amrasca biguttula biguttula*), whitefly (*Bemisia tabaci*), aphid (*Aphis gossypii*), hadda beetle (*Epilacna vigintioctopunctata*) and shoot and fruit borer (*Leucinodes orbonalis*) were revealed as major insect pests on brinjal crop. Lady bird beetle and spider as natural enemies on sucking pests of brinjal were also recorded. The peak activity of jassids (19.8/plant), whitefly (14.82/plant), aphid (21.92/plant) and

hadda beetle (1.2/plant) were recorded during second week of March, fourth week of February, first week of February and second week of February, respectively. The seasonal incidence of shoot and fruit borer was started on shoots (0.3% infested shoots/plant) in first week of January on vegetative stage and it to be continued on flowering and fruiting stage with maximum infestation of fruit 76.4% during period of second week of April and its infestation was remained till last stage of the crop. The natural enemies incidence *viz.* lady bird beetle and spider population was recorded as maximum 4.8 per plant during third week of April and 2.9 per plant during the first week of January, respectively.

The shoot and fruit borer infestation had positive and significant correlated with maximum (r = 0.866) and minimum (r = 0.846) temperature, wind velocity (r = 0.579) and sunshine hours (r = 0.551) and negative significant with morning (r = -0.834) and evening (r = -0.570) relative humidity. The population of jassids showed positively and significant with wind velocity (r = 0.411). The population of aphid showed negative and significant with minimum temperature (r = -0.434). Jassids population had negative and significance correlated with lady bird beetle (r = -0.476) and spider (r = -0.493). Whitefly population had negative and significance correlated with lady bird beetle (r = -0.564) and spider (r = -0.401). Aphid population had negative and significance correlated with lady bird beetle (r = -0.391).

On the basis of pest susceptibility grade formula on brinjal shoot and fruit borer infestation, formulated by subbaratnam and bhutani (1981), the overall mean percentage of shoot and fruit infestation due to *L. orbonalis* was recorded on all the 124 brinjal germplasm. Out of the 124 germplasm none of the brinjal germplasm was tolerant against shoot and fruit borer infestation in the category of 1.00 and 15.00 per cent. Two germplasm viz. IGB-52 and IGB-53 were moderately tolerant under the category of 16.00 and 25.00 per cent infestation. While susceptible reaction *i.e.* infestation ranged from 26.00 to 40.00 per cent was exhibited by 26 germplasm. The highly susceptible (above 40%) reaction was observed in rest of the 96 brinjal germplasm against shoot and fruit borer incidence.

Dimethoate 20% + Cypermethrin 3% EC @ 141.3 g a.i./ha was found most effective insecticide against shoot and fruit borer and jassids of brinjal, as it was recorded lowest fruit infestation percentage (12.66 %), along with maximum healthy fruit yield (220.00 q/ha) with highest benefit cost benifit ratio of 1 : 2.67. Impact of Dimethoate 20% + Cypermethrin 3% EC was recorded that no significant impact on natural enemies *viz.* coccinellid and spider population.

शोध ग्रंथ का सारांश

अ) शोध ग्रंथ का शीर्षक	:	बैगन के कीट व्याधियों पर मौसमीय प्रभाव, जनसंख्या गतिशीलता, जननद्रव्य स्क्रीनिंग तथा उनके विरूद्ध कीटनाशको के जैव प्रभावकारिता का अध्ययन
ब) छात्र का पूरा नाम	:	हर्षल कुमार चन्द्राकर
स) प्रमुख विषय	:	कीट विज्ञान
द) मुख्य सलाहकार नाम और पता	:	डॉ. गजेन्द्र चन्द्राकर (वरिष्ठ वैज्ञानिक) कीट विज्ञान विभाग, कृषि महाविद्यालय, रायपुर- 492012
इ) प्रदान की जाने वाली उपाधि	:	एम .एस .सी .(कृषि) कीट विज्ञान

छात्र का हस्ताक्षर

मुख्य सलाहकार का हस्ताक्षर

दिनांक 28/11/2019

विभागाध्यक्ष के हस्ताक्षर

सारांश

वर्तमान प्रयोग **"बैगन के कीट व्याधियों पर मौसमीय प्रभाव, जनसंख्या गतिशीलता, जननद्रव्य स्क्रीनिंग तथा उनके विरूद्ध कीटनाशको के जैव प्रभावकारिता का अध्ययन"** को इन्दिरा गाँधी कृषि विश्वविद्यालय रायपुर (छत्तीसगढ़) के अनुसन्धान प्रक्षेत्र में रबी मौसम 2018-19 के दौरान आयोजित किया गया ।

बैगन के फसल पर फुदका (*एमरेसका बिगुटुला बिगुटुला*), सफेदमक्खी (*बेमिसिया टेबिसी*), माहू (*एफिस गासिपी*) तथा शाखा एवं फल भेदक (*ल्युसीनोडेस आर्बोनेलिश*) का प्रभाव प्रमुख कीट के रूप में देखा गया। सोनपंखी (लेडी बर्ड बीटल) एवं मकड़ी को बैगन के चुसक कीटो पर प्राकृतिक शत्रु के रूप में दर्ज किया गया । फुदका (19.8/पौधा), सफेदमक्खी (14.82/पौधा), माहू (21.92/पौधा) तथा हड्डा भृंग (1.21/पौधा) का शिखर गतिविधि क्रमशः मार्च के दुसरे सप्ताह, फरवरी के चौथे सप्ताह, फरवरी के पहले सप्ताह तथा फरवरी के दुसरे सप्ताह में दर्ज किया गया । शाखा एवं फल भेदक के पहले मौसमीय घटना की शुरुआत, शाखा (0.3% प्रभावित शाखा/पौधा) से जनवरी के पहले सप्ताह में वानस्पतिक अवस्था के समय हुआ तथा इसे अप्रैल के दुसरे सप्ताह की अवधि के दौरान फलों के अधिकतम संक्रमण 76.4% के साथ फूलने और फलने की अवस्था पर जारी रहा तथा इसका संक्रमण फसल के अंतिम चरण तक बना रहा । प्राकृतिक शत्रु घटना जैसे सोनपंखी (लेडी बर्ड बीटल) तथा मकड़ी की अधिकतम जनसंख्या क्रमशः अप्रैल के तीसरे सप्ताह में 4.8 प्रति पौधा तथा जनवरी के पहले सप्ताह में 2.9 प्रति पौधा दर्ज किया गया ।

शाखा एवं फल संक्रमण का महत्वपूर्ण एवं साकारात्मक सहसंबंध मौसम के विभिन्न कारको अधिकतम ($r = 0.866$) और न्यूनतम ($r = 0.846$) तापमान, वायु वेग ($r = 0.579$) तथा धूप के घंटे ($r = 0.551$) के साथ तथा महत्वपूर्ण नकारात्मक सहसंबंध प्रातःकालीन ($r = - 0.834$) एवं संध्याकालीन ($r = - 0.570$) आपेक्षिक आद्रता के साथ दर्ज किया गया । फुदका की जनसंख्या का महत्वपूर्ण साकारात्मक सहसंबंध वायु वेग ($r = 0.411$) के साथ दर्ज किया गया । माहू की जनसंख्या का महत्वपूर्ण नाकारात्मक सहसंबंध न्यूनतम तापमान ($r = - 0.434$) के साथ दर्ज किया गया । फुदका की जनसंख्या का महत्वपूर्ण नाकारात्मक सहसंबंध

सोनपंखी (लेडी बर्ड बीटल) (r = - 0.476) तथा मकड़ी (r = - 0.493) के साथ दर्ज किया गया। सफेदमक्खी की जनसंख्या का महत्वपूर्ण नकारात्मक सहसंबंध सोनपंखी (लेडी बर्ड बीटल) (r = - 0.564) तथा मकड़ी (r = - 0.401) के साथ दर्ज किया गया। माहू की जनसंख्या का महत्वपूर्ण नकारात्मक सहसंबंध सोनपंखी (लेडी बर्ड बीटल) (r = - 0.391) के साथ दर्ज किया गया।

शाखा एवं फल भेदक संक्रमण पर, सुब्बरत्नम एवं भूटानी (1981) के द्वारा बनाये गये कीट संवेदनशीलता सूत्र के आधार पर, *एल आर्बोनेलिस* के द्वारा शाखा एवं फल भेदक संक्रमण का समग्र औसत प्रतिशत पुरे 124 जननद्रव्य पर दर्ज किया गया। 124 बैगन जननद्रव्य में से कोई भी जननद्रव्य 1.00 और 15.00 प्रतिशत की श्रेणी में शाखा एवं फल भेदक के प्रति सहनशील नहीं था। दो जननद्रव्य अर्थात आई जी बी-52 तथा आई जी बी-53, 16.00 और 25.00 प्रतिशत की श्रेणी में माध्यम रूप से सहनशील थे। जबकि संवेदनशील प्रतिक्रिया 26.00 से लेकर 40.00 प्रतिशत तक 26 जननद्रव्य द्वारा प्रदर्शित किया गया। अतिसंवेदनशील (40% से ऊपर) प्रतिक्रिया बाकी 96 बैगन जननद्रव्य द्वारा शाखा एवं फल भेदक के विरुद्ध देखी गयी।

डाईमेथोएट 20 % + साइपरमेथ्रिन 3 % ई सी @ 141.3 ग्राम ए आई/ हेक्टेयर बैगन के शाखा एवं फल भेदक तथा फुदका के खिलाफ सबसे प्रभावीशाली कीटनाशक पाया गया, क्योकि सबसे कम क्षतिग्रस्त फल प्रतिशत (12.66 %) के साथ अधिकतम स्वस्थ फलों की पैदावार (220 क्यु./हे.) तथा उच्चतम लाभ लागत अनुपात 1:2.67 पाया गया। प्राकृतिक शत्रु जैसे सोनपंखी (कोक्सिनेलिड) तथा मकड़ी पर डाईमेथोएट 20 % + साइपरमेथ्रिन 3 % ई सी का कोई विपरीत प्रभाव लक्षित नहीं पाया गया।

CHAPTER-I
INTRODUCTION

The **eggplant** or **brinjal** (*Solanum melongena L.*) is one of the most popular and major vegetable crops cultivated throughout in India and other parts of the world for its purple, white or green pendulous fruit. It is belong to the Solanaceae family and is intimately related to potato and tomato. The British name of brinjal is Aubergine and it is known as name eggplant in United States, Canada and Australia, because of the earlier cultivars its fruits resemble like eggs of hen or goose. Brinjal is a economically important and most popular vegetable crop among low-income consumers and small-scale farmers of South Asia and this region account for about 60 % world's area and 53 % of world's production, respectively. The China and South East Asia shows its secondary diversity (Singhal 2003).

In brinjal production rank of India is second and rank of China is first accounting for nearly 50% of the world's area under its farming (Alam *et. al*., 2003). The top 5 brinjal producing countries are China (28.4 million tons; 57 percentage of world's total), India (13.4 million tons; 27 percentage of world's total), Egypt (1.2 million tons), Turkey (0.82 million tons), and Iran (0.75 million tons). In the Mediterranean and Asia, brinjal ranks among the top 5 most important vegetable crops (Frary *et al.,* 2007).

The brinjal crop is principally cultivated for its fruits which are extensively used in different cooking purposes *viz.*, bertha, stuffed curry, pickles, vangibath, chutney, etc. opposite to the common faith, it has very rich in nutritive values being rich source of vitamins (124 IU of vitamin 'A', 12 mg of vitamin 'C' and 0.11 mg of vitamin 'B_2'), 1.4 gm of proteins, 0.3 gm of ash content and 4 gm of carbohydrates. In addition to these it also possesses an alkaloid known as solanin and trace elements which has remedial properties.

In addition brinjal use as a fresh vegetable, it is known to have some curative properties in therapeutic diabetes and a curative for liver problems. The fruit of brinjal is an tremendous cholesterol controller. To one side from these, it is a good source of vitamin 'C' and phenolics, which are potent antioxidants. The flavonoid nasunin, an antioxidant and occurrence of free-radical scavenger to protect the cell membrane from injury. Brinjal is also considered as a very good dietary fiber source, which minimize the risk of coronary disease of heart.

The brinjal is of very importance in the warm areas of East, it is being grown widely in India, Bangladesh, China, Pakistan and Philippines. It is also popular in France, Egypt, Italy and USA. In India, brinjal is one of the most popular and common vegetable crops cultivated throughout the country except higher altitudes. In India, the major brinjal growing states are Tamil Nadu, Andhra Pradesh, Karnataka, West Bengal, Orissa, Jharkhand, Madhya Pradesh, Bihar, Uttar Pradesh, etc.

Brinjal is of grown widely on small landholding farmers where sale of its fruits from repeated pickings through the up to harvest season generates more cash income to farmers. In the hot-humid monsoon season, when other vegetables are short in supply, brinjal is the only vegetable that is available at low price for rural as well as urban poor people.

The temperature 20-30°C optimum for growth and setting of fruits. The fruit shape varies from oblong, ovoid, long or round cylindrical. The mature fruit colour varies from purple, purple black, white, green, yellowish and green with white / light green stripes, variegated types of purple with white stripes or even mixture of three colours.

There are several constraint in brinjal production which are liable for yield reduction amongst them, insect pest is one of the most key factor. One hundred forty (140) species of insect pests has been reported to be damaged at different stages of the crop growth (Prempong *et al.* 1977).

Although, brinjal crop usually damages by number of insect pests viz. shoot and fruit borer (*Leucinodes orbonalis*), jassids (*Amrasca biguttula biguttula*), whitefly (*Bemisia tabaci*) etc. Out of these, shoot and fruit borer (*Leucinodes orbonalis*) is a most serious pest of brinjal all over India (Mote, 1976; Roy and Pande, 1994).

Leucinodes orbonalis is a major insect pest of brinjal throughout the year as it damages the crop. This pest is recorded from all brinjal cultivated areas of the world including USA, Burma, Srilanka, Germany and India. It is known to infested shoot and fruit of crop in its all growth stages. The larva of the borer confines its feeding activities on shoots in the early stages of crop and on fruits during later stages. The injury caused by the insect results in the drooping of twigs and holes in the fruits, which are usually plugged by caterpillars with their excreta. The damage is caused by the insect to fruits follow secondary fungal infection, interpretation most part of infested fruit unfit and unhealthy for consumption. On account of this, the infested fruits fetch less price in the market. The loss of yield extent 70-92 per cent due to this pest.

Whitefly, is one of the most disruptive pest and affect to the crop by direct and indirect damages. The population of nymph and adult of whitefly (*Bemisia tabaci*) feeds on the underneath of the leaves, where they suck the sap of cell from the plant. High invasion can cause seedling death and old plant wilting. The whitefly is also transmit harmful plant viruses such as yellow vein mosaic virus of okra and green gram, tobacco leaf curl virus. Growth of sooty mould due to the honeydew exuded by the insect which affects photosynthesis. 25 to 40 per cent as high as reduction in yield causes due to suck the cell sap by sucking pests from the leaves (Anonymous, 1999).

Epilachna beetle, also known as hadda beetle is also one of the most destructive pests widely found all over India and in other countries (Rahaman *et al*., 2008). It is a polyphagous pest which shows its presence on brinjal and other solanaceous and cucurbitaceous crops.

Control of shoot and fruit borer, uses of insecticide is one of most common means, many of applied insecticides are not very effective in the adequate control of this pest. High toxic residues on fruits will leave by uses chemical insecticides. Besides this, for the control measure of this pest single dependence on insecticides has led to resistance of insecticide by the pest (Harish *et al*. 2011).

Use of Indiscriminate pesticides mainly at stage of fruiting and no safe waiting period adoption may leads to buildup of pesticide residues in vegetables. Several researchers has been reported that vegetables contamination with pesticide residues.

Keeping in this view the importance the crop of brinjal in mind present at piece of investigation had been conducted with the following objectives to overcome the pest problem.

1. Studies on seasonal incidence of major insect pests of brinjal and their natural enemies.
2. To study the correlationship between weather parameters and incidence of major insect pests on brinjal crop.
3. Screening of the different brinjal germplasm against shoot and fruit borer (*Leucinodes orbonalis* Guenee).
4. To evaluate the bio-efficacy of different combination of insecticides against major insect pests of brinjal crop.

CHAPTER-II
REVIEW OF LITERATURE

The literature pertaining to present investigation entitled "**Seasonal incidence, population dynamics, germplasm screening and bio-efficacy studies of insecticides against insect pests of brinjal**" was collected and grouped under the following objectives.

1. Studies on seasonal incidence of major insect pests of brinjal and their natural enemies.
2. To study the correlationship between weather parameters and incidence of major insect pests on brinjal crop.
3. Screening of the different brinjal germplasm against shoot and fruit borer (*Leucinodes orbonalis* Guenee).
4. To evaluate the bio-efficacy of different combination of insecticides against major insect pests of brinjal crop.

2.1. Studies on seasonal incidence of major insect pests of brinjal and their natural enemies.

The brinjal is cultivated country wide range and in another place throughout the year. Several research workers have studied variation in the incidence and activity of crop pests in different places and growing seasons.

Mote (1976) revealed the incidence of *L. orbonalis* on brinjal both on shoot and fruits. Even though, the incidence of the pest on shoot was noticed in the entire seasons, intensity of the pest was much more in *kharif* followed by *rabi* and *summer* seasons. The incidence on shoots in *kharif, rabi* and *summer* started in 5th, 6th and 7th week after transplanting, respectively and reached peak at 10th week during *kharif* while in *rabi* and *summer* the peak incidence was at 11th week after transplanting. In *kharif, rabi* and *summer* seasons the occurrence of the fruit borer started in 12th week after transplanting corresponding with the fruits setting. After that, the maximum occurrence of the pest was increase in between the 15th and 16th weeks in *kharif* crop. While in *summer* and *rabi*, it was more or less gradually increased and reached its peak at 21st week after transplanting. The highest percentage of affected fruits was noticed in the order of 67.11, 48.32 and 32.93 in *kharif, summer* and *rabi*, respectively. The mean temperature and relative humidity were 22.96^{0}C and 59.51 per cent in *kharif*, 20.32^{0}C and 53.75 per cent in *summer*, respectively.

Thanki and Patel (1988) recorded that the seasonal occurrence of *L. orbonalis* on brinjal. The maximum 10.40 per cent shoot damage with maximum 5.25 per cent fruit damage recorded in July transplanted brinjal crop. In decreasing trend the incidence of the pest was recorded in the succeeding transplanting of September (4.49%), November (2.21%) and January (1.63%).

Shukla (1989) noticed that the population of shoot and fruit borer (*L. orbonalis*) started enhance from during the period of third week of August while, *A. biguttula biguttula* population of begin enhance during first week of June and peaked activity during last week of August. These pests population had showed positive correlation with relative humidity, mean temperature and total rainfall.

Borah (1995) reported that *Bemisia tabaci*, *Amrasca biguttula biguttula* and *Aphis gossypii* were active on brinjal all through the season of crop growth in Assam.

Veeravel and Baskaran (1995) noticed that pest population during the monsoon and summer season, the highest population of pest (jassids and aphid) was recorded at vegetative stage during the monsoon season. However, these pests occurred at flowering and fruiting stages during *summer* season.

Suresh *et al*. (1996) recorded that *Amrasca biguttula biguttula* and *Aphis gossypii* were active on brinjal all through the growing season with their activities at peak in the first week of August and middle of February, respectively.

Prasad and Logiswaran (1997) revealed that the activity *Amrasca biguttula biguttula* and *Aphis gossypii* at peak occurred during summer (March-April) and winter (September- October).

Tripathy *et al*. (1998) reported the occurrence of shoot and fruit borer (*Leucinodes orbonalis*) on brinjal in relation to date of planting and weather parameters in Bhubaneswar. The activity of pests remained all through the year. The peak shoot infestation (8.05%) was recorded on 15-21 November and peak fruit infestation was on 13-19 December. The average fruit infestation on the number basis (4.45-62.5%) and weight basis (4.03-57.01%), respectively.

Tatwadi (1999) recorded that the peak occurrence of *L. orbonalis* infestation and population of jassids and whitefly at Raipur during the period of first week of May which was related with maximum (40-41^{0}C), minimum (23-25^{0}C) temperatures and relative humidity (50-60%), respectively.

Patnaik (2000) revealed that the seasonal occurrence of shoot and fruit borer of brinjal planted in July, the peak infestation was frequently recorded at 64-83.3 days after planting, during September and October. The only weather parameter was relative humidity to have a direct effect on seasonal activity of pest. Peak infestation occurred on flower buds during month of March (68.0%) and August (29.2%).

Devi *et al.* (2002) recorded that the seasonal occurrence of the aphid started from the second week of March and continuous till the fourth week of June on brinjal *cv*. “Pusa Purple Round” for two successive growing seasons (1999 and 2000). Its peak population reached during May month with the abundance of aphids, maximum 365.39 and 330.44 per sample, during 1999 and 2000, respectively. The 25.15^{0}C average temperature and 70.71% relative humidity, respectively.

Ghosh and Senapati (2003) recorded that the maximum jassids population (4.63/leaf) was in April-May and minimum (0.50/leaf) was in mid-July.

Ghosh *et al.* (2004) found that aphid, *Aphis gossypii* of West Bengal was active throughout the year and reached to its peak population (94.08/leaf) in early August.

Bharadiya and Patel (2005) noticed that the seasonal occurance of jassids activity at maximum through the third week of November; aphid during fourth week of October and whitefly, during third week of November. The infestation by the shoot and fruit borer, *Leucinodes orbonalis* on shoots was maximum in September and infestation on fruits was in November. Seasonal activity of the epilachna beetle maximum all through the third week of September.

Singh *et al*. (2005) recorded that the incidence of jassids from the third week of August till the last week of December. The population of jassids gradually raised from the last week of October until the third week of November (82.20-100.0%

occurance and 1.11 - 1.84 jassids/leaf). The maximum density of jassids was observed during first week of November. Aphid occurrence had started from the third week of August and its peak population during third week of November (4.28 aphid/leaf, 92.20% incidence).

Nonita *et al*. (2006) concluded that the seasonal incidence of *A. gossypii* started during second week of April and occurance until first week of August. The coccinellids appeared during the first week of May month in the field condition and extended their activities until the last week of July.

Sardana (2006) revealed that predatory spiders and coccinellids were present throughout the crop growing season starting from September month until middle of March.

Mahesh and Men (2007) revealed that the peak occurrence of infestation of shoot and fruit borer at Akola was found during middle of November which weather parameters was related with temperature ranging between 18.3^0C to 31.8^0C, relative humidity (49-86%), rainfall (41.0 mm) and sunshine hours (8 hrs), respectively.

Jain (2008) reported the maximum population of whitefly (8.50/plant) and jassid (12.13/plant) was observed in month of March; population of aphid (5.23/plant) was highest in February, whereas the maximum fruit infestation of brinjal (20.67%) was noticed in month of May.

Naik *et al.* (2008) revealed that the seasonal incidence of infestation of shoot and fruit borer, in terms of infestation of shoot was noticed at the period of third week of February and it had no significant relationship with weather parameters like: relative humidity, rainfall and temperature.

Varma *et al*. (2009) revealed that the highest infestation of shoot and fruit borer of brinjal in Allahabad, U.P. was recorded during second week of December. It had positive correlated with rainfall, maximum relative humidity and wind speed.

Shukla and Khatri (2010) reported that the seasonal occurrence of *Leucinodes orbonalis* increased in the month of October- November and in subsequent weeks of December it was decreased. Incidence of *Leucinodes orbonalis* was positive correlated with maximum and minimum temperatures.

Singh *et al*. (2011) revealed that the peak period of the *L. orbonalis* on shoot was found in the 1st week of June during the first cropping season and 4th week of May during second cropping season. The correlation had revealed that relative humidity and mean temperature showed positive and significant relationship while mean sunshine hours while negative and significant relationship with the infestation of *L. orbonalis* on brinjal.

Mathur *et al* (2012) studied that the seasonal activity of *Amrasca biguttula biguttula*, *Bemisia tabaci* and *Leucinodes orbonalis* Guenee was correlated with different abiotic factors.

Shaik (2012) recorded the population of jassids activity peak at the time Second week of May which was correlated with maximum (40.71^{0}C) and minimum (25.52^{0}C) temperatures and relative humidity (59.71%), respectively.

2.2. To study the correlationship between weather parameters and incidence of major insect pests on brinjal crop.

Mehta *et al.* (1979) indicated that the highest infestation of shoots (24.48%) and fruits (20.41%) was observed during March when the average temperature and relative humidity were 24.3^{0}C and 59 per cent, respectively, while it was lowest (shoots 6.04 and fruits 9.67%) during February when the average temperature and relative humidity were 17.9^{0}C and 73 per cent, respectively.

Ratanpara *et al.* (1994) stated that minimum temperature, average temperature and vapour pressure were negatively associated with population build up of *Amrasca biguttula biguttula.* Sunshine hours had a positive association with increasing number of the pests.

Dhamdhere *et al.* (1995) reported that a mean maximum temperature of 32.5^{0}C and 75 per cent relative humidity during the kharif season favoured the *Leucinodes orbonalis* infestation. *Amrasca biguttula biguttula* remained active during *summer* and *kharif* season. The most favourable conditions increased the pest population on an average with minimum (27.3^{0}C) and maximum (28.2^{0}C) temperatures, at minimum (43.5%) and maximum (72.5%) relative humidity.

Prasad and Logiswaran (1997) found a significant positive correlation of maximum temperature, relative humidity and a negative of minimum temperature during winter on the population of insect pests during winter 1991 and summer, 1992 on brinjal cv. MUT-1. The population of *Amrasca biguttula biguttula* showed a significant positive correlation with maximum temperature and negative correlation with rainfall. During winter, the population of *Bemisia tabaci* showed a significant positive correlation with maximum temperature, relative humidity and wind velocity whereas, during summer a significant negative correlation was observed with rainfall.

Mahmood *et al.* (2002) reported that incidence of leafhopper, *A. biguttula biguttula* showed positive and significant correlation with maximum and minimum temperatures. Relative humidity and rainfall was negatively and non significantly correlated with population fluctuation. Sunshine was also positive but non significant.

Vishwanathrao (2002) concluded that the activity of aphid, jassid, thrips and population of whitefly had significant negative correlation with wind velocity and positive with sunshine hours.

Muthukumar and Kalyanasundaram (2003) reported that the peak activity of shoot and fruit borer was observed during May to July. Maximum and minimum temperatures, evaporation, sunshine hours had positive association with shoot and fruit damage, while relative humidity had negative influence. *Henosepilachna vigintioctopunctata* incidence peaked during March-April. It was positively associated with maximum temperature. *A. biguttula biguttula* had a negative association with minimum temperature and rainfall. *Bemisia tabaci* had a positive association with relative humidity and negative association with minimum temperature, evaporation and wind velocity.

Ghosh *et al.* (2004) reported that population of aphid showed significant positive correlation with average temperature, relative humidity and weekly rainfall.

Arvind *et al.* (2007) conducted field experiment in Jammu, India and reported that relative humidity and average rainfall were positively correlated with the population build up of *L. orbonalis*. Maximum temperature had a positive correlation with shoot infestation.

Mahesh and Men (2007) reported that the shoot and fruit borer population at Akola was found positive association of *L. orbonalis* infestation with maximum temperature and bright sunshine hours.

Jain (2008) reported the jassids, aphid and whitefly had non significant relationship with all the meteorological parameters; while, the brinjal shoot and fruit borer population showed significant positive correlation with maximum and minimum temperatures and wind velocity and significant negative relationship were observed with maximum and minimum relative humidity. The population of lady bird beetle and spider showed significant positive correlation with jassids, aphid and whitefly population.

Haseeb *et al.* (2009) reported that the incidence of hadda beetle population incidence showed negative correlation with maximum and minimum temperatures and positive with minimum and maximum relative humidity.

Varma *et al.* (2011) reported that the peak activity of leafhopper *A.biguttula biguttula* on brinjal crop was observed during February to first week of March. The leafhopper incidence showed positive correlation with maximum temperature, relative humidity, rainfall, wind speed and sunshine hours.

Shaik (2012) reported that the jassids incidence showed positively non significant correlation with maximum and minimum temperatures, maximum and minimum relative humidity, rainfall and sunshine hours.

2.3. Screening of the different brinjal germplasm against shoot and fruit borer (*Leucinodes orbonalis* Guenee).

Subbaratnam (1982) observed the variety of Pusa Purple Long had less infestation of fruit borer than Pusa Purple Round. The positive significant correlation between diameter of fruit and infestation.

Khaire and Lawande (1986) screened 49 *S. melongena* cultivars for resistance under natural condition during 1981-82 and found eight (8) cultivars noticed < 10 M. persicae individuals /plant and eleven (11) < 3 shoots /plant damaged by *L. orbonalis.*

Das and Singh (1990) found that one of the nine brinjal cultivars was free from the attack of *L. orbonalis* in Orissa during kharif 1985. Pusa Purple cluster was evaluted as least susceptible with 18.76 per cent fruit damage. Cultivar Muktakeshi recorded highest mean number of holes per fruit.

Grewal and Singh (1995) reported that long fruited varieties were more susceptible to fruit borer attack, dark purple coloured fruits more susceptible, light purple coloured as less susceptible and green fruited varieties had low fruit damage.

Singh and kalda (1997) screened ten varieties and 25 lines of eggplant and *S.gilo* and S. anomalum for resistance to shoot and fruit borer. *L. orbonalis*. Annamalai, Aushey and Pusa Purple Cluster were resistant at seedling stage, while Annamalai and Aushey were also moderately resistant at the vegetative and bearing stages. The incidence of infestation in hybrids varied from 30.5 to 39.3 per cent indicating that susceptibility is a dominant character.

Pal (1999) reported the variety Pusa Purple Cluster, Green Long White Cluster F1 Hy Nishant and Pusa Purple Long were found to be less susceptible to *L. orbonalis*. The negative correlation of fruit length and significant positive correlation of fruit width and calyx diameter with fruit damage.

Panda (1999) conducted experiment in 174 brinjal cultivars for resistance to *L. orbonalis* in the field at Bhubaneswar. None of the brinjal entry was immune to larval attack of shoots and fruits. The mean percentage of shoot infestation varied from 1.61 to 44.11 percent and fruit damage varied from 8.5 to 100 per cent Maximum shoot damage was recorded at 75 DAT, while maximum fruit damage recorded at 76-121 DAT and 99-114 DAT in susceptible and resistant cultivars, respectively.

Patnaik (2000) reported the incidence of *L. orbonalis* in Orissa. In July planted aubergines, the peak infestation levels (in the range 59.2-75.5%) were mostly recorded at 64-83 days after planting, during September and October.

Ghosh and Senapati (2001) reported variety pusa purple long as more susceptible to fruit borer.

Sridhar *et al*. (2001) evaluated fifty-four brinjal (aubergine) germplasms, including 5 wild species and some F1 crosses, were screened for resistance to *L. orbonalis*, during 1999-2000, under field conditions in Bhubaneswar, Orissa, India. None of the cultivated/wild species of brinjal was found resistant to this pest. Three wild species, *i.e. S. khasianum*, *S. viarum* and *S. incanum*, were found to be resistant from fruit infestation (0.5-10.0%). Among the cultivated lines, CHB-103, 187 and 259 were identified as fairly resistant. Among the brinjal groups, it was observed that the attack of *L. orbonalis* was less in genotypes with relatively long fruits and tightly arranged seed.

Mannan *et al.* (2003) reported 24 brinjal varieties at the Regional Agriculture Research Station Jamalpur Bangladesh to find the suitable resistant brinjal variety against brinjal *L. orbonalis* Gunee. Both in number and weight the brinjal varieties Jumki-1, and Jumki -2 were highly resistant, Islampuri – 3, BL – 34, and Muktakeshi were fairly resistant, Singnath Long and Singnath – 4 were tolerance to brinjal shoot and fruit borer. The susceptible varieties were Islamapuri and Irribegoon – 1. Singnath – 3 and muktakeshi gave the highest yield from the three years study and the lowest yield was obtained from jumki.

Mandal *et al*. (2005) evaluated thirty-one brinjal (aubergine) cultivars for resistance to *L. orbonalis* in field experiments in Umerkote, Orissa, India during winter 1995-96 and 1996-97. None of the cultivar was highly resistant. Only three cultivars, *i.e.* BBS 103, BB 112 and Pusa purple cluster, were detected as moderately resistant, recordings were 11.28, 12.98 and 13.33% for fruit damage on number basis and 12.13, 13.36 and 13.86% on weight basis, respectively. These moderately resistant cultivars produced comparatively higher yield of 23.60, 16.19 and 17.51 t/ha, respectively.

Gupta and Kauntey (2008) Observed that varieties with dark purple or white coloured fruit were more susceptible damage (54.65-64.00%) and those with light purple, purple or green colours were less susceptible (24.38-36.05).

Daniel, *et al*. (2013) observed that the percentage stems attacked by *L. orbonalis* were not significantly different among accessions in both years. With respect to fruit infestation by *L. orbonalis*, although fruits of accessions GH 1208, GH 3944 and GH 3947 were significantly ($P < 0.001$) less susceptible to infestation in 2009 their yields were relatively low. Yield obtained ranged from 0 kg/ha in accession GH 1202 (2009) to 837.86 kg/ha in accession GH 5183 (2010). Accessions GH 1113 and GH 5171 combined a relatively good yield with moderate levels of tolerance to all insect pest species identified in this experiment.

Khan and Singh (2014) observed the response of different brinjal genotypes against brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee) in *kharif* (rainy season).Among 192 genotypes of brinjal tested, two of them EC305163 and IC090132 were found immune to shoot and fruit borer, three genotype namely IC545256, IC433625 and IC264470 found resistance, 21 fairly resistance, 38 tolerant, 52 susceptible and rest 76 genotypes were highly susceptible to brinjal shoot and fruit borer.

Devi *et al.* (2015) studied the response of different brinjal genotypes against brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee.) was evaluated Indira Gandhi Krishi Viswavidyalaya, Raipur (Chhattisgarh) in *rabi summer* season. Minimum mean infestation in fruits was found in genotype Punjab Sadabahar, 2010/ BRLVAR-3, 2010/BRLVAR-1, 2010/BRLVAR- 4 while maximum mean infestation in fruits was recorded in Swarnamani.

Netam *et al.* (2018) studied the response of different brinjal genotypes against brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee.) was evaluated at horticulture research field of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G) during *kharif.* 106 brinjal germplasm lines were evaluated for resistance to shoot and fruit borer. Minimum mean infestation in fruits was found in genotype IGB-92 (20.83%) while maximum mean infestation in fruits was recorded in IGB-89 (79.30%).

2.4. To evaluate the bio-efficacy of different combination of insecticides against major insect pests of brinjal crop.

Gumbek (1986) tested seven insecticides against *L. orbonalis* on brinjal in Sarawak and recorded good control of the pyralid with carbofuran 3G (5 g/plant) and 0.01 per cent acephate and dimethoate.

Mohan and Prasad (1986) evaluated four synthetic pyrethroids and seven other insecticides for the control of *L. orbonalis* and other pest complex on brinjal. All the pyrethroids (deltamethrin, cypermethrin, permethrin and fenvalerate at 0.1 kg a.i./ha) were most effective against *L. orbonalis*. The highest yield was recorded in plots treated with deltamethrin followed by other insecticides.

Ashraf *et al.* (1993) carried out multilocation trials (Muaffarabad, Jammu and Kashmir) on the chemical control of *L. orbonalis* in brinjal. Insect damage started in August with a peak in September in all the three (3) localities. Decamethrin (deltamethrin) @ 10 g a.i./ha was most effective among all the three insecticides.

Roy and Pande (1994) evaluated three insecticides *viz.*, fenvalerate (230 g a.i./ha), deltamethrin (280 g a.i./ha) and endosulfan (1400 g a.i./ha) each sprayed four times commencing from eight weeks after transplanting. They concluded that fenvelarate was the best in managing the pest and was cost effective.

Radhika *et al.* (1997) tested three insecticides *viz.*, triazophos, cartap and methomyl at recommended and 25 per cent less than recommended concentration each applied on schedule basis and also on need basis were evaluated against shoot and fruit borer of brinjal. Triazophos 0.1 per cent on need base followed by triazophos 0.1 per cent on schedule basis and carbaryl 0.15 per cent on schedule basis were effective in checking pest and gave increased yield of healthy fruit and higher net additional returns.

Mehta *et al.* (1998) conducted a field experiment in Himachal Pradesh for the control of brinjal shoot and fruit borer, *L. orbonalis* (Guen.) on variety pusa purple cluster. Two sprayings each of malathion (0.05%), endosulfan (0.07%), monocrotophos (0.036%), fenitrothion (0.05%), deltamethrin (0.008%), fenvalerate (0.01%) were done at an interval of 15 days commencing from the initiation of flowering in the crop. Fenvalerate followed by monocrotophos proved to be the most effective insecticides against the pest.

Walnuj *et al.* (1998) found that spraying of spark 36 EC (Triazophos 35% + deltamethrin 1%) @ 1250 ml per ha was observed to be significantly superior and recorded least fruit damage both in number and weight basis giving highest yield of 164.2 q / ha of brinjal fruits.

Mote and Bhavikatti (2001) reported that Bt 0.04 per cent and 0.05 per cent spark (triazophos + deltamethrin) were highly effectively against fruit borer and recorded higher yield of brinjal fruits. However, 0.05 per cent, nurelle D-505 (cypermethrin + chlorpyriphos) and 0.05 per cent Buldock star (B-cyfluturin + chlorpyriphos) were equally effective against the pest.

Sahu *et al.* (2004) conducted studies at Bhubaneswar, India to evaluate the bioefficacy of thiodicarb (@ 0.28125, 0.46875 and 0.75 kg a.i./ha) and other insecticides, *i.e.* cartap hydrochloride (cartap 0.5 kg a.i./ha), diflubenzuron (0.1 kg a.i./ha), carbofuran (1.0 kg a.i./ha) and triazophos (0.5 kg a.i./ha) and fipronil (0.1 kg a.i./ha) against brinjal shoot and fruit borer, *L. orbonalis*. The results revealed the superiority of thiodicarb at its highest dose of 0.75 kg a.i./ha it recorded the lowest shoot (1.41%) and fruit (20.86%) damage.

Suroshe *et al.* (2004) conducted an experiment to evaluate the efficacy of six insecticides against the pests of brinjal. Among them endosulfan 35 EC @ 350 g a.i./ha was the most effective in controlling jassids, followed by profenophos 50 EC @ 250 g a.i./ha and cypermethrin 44 EC @ 220 g a.i./ha. Endosulfan was also effective against whiteflies, followed by triazophos + deltamethrin @ 180 g a.i./ha and profenophos.

Deshmukh and Bhamare (2006) conducted a field experiment for evaluating newer insecticides in comparison with conventional insecticides against brinjal shoot and fruit borer, *Leucinodes orbonalis* at Akola. The results revealed that among newer insecticides cartap hydrochloride 50SP @ 0.1% was found most effective in reducing infestation of shoot (4.20%), fruit (23.72% on number basis and 25.30% on weight basis) and increasing yield (78.73 q/ha) of brinjal fruit whereas, spinosad 45EC @ 0.01% and thiodicarb 75WP @ 0.1% were also found effective caused increase in yield with less shoot and fruit borer infestation.

Kumar and Devappa (2006) reported that when Proclaim 5 SG was tested against brinjal shoot and fruit borer during 2002-03 and 2003-04. The results indicated that the application of Proclaim 5 SG at 200 g/ha was effective in reducing the dead hearts and also fruit damage in brinjal with higher yields.

Singh and Vishwanath (2007) reported that carbosulfan was the most potent insecticide in reducing the damage of fruit and shoot borer and increasing the yield of healthy fruits among cartap hydrochloride, betacyfluthrin, chlorpyrifos, endosulfan and econeem.

Misra (2008) evaluated two new insecticides *viz.,* rynaxypyr 20% SC and flubendiamide 480 SC in the field against brinjal shoot and fruit borer, *Leucinodes* *orbonalis* Guen with brinjal *cv.* “Utkal Anushree” in Orissa. The results revealed that rynaxypyr 20SC @ 40 and 50 g a.i./ha gave 95–97 per cent reduction in the shoot damage and healthy fruit yield.

Naik *et al.* (2008) reported that profenophos at 0.1% and spinosad at 0.015% were the most effective in the reduction of shoot infestation of *Leucinodes orbonalis*, aside from recording higher aubergine fruit yield. Among the 15 treatments tested, profenophos was the most effective followed by spinosad.

Hirekurubar and Ambekar (2008) carried out a study to assess the bio-efficacy of novel insecticides, *i.e.* thiamethoxam 25 WG at 25 g/ha, emamectin benzoate 5 SG at 8.5 g/ha, flufenoxuron 10 DC at 40 g/ha, spinosad 45 SC at 50 g/ha, indoxacarb 14.5 SC at 50 g/ha, and fipronil 5 SC at 50 g/ha, along with conventional insecticides, *i.e.* profenophos 50 EC at 750 g /ha and endosulfan 35 SC at 420 g/ha, against okra shoot and fruit borer (*Earias* spp) and their impact on natural enemies. Indoxacarb was the most effective treatment in reducing fruit damage on basis of number (5.14%) and weight (4.16 %) width (50.96 q/ha) maximum yield.

Biswas *et al.* (2009) studied the efficacy of Takumi 20WG (flubendiamide), emamectin benzoate 5SG @ 220 g/ha , indoxacarb 14.5SC @ 517 ml/ha, thiodicarb 75WP @ 1000 g/ha, spinosad 45SC2 180 ml/ha in the field for the control of shoot and fruit borer, *Leucinodes orbonalis* of brinjal. They found that Takumi 20% WG @ 500 g/ha was the best treatment and recorded zero per cent shoot infestation with (8.21 q/ha) maximum yield.

Pareet and Basavanagoud (2009) conducted an experiment to evaluate the efficiacy of bio-pesticides against sucking pests of aubergine *cv.* Mahyco-11. Treatments comprised spinosad @ 0.1 ml/litre, emamectin benzoate @ 0.2 ml/litre, avermectin @ 0.5 ml/litre, *Bacillus thuringiensis var.* Kurstaki (Btk) @ 2 ml/litre, diafenthiuron @ 1 g/litre and untreated control. Lowest whiteflies were recorded in diafenthiuron among all treatments. Lowest jassids were recorded in avermectin, spinosad and diafenthiuron. Btk was the least effective, recorded significantly higher whiteflies and jassids.

Patra *et al.* (2009) reported that spinosad 2.5 SC (50 g a.i./ha) showed lowest mean shoot as well as fruit infestation (7.47 and 9.88%) among emamectin benzoate 5

SG, lufenuron 10 EC, indoxacarb 14.5 SC and methoryfenozide 24 SC evaluated against brinjal shoot and fruit borer.

Singh *et al.* (2009) reported that profenofos 15EC @ 0.1% and spinosad 45 SC @ 0.01% were most effective in reduction of shoot and fruit infestation of *Leucinodes orbonalis* besides recorded higher yield of brinjal fruits.

Wankhede *et al.* (2009) evaluated the efficacy of four insecticidal formulations against brinjal shoot and fruit borer, revealed that emamectin benzoate 5 SG (200 g/ha) was the most effective in reduction of shoot damage (4.89%) at par with novaluron 10 EC (250 ml/ha) (5.29%) and diflubenzuron 25WP (200 g/ha) (6.44%), the later being at par with *Bacillus thuringiensis var.* Kurstaki (Btk) 500 g /ha, all being significantly lower than untreated control (10.86%). Fruit damage was minimum in emamectin benzoate treatment (2.45, 14.47 and 10.25% on number basis) and (12.52, 14.42 and 10.39% on weight basis), respectively at par with novaluron and diflubenzuron but significantly lower than Btk treatment. The yield was also maximum in emamectin benzoate (20.46 t/ha).

Anil and Sharma (2010) studied the bio-efficacy of insecticides against shoot and fruit borer, *Leucinodes orbonalis* on brinjal. The results revealed that emamectin benzoate 5SG (0.002%) was highly effective in reducing the shoot (0.56%) and fruit (16.58%) infestation among endosulfan 35EC (0.05%), novaluran 10EC (0.01%), lambda-cyhalothrin 5EC (0.004%), spinosad 2.5SC (0.0024%) and agrospray oil (0.2%).

Kumar *et al.* (2010) tested flubendiamide + thiacloprid 480 SC in different concentrarions for the management of bollworms and sucking pests of cotton. Flubendiamide + thiacloprid 480 SC @120 g a.i./ha showed significantly lower bollworm damage and increased control of population of bollworms, aphids, whitefly and leafhopper compared to standard checks spinosad 45 SC + imidacloprid 200 SL @ 90 + 30 g a.i./ha and indoxacarb 14.5 SC + imidacloprid 200 SL @75 + 30 g a.i./ha.

Latif *et al.* (2010) tested nine insecticides *viz.* Azadirachtin 0.03EC, abamectin 1.8EC, flubendiamide 24WG, chlorpyriphos 20EC, cartap 50SP, carbosulfan 20EC, thiodicarb 75WP, cypermethrin 10EC and lambda-cyhalothrin 2.5EC against brinjal shoot and fruit borer. Among these insecticides carbosulfan and flubendiamide reduced more than 80 per cent shoot and fruit infestation in winter, 80 per cent shoot and 70 per cent fruit infestation in summer over control.

Misra (2011) evaluated chlorantraniliprole 20SC in the field against brinjal shoot and fruit borer, *Leucinodes orbonalis* with standard check carbosulfan 25EC @ 500 g a.i/ha and untreated control. The results revealed that chlorantraniliprole @ 40 and 50 g a.i/ha were significantly superior in per cent reduction (95-97%) of shoot and fruit damage on the basis of number (87-90%) and weight (88-90%), respectively.

Sinha and Vishwanath (2011) conducted a field experiment to evaluate insecticides and mixture against insect pests of brinjal var. pusa purple round. The study revealed that bifenthrin @ 25 g a.i./ha, fipronil @ 50 g a.i./ha, indoxacarb @ 70 g a.i./ha and endosulfan @ 700 g a.i./ha and insecticide mixture, profenofos+cypermethrin @ 440 g a.i./ha were effective in managing the population of sucking pests viz., leafhopper and whitefly. As far as shoot and fruit borer was concerned, treatments with deltamethrin @ 15 g/ha, fipronil @ 50 g a.i./ha or indoxacarb @ 70 g a.i./ha gave minimum per cent infestation of brinjal fruits on basis of number (26.41%) and weight (27.95%).

Vishwanath and sinha (2011) evaluated efficacy of two doses of insecticide viz ., Triazophos (350g and 720g a.i./ha) and Deltametrin (10g and 20g a.i./ha) and their registered mixture (spark) Triazophos +Deltametrin 360g a.i./ha, Triazophos +Deltametrin 720g a.i./ha were studied against insect pests of brinjal var. Pusa Purple Long. Triazophos 360g a.i./ha, Triazophos 700g a.i./ha, Triazophos +Deltametrin 720g a.i./ha are successful in managing the leafhopper and whitefly.

Shaik (2012) observed that Phrofenophos 50 EC @ 1000ml/ha was most effective against sucking pests with 3.42 whiteflies and 5.31 jassids per plant. It was followed by Chlorpyriphos 50 + Cypermethrin 5 EC @1000ml/ha for whitefly (4.35/plant) and Spinosad 45 SC 187.5 ml/ha for jassids (6.97/plant).

Impact of insecticide molecules on natural enemies.

Dunbar *et al.* (1998) reported emamectin benzoate 5SG is a safe chemical to *Chrysoperla carnea* and Coccinellids. This might be due to rapid degradation on the surface of foliage, limiting contact of phytophagous insects as its mode of action is mainly by ingestion, ecologically selective to wide range of beneficial species due to rapid breakdown of the active ingredient by photo-oxidation to non-toxic level on the leaf surface.

Ishaaya and Ohsawa (2002) revealed that emamectin benzoate 5 SG, macrocyclic lactone insecticide was less toxic to non-target organisms and to the environment.

Udikeri *et al.* (2004) revealed that the activity of insect predatory population (Chrysoperla and Coccinellids) on emamectin benzoate 5SG @ 11 g a.i./ha was at par with untreated check indicating safety to these predominant natural enemies in cotton ecosystem.

Bheemanna *et al.* (2005) reported that the field performance of emamectin benzoaten 5SG @ 11.0 g a.i./ha recorded to be highly promising with lower fruit damage and higher seed cotton yield. It was found to be highly promising and was at par with other new molecules like spinosad 45 SC and indoxacarb 14.5SC @ 75 g a.i./ha dosage.

Shinde *et al.* (2007) reported that spinosad 45 SC @ 75 g a.i./ha was most safer insecticide to the predators on okra. The maximum population of ladybird beetle (1.78), chrysopa (0.55) and spiders (1.36) per plant, respectively were recorded in the treatment of spinosad 45 SC @ 75 g a.i./ha over different treatments.

Hirekurubar and Ambekar (2008) carried out a study to assess the bio-efficacy of novel insecticides, *i.e.* thiamethoxam 25 WG at 25 g/ha, emamectin benzoate 5 SG at 8.5 g/ha, flufenoxuron 10 DC at 40 g/ha, spinosad 45 SC at 50 g/ha, indoxacarb 14.5 SC at 50 g/ha, and fipronil 5 SC at 50 g/ha, alongwith conventional insecticides, *i.e.* profenofos 50 EC at 750 g /ha and endosulfan 35 SC at 420 g/ha, against okra shoot and fruit borer (*Earias spp.*) and their impact on natural enemies. Among all insecticides, emamectin benzoate and spinosad recorded higher population of coccinellids and *Chrysoperla carnea* larvae and were most safer insecticides.

Sharma and Kaushik (2010) evaluated spinosad 45 SC along with six chemical insecticides *viz.,* emamectin benzoate 5 SG, cypermethrin 10 EC, quinalphos 25 EC, endosulfan 35 EC, lambda cyhalothrin 5 EC, chlorpyriphos 20 EC against shoot and fruit borer, sucking pests and natural enemies (*Chrysoperla carnea* and ladybird beetles) on eggplant. Spinosad 45 SC (162.5 ml/ha) was most effective against shoot and fruit borer, but not effective against sucking pests. It was safe to natural enemies whereas the chemical insecticides proved toxic to them.

Misra (2011) evaluated chlorantraniliprole 20 SC in the field against brinjal shoot and fruit borer, *Leucinodes orbonalis* with standard check carbosulfan 25 EC @ 500 g a.i./ha and untreated control. The results revealed that chlorantraniliprole @ 40 and 50 g a.i./ha were significantly superior. Chlorantraniliprole at doses ranging 20-50 g a.i./ha was safe to natural enemies.

Yadav *et al.* (2015) carried out the experiments under field conditions at the Vegetable Research farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. Bioefficacy of seven insecticidal treatments comprising Emamectin Benzoate 5 SG, Spinosad 45 SC, Deltamethrin 2.8 EC, NSKE 5 per cent, Acephate 75 SP, Indoxacarb 14.5 SC, Profenofos 50 EC was determined. Brinjal variety Pusa ankur was shown in Randomized Block Design.

CHAPTER-III

MATERIALS AND METHODS

Description of materials used and methods adopted during the course of investigation in order to conduct the experiment and record scheduled observations, the present investigaton entitled **"Seasonal incidence, population dynamics, germplasm screening and bio-efficacy studies of insecticides against insect pests of brinjal''** was carried out at Indira Gandhi Krishi Viashwavidyalaya, Raipur (C.G) during the *Rabi* 2018-19.

3.1. Geographical location

Raipur is situated in mid eastern part of Chhattisgarh in the latitude at 21.16^0 North and 81.36^0 East of 289 meters above mean sea level.

3.2. Climate

The experimental site, Raipur comes under the seventh agroclimatic region of India *i.e.* eastern plateau and hills which is termed as sub humid with hot summer and cold winter. The source of rainfall is south western monsoon. It receives an average annual rainfall of 1200-1400 mm, mostly (85%) concentrate during the period of June to September. A few showers expected during winters and occasionally during summer months. May is the hottest and December is the coolest month of the year. The weekly maximum temperature raised up to 46^0C during summer and minimum temperature reaches as low as to 6^0 C during winter season.

During the course of conducting research, following objectives were undertaken

1. Studies on seasonal incidence of major insect pests of brinjal and their natural enemies.
2. To study the correlationship between weather parameters and incidence of major insect pests on brinjal crop.
3. Screening of the different brinjal germplasm against shoot and fruit borer (*Leucinodes orbonalis* Guenee).
4. To evaluate the bio-efficacy of different combination of insecticides against major insect pests of brinjal crop.

Table 3.1: Meteorological data during the crop growth period (*Rabi* 2018-19)

S. No.	Week No.	Date	Temperature (^0C)		Rain fall (mm)	Relative Humadity (%)		Wind Velocity (Km/h)	Sun Shine (hours)
			Max. Temp. (^0C)	Min. Temp. (^0C)		Morning	Evening		
1.	46	**Nov** 12-18	31.5	14.4	0.0	86	29	1.1	9.1
2.	47	19-25	31.4	15.3	0.0	88	28	1.1	7.8
3.	48	26-02	29.3	13.6	0.0	89	33	1.0	7.5
4.	49	**Dec** 03-09	28.2	14.3	0.0	87	38	0.9	4.4
5.	50	10-16	27.4	15.7	0.0	86	51	1.0	1.2
6.	51	17-23	22.1	11.0	47.2	90	57	3.1	4.5
7.	52	24-31	25.1	8.6	0.0	86	28	1.3	7.5
8.	1	**Jan** 01-07	27.4	8.5	0.0	88	28	0.7	6.6
9.	2	08-14	27.1	10.2	0.0	87	34	0.9	6.1
10.	3	15-21	28.1	9.2	0.0	85	21	0.9	6.8
11.	4	22-28	26.3	14.3	23.6	85	53	2.0	4.0
12.	5	29-04	26.4	9.5	0.0	87	24	1.3	8.2
13.	6	**Feb** 05-11	28.8	12.5	3.4	81	36	1.5	7.6
14.	7	12-18	30.2	13.6	9.0	84	34	1.8	8.3
15.	8	19-25	33.1	17.0	0.0	81	30	1.7	9.1
16.	9	26-04	31.0	17.3	0.2	72	36	2.4	7.8
17.	10	**Mar** 05-11	33.3	17.6	0.0	70	32	8.3	8.9
18.	11	12-18	35.6	21.6	0.0	72	33	3.2	6.8
19.	12	19-25	34.5	19.8	9.2	80	28	2.4	8.4
20.	13	26-01	38.2	20.6	10.8	64	19	2.0	8.7
21.	14	**Apr** 02-08	39.7	23.4	0.0	50	18	3.4	8.3
22.	15	09-15	40.8	24.5	0.0	47	20	4.3	8.3
23.	16	16-22	38.0	24.1	11.2	61	27	4.3	9.0
24.	17	23-29	42.0	26.3	0.0	45	15	2.9	10.1
25.	18	30-06	40.8	26.2	10.6	60	26	4.1	8.2
26.	19	**May** 7-13	40.7	26.8	0.0	42	12	2.6	9.3
27.	20	14-20	42.8	27.5	0.0	40	15	3.4	10.3

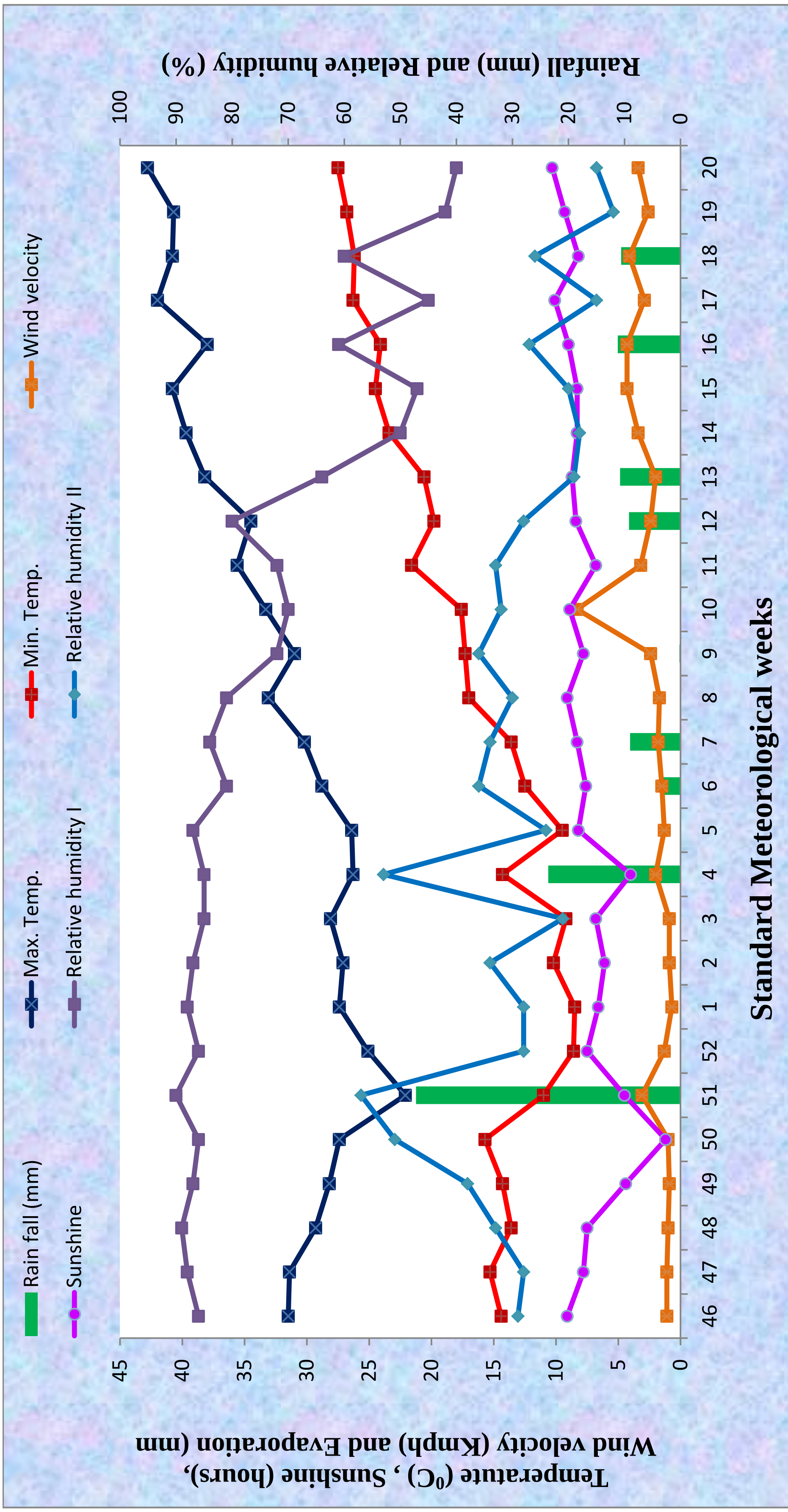

Fig 3.1 : Weekly meteorological data recorded during the crop growth (12th November, 2018 to 20th May, 2019)

3.3. Studies on seasonal incidence of major insect pests of brinjal and their natural enemies.

3.3.1. Experimental details

Season	:	*Rabi* 2018-19
Crop	:	Brinjal
Plant spacing	:	60 x 60 cm
Plot size	:	20 x 10 m^2
Fertilizer application	:	100:80:60 NPK kg/ha a. Half N- full- P- full- K (Basal) b. Half N- Top dressing (45 DAS)
Date of sowing	:	07/10/2018
Date of transplanting	:	13/11/2019
Irrigation	:	Crop was irrigated by plot to plot system as per requirement of the crop.
Weed management	:	One hoeing and two manual weeding were done. For raising a healthy crop, all the recommended package of practices were followed.

3.3.2. Method of observations

Observation of insect-pests

To determine the seasonal incidence of insect pests on brinjal crop, weekly populations was recorded on randomly selected twenty five plants from four corners and center starting from 7 days after transplanting to the late stage of the cropping season.

The population of sucking pests *viz.*, aphid, jassids and whitefly was recorded on three leaves one each from top, middle and bottom canopy of the five plants at each spot at weekly intervals during morning hours.

The incidence of Epilachna beetle was recorded in terms of damage to leaves of five randomly selected plants in each spot and the incidence of brinjal shoot and fruit borer on shoot and fruit recorded by counting total number of shoots and fruits with the damaged ones five randomly selected plants in each spot. Total number of plants and number of infested shoots from each plot were observed for shoot infestation. Thereafter its incidence was noticed by each fruit picking on randomly selected ten plants. The number of healthy and damaged fruits of ten randomly selected plants were counted at each picking. The seasonal fluctuation in the activity of shoot and fruit borer was observed by recording percentage of infested fruits at each picking.

Observation of Natural enemies

The population of natural enemies was recorded at weekly interval on randomly selected five plants in each spot.

3.4. To study the correlationship between weather parameters and incidence of major insect pests on brinjal crop.

3.4.1. Experimental details

Season	:	*Rabi* 2018-19
Crop	:	Brinjal
Plant spacing	:	60 x 60 cm
Plot size	:	20 x 10 m^2
Date of sowing	:	07/10/2018
Date of transplanting	:	13/11/2019

3.4.2. Method of observations:

To find out the incidence of major insect pests on brinjal. The observations were recorded at weekly interval on five spots each consisting of five plants randomly selected from experiment plot. The observations were recorded weekly interval starting from one week after transplanting to till harvest of the crop.

Effect of weather parameters on incidence of major insect pests of brinjal crop-

The data on meteorological parameters wre collected from agricultural meteorology, college of Agriculture Raipur. Weather parameters population of various insect pests *viz.*, aphid, whitefly, jassids and shoot and fruit borer and their natural enemies was correlated and recorded at weekly interval with the simple correlation coefficient.

3.4.3 Statistical analysis

The seasonal incidence of pests and their natural enemies with abiotic factors, were correlated on the basis of following formula :

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

Where,

X = Mean of first factor

Y= Mean of second factor

n = Total no. of observations

r = Correlation coefficient

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,

$\boldsymbol{H_0 : \rho = 0}$ **vs.** $\boldsymbol{H_1 : \rho \neq 0}$

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

t-test value n-2 degrees of freedom

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*

$Y = a + b_{yx} X$

Regression equation of *X*on *Y*

$X = a + b_{xy} Y$

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,

b_{yx} = Regression coefficient of Y on X.

bxy= Regression coefficient of X on Y.

σ_y = Standard deviation of Y

σ_x = Standard deviation of X.

r = Correlation coefficient between X and Y

3.5. Screening of the different brinjal germplasm against shoot and fruit borer (*Leucinodes orbonalis* Guenee).

3.5.1. Technical program of work

124 brinjal germplasm lines was screened out against brinjal shoot and fruit borer. Genotypes was sown in a two row of 2.5 meters length, with the spacing of 60 cm row to row and 50 cm from plant to plant.

3.5.2. Method of observations

Five plants was tagged at random and observed for the incidence of shoot and fruit borer in each brinjal genotype at seven days interval from transplanting to harvest.

Percent shoot infestation calculated using the following formula

$$\text{Per cent shoot infestation} = \frac{\text{Number of infested shoot}}{\text{Total number of shoot}} \times 100$$

Percent fruit infestation calculated using the following formula

$$\text{Per cent fruit infestation} = \frac{\text{Number of infested fruit}}{\text{Total number of fruit}} \times 100$$

To screen the brinjal germplasms against brinjal shoot and fruit borer, different resistance degrees of category were formulated as tolerant, moderately tolerant, susceptible and highly susceptible as per the rating given by Subbaratnam and Bhutani (1981). Following rating index was formulated for different categories of germplasms:

Table 3.2 : Name enlisted of brinjal germplasm lines.

IGB-1	IGB-32	IGB-63	IGB-94
IGB-2	IGB-33	IGB-64	IGB-95
IGB-3	IGB-34	IGB-65	IGB-96
IGB-4	IGB-35	IGB-66	IGB-97
IGB-5	IGB-36	IGB-67	IGB-98
IGB-6	IGB-37	IGB-68	IGB-99
IGB-7	IGB-38	IGB-69	IGB-100
IGB-8	IGB-39	IGB-70	IGB-101
IGB-9	IGB-40	IGB-71	IGB-102
IGB-10	IGB-41	IGB-72	IGB-103
IGB-11	IGB-42	IGB-73	IGB-104
IGB-12	IGB-43	IGB-74	IGB-105
IGB-13	IGB-44	IGB-75	IGB-106
IGB-14	IGB-45	IGB-76	IGB-107
IGB-15	IGB-46	IGB-77	IGB-108
IGB-16	IGB-47	IGB-78	IGB-109
IGB-17	IGB-48	IGB-79	IGB-110
IGB-18	IGB-49	IGB-80	IGB-111
IGB-19	IGB-50	IGB-81	IGB-112
IGB-20	IGB-51	IGB-82	IGB-113
IGB-21	IGB-52	IGB-83	IGB-114
IGB-22	IGB-53	IGB-84	IGB-115
IGB-23	IGB-54	IGB-85	IGB-116
IGB-24	IGB-55	IGB-86	IGB-117
IGB-25	IGB-56	IGB-87	IGB-118
IGB-26	IGB-57	IGB-88	IGB-119
IGB-27	IGB-58	IGB-89	IGB-120
IGB-28	IGB-59	IGB-90	IGB-121
IGB-29	IGB-60	IGB-91	IGB-122
IGB-30	IGB-61	IGB-92	IGB-123
IGB-31	IGB-62	IGB-93	IGB-124

Table 3.3: level of infestation by shoot and fruit borer in brinjal germplasm (subbaratnam and bhutani 1981).

Grade	Per cent infestation	
	Shoot	Fruit
Tolerant	< 2.0	< 15
Moderately tolerant	2.1-3.0	16-25
Susceptible	3.1-5.0	26-40
Highly susceptible	> 5.0	> 40

3.5.3 Biophysical attributes of brinjal crop

In addition to insect pest population different attributes of the brinjal cultivars were also observed which are mentioned below.

The varieties were also grouped according to fruit morphology based on length, width, fruit colour and shape of fruit as observed on five randomly selected fruits/plants.

Length of fruit

Five fruits were selected randomly from each cultivar .Fruit length was measured by stretching a thread from the point of attachment of calyx to the bottom of fruit after vertically cutting it into two halves.

Fruit diameter (Width)

To measure the fruit diameter, the fruit was cut into two equal halves horizontally. The fruit diameter measured at the middle of fruit length with the help of the scale.

Fruit colour

Fruit colour is rated as purple, dark purple, greenish purple, light green, white, green with the help of standard colour chart.

Fruit weight

From each germplasms, single fruit was taken from five randomly selected plants and weighed in weighing machine and average value was worked out.

Calyx and pedicle length:

Length of calyx and pedicle were measured by standard scale.

Pedicle thickness:

Thicknesses of pedicle were measured by stretching a thread and standard scale.

3.6. To evaluate the bio-efficacy of different combination of insecticides against major insect pests of brinjal crop.

3.6.1. Experimental details:

Season : *Rabi* 2018-19

Design : RBD

Replications : 03

Treatment : 07

Plant spacing : 60X60 cm

Plot size : 4.5X3 m^2

Table 3.4: Details of different combination of insecticides treatments:

SI. No.	Treatments	Dosage (ml/ha)
T_1	Dimethoate 20% + Cypermethrin 3% EC	650
T_2	Dimethoate 20% + Cypermethrin 3% EC	700
T_3	Dimethoate 20% + Cypermethrin 3% EC	750
T_4	Dimethoate 20% + Cypermethrin 3% EC	800
T_5	Dimethoate 30%	660
T_6	Cypermethrin 25% EC	200
T_7	Control (Untreated)	-

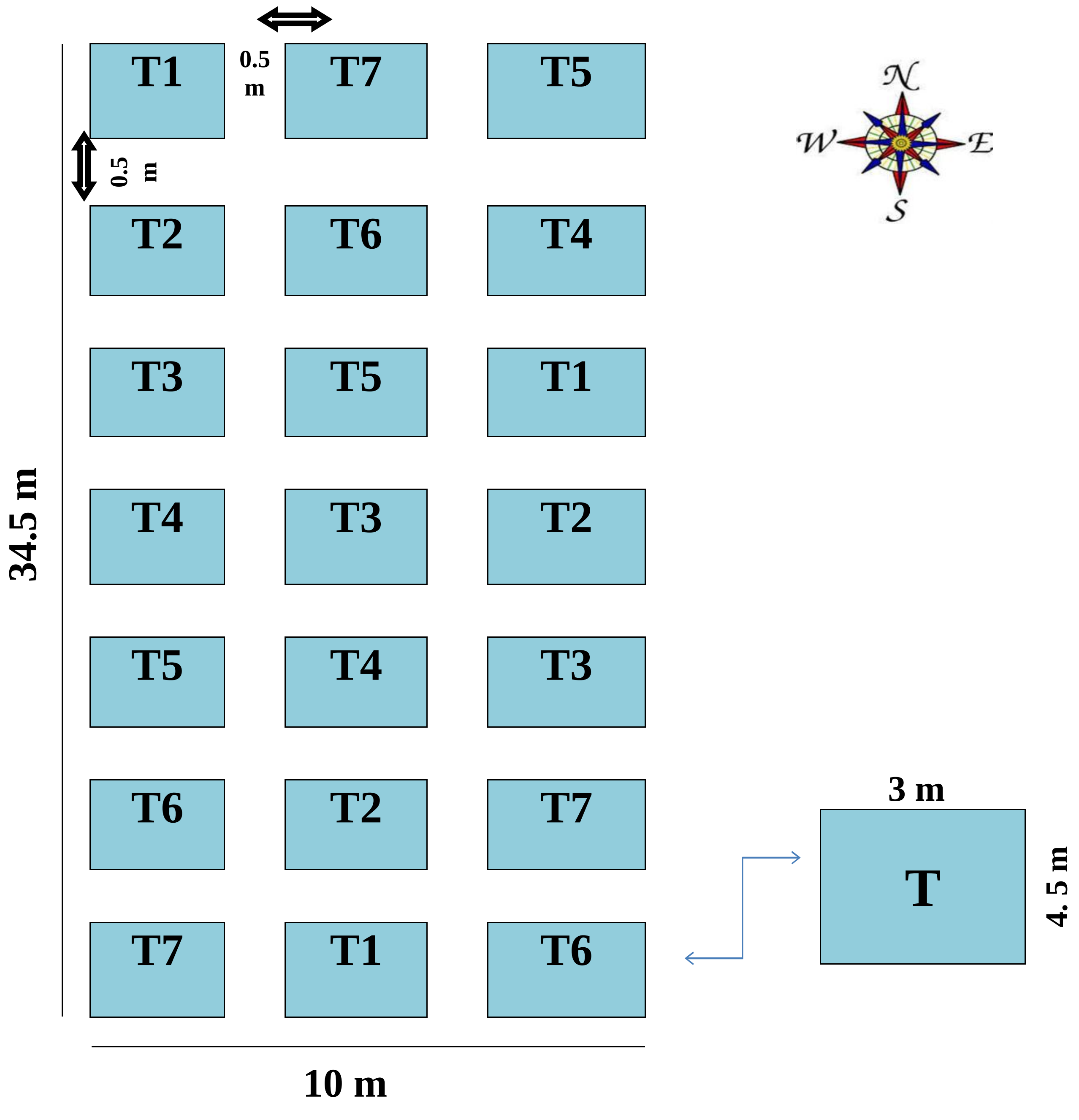

Fig. 3.2: Field layout of experimental block

3.6.2. Methods of observations

Need based sprays were to be given as soon as appearance of the pest in the experimental plots. Pre- treatment population of insect or fruit infestation (damage) per cent for shoot and fruit borer recorded one day before spray while post-treatment observation at suitable interval of each spray to worked out the % reduction in the insect population over control in randomly selected five plants from each plot.

3.6.3. Statistical analysis

Observations on brinjal shoot and fruit borer infestation was transformed before statistical analysis. Fruit infestation and yield (q/ha) were worked out with the help of following formula:-

$$\text{Per cent fruit damage} = \frac{\text{Number of damaged fruits}}{\text{Total number of fruits (healthy + damaged)}} \times 100$$

$$\text{Percent fruit yield} = \frac{\text{Weight of fruit (kg/plot)}}{\text{Plot area (m}^2\text{)}} \times 100$$

To find out the efficacy of newer insecticide, the observed pretreatment and post treatment reduction in per cent fruit damage of shoot and fruit borer were transformed to arcsine Sin - 1√X transformation and subjected to statistical analysis under Randomized block design as per formula suggested by Gomez and Gomez (1984) for interpretation of results.

Critical difference (CD) values were analyzed at 5 per cent level of significance. The skeleton of analysis of variance and formula used for various estimations are given in table 3.5.

Table 3.5: The skeleton of the analysis of variance

Source of variation	DF	SS	MSS	F cal	F tab	S.Em±	CD 5%
Replication (R)	(R-1)						
Treatment (T) Error	(T-1)						
	(R-1)(T-1)						
Total	RT-1						

The following formulae were used for standard error, critical difference and coefficient of variance estimations.

(a) S.Em + = √EMS/ R

(b) C.D. = √2EMS/ R× t (D.F. at 5%)

(c) C.V. (%) = √EMS/ GM × 100

Where,

R = Number of Replications,	D.F = Degrees of Freedom
T = Number of Treatments,	S.S. = Sum of Square
C.D. = Critical Difference,	C.V. = Coefficient of Variance
M.S.S= Mean Sum of Square,	EMS = Error Mean Square
S.Em ± = Standard Error of means.	GM = Grand Mean

Avoidable losses

Pradhan (1969) suggested the formula to calculate avoidable losses of various treatments:

$$\text{Percent avoidable losses} = \frac{T - C}{T} \times 100$$

Where,

T is the yield obtained from treated plots.

C is the yield obtained from the untreated control.

CHAPTER - IV

RESULTS AND DISCUSSION

The experiments on different piece of present study entitled "Seasonal incidence, population dynamics, germplasm screening and bio-efficacy studies of insecticides against insect pests of brinjal" were carried out during *rabi* 2018-19 at Horticulture field, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C. G.). The results are presented under following heads:

4.1 Studies on seasonal incidence of major insect pests of brinjal and their natural enemies.

4.2 To study the correlationship between weather parameters and incidence of major insect pests on brinjal crop.

4.3 Screening of the different brinjal germplasm against shoot and fruit borer (*Leucinodes orbonalis* Guenee).

4.4 To evaluate the bio-efficacy of different combination of insecticides against major insect pests of brinjal crop.

4.1 Studies on seasonal incidence of major insect pests of brinjal and their natural enemies

The data of different major insect pests and their natural enemies occurrence on brinjal was recorded on variety VNR research brinjal during *Rabi* 2018-19, starting from 14th November to till maturity of crop growth period at weekly interval along with prevailing weather condition has been presented in Table 3.1 and Fig.3.1

Whitefly (*Bemisia tabaci*), jassids (*Amrasca biguttula biguttula*), aphid (*Aphis gossypii*), hadda beetle (*Epilacna vigintioctopunctata*) and brinjal shoot and fruit borer (*Leucinodes orbonalis*) and predators *viz.*, lady bird beetle (*Menochilus sexmuculata*), spider (*Lynx spp.*) were inscribed at the time of crop growth period have been presented in Table 4.1 and 4.2

The population of jassids, whitefly and aphid were associated throughout period of crop growth whereas hadda beetle and shoot and fruit borer was associated to the crop from stage of late vegetative to fruiting.

4.1.1 Brinjal jassids

The incidence of nymph and adult of jassids was first appeared in fourth week of November (47 SWM). Initially recorded on nymph and adult population of brinjal jassids was 0.5 per plant. The highest population of jassids (19.80/plant) was observed at the time second week of March (11 SWM); during this period, maximum temperature (35.6^{o}C) and minimum temperature (21.6^{0}C), morning (72%) and evening (33%) relative humidity, wind velocity (3.2km/hours) and bright sunshine hours (6.8hours) prevailed. After that gradually decreased the population of jassids, reaching to 0.3 jassids/plant at third week of may. The population of jassids ranged between 0.20 and 19.80/plant during November to May months (Table 4.1).

Finding present conditions are in authentication with the finding of Prasad and Logiswaran (1997) they revealed that the activity of *Amrasca biguttula biguttula* peak for the period of March – April. Ghosh and Senapati (2003) also revealed the population of jassids highest during April-May. Shaik (2012) recorded the population of jassids activity peak at the time Second week of May which was correlated with maximum (40.71^{0}C) and minimum (25.52^{0}C) temperatures and relative humidity (59.71%), respectively. Borah (1995) and Suresh *et al.* (1996) revealed that *Amrasca biguttula biguttula* was active throughout the growing crop season on brinjal.

On the contrary, Singh (2005) *et al.* observed the density of jassids was highest in the first week of November. Bharadiya and Patel (2005) also revealed the jassids activity was highest at the time of third week of November.

4.1.2 Brinjal whitefly

The population of whitefly nymph and adult was observed from initially vegetative stage to late fruiting stage. It was first appeared during third week of November. Initially, whitefly nymph and adult population was 0.88/plant. Thereafter, population increased progressively up to last week February; recorded highest population (15.45/plant), at the time maximum (31^{0}C) and minimum (17.30^{0}C) temperature, rainfall (0.2mm), morning (72%) and evening(36%) relative humidity, wind velocity(2.4km/hr) and bright sunshine hours (7.8 hours) were revealed. After that, there was decrease the density of whitefly. Population of whitefly 1.4/plant was recorded at last stage of crop. Population of whitefly ranged from 0.88 to 15.45/plant during November to May months (Table 4.1)

Borah (1995) recorded that activity of *Bemisia tabaci* on *Solanum melongena* L. all through the crop growing season. Jain (2008) also recorded the whitefly population highest (8.50/plant) during month of March. Similarly, On the contrary, Bharadiya and Patel (2005) recorded activity of whitefly, *Bemisia tabaci* maximum at the time fourth week of October.

4.1.3 Brinjal aphid

The population of aphid nymph and adult was observed from initially vegetative stage to late fruiting stage. It was first appeared during third week of November. Initially, aphid nymph and adult population was 0.25/plant. Thereafter, population increased progressively up to first week February; recorded highest population (21.92/plant), at the time maximum (28.8^{0}C) and minimum (12.5^{0}C) temperature, rainfall (3.4mm), morning (81%) and evening(36%) relative humidity, wind velocity(1.5 km/hr) and bright sunshine hours (7.6 hours) were revealed. After that, there was decrease the density of aphid. Population of aphid 0.15/plant was recorded at last stage of crop. Population of aphid ranged from 0.15 to 21.92/plant during November to May months (Table 4.1)

Borah (1995) recorded that Aphid were active on brinjal all through the growing season. Suresh *et al.* (1996) revealed that Aphid were active on brinjal all through the growing season with their peak movement in the middle of February. Prasad and Logiswaran (1997) observed that the peak movement of Aphid during September- October.

4.1.4 Hadda beetle

The population of hadda beetle occurrence to late vegetative stage. It was first appeared during third week of January. Initial population of hadda beetle 0.2 adult/plant was recorded at the time, third week of January. Thereafter, population of hadda beetle increased progressively up to 1.2 adult/plant was recorded during second week of January; at the time maximum (30.2^{0}C) and minimum (13.6^{0}C) temperature, rainfall (9mm), morning (84%) and evening(34%) relative humidity, wind velocity(1.8 km/hr) and bright sunshine hours (8.3 hours) were revealed. After that, there was gradually decrease the density of hadda beetle up to last week of March and no population was recorded during last seven weeks of crop stage. Population of hadda beetle ranged from 0.2 to 1.2/plant during January to March months (Table 4.1)

Bharadiya and Patel (2005) revealed the epilachna beetle population was noticed to be highest all through the third week of September.

4.1.5 Brinjal shoot and fruit borer

Periodical based observations, on the incidence of brinjal shoot and fruit borer, recorded that percentage of infested shoots (0.3%) first appeared at the time first week of January and reached peak infestation (0.45%) at the time second week of January. Thereafter, suddenly decreased shoot infestation (0.25%) during third week of January. Initial fruit infestation (7.9%) was observed at time fourth week of January and it reached to peak infestation (76.4%) during second week of April; at that time maximum (40.8^{0}C) and minimum (24.5^{0}C) temperature, morning (47%) and evening (20%) relative humidity, wind velocity (4.3km/hr) and bright sunshine hours (8.3 hours) were revealed. Thereafter, fruit infestation gradually decreased up to third week of May. Shoot infestation ranged from 0.24% to 0.45% and fruit infestation ranged from 7.9% to 76.4%.

Similar result were revealed by Shaik (2012) that the shoot and fruit borer population activity peak at Raipur throughout second week of May which was correlated with maximum (39.11 to 42.57 ^{0}C) and minimum (23.27 to 26.98^{0}C) temperatures and morning (53.28 to 42.85 %) relative humidity. Jain (2008) revealed the shoot and fruit borer infestation highest (20.67%) throughout month of May. Naik *et al.* (2008) revealed that the incidence of shoot and fruit borer, in conditions of shoot infestation was recorded through the third week of February.

On the contrary, Mahesh and Men (2007) revealed that the shoot and fruit borer population peak activity was reported in middle of November which was correlated with maximum (18.3 to 31.8^{0}C) temperature, morning (49 to 86%) relative humidity, rainfall (41.0 mm) and sunshine hours (8 hrs), respectively. Shukla and khatri (2010) noticed that shoot and fruit borer incidence increased in month of October- November.

4.1.6 Natural enemies

The lady bird beetle (*Menochilus sexmuculata*) and spider (*Lynx spp.*) population observed in crop growth period from vegetative to fruiting stage. These natural enemies feed on aphid, jassids and whitefly.

4.1.6.1 Lady bird beetle

The population of lady bird beetle (0.8/plant) recorded first on the brinjal crop at third week of November. Occurrence of lady bird beetle started from early vegetative stage to second last week of crop growth period. The highest population of lady bird beetle (4.8/plant) was recorded during third week of April. The lowest population of lady bird beetle (0.2/plant) during third and fourth week of February. The population of lady bird beetle ranged from 0.2 to 4.8/pant was during November to May month (Table 4.2).

4.1.6.2 Spider

The population of spider (0.9/plant) recorded first on the brinjal crop at fourth week of November. Occurrence of spider started from early vegetative stage to second last week of crop growth period. The highest population of spider (2.9/plant) was recorded during first week of January. The lowest population of spider (0.2/plant) during first to second week of March. The population of spider ranged from 0.2 to 2.9/pant was during November to May month (Table 4.2).

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

S. No.	Months and date	Jassids/plant	Whitefly/plant	Aphid/plant	Hadda beetle	Shoot/ Fruit infestation (%)
1.	Nov 14-20	0	0.88	0.25	0	0 (s)
2.	Nov 21-27	0.5	1.15	0.42	0	0 (s)
3.	Nov 28-4	0.3	1.08	0.58	0	0 (s)
4.	Dec 5-11	0.2	1.45	0.92	0	0 (s)
5.	Dec 12-18	0.4	2.15	1.78	0	0 (s)
6.	Dec 19-25	0.3	1.78	1.38	0	0 (s)
7.	Dec 26-1	0.8	3.38	1.72	0	0 (s)
8.	Jan 2-8	0.6	4.85	2.22	0	0.3 (s)
9.	Jan 9-15	1	3.75	4.52	0	0.45 (s)
10.	Jan 16-22	1.4	6.88	6.12	0.2	0.25 (s)
11.	Jan 23-29	2.6	8.05	8.42	0.3	7.9 (f)
12.	Jan 30-5	5.7	9.52	12.28	0.5	11 (f)
13.	Feb 6-12	7.7	11.52	21.92	0.9	13.7 (f)
14.	Feb 13-19	8.9	13.38	12.4	1.2	19.9 (f)
15.	Feb 20-26	13.4	14.82	5.88	0.7	22.4 (f)
16.	Feb 27-5	15.6	15.45	2.05	0.6	26.3 (f)
17.	March 6-12	16.6	10.65	0.58	0.5	30.39 (f)
18.	March 13-19	19.8	7.45	0.48	0.7	33.29 (f)
19.	March 20-26	13.7	4.85	1.92	0.3	53.3 (f)
20.	March 27-2	9.8	3.25	2.72	0.2	64.3 (f)
21.	April 3-9	7.3	1.58	1.95	0	72 (f)
22.	April 10-16	4.6	1.88	0.62	0	76.4 (f)
23.	April 17-23	4	2.62	0.52	0	73.4 (f)
24.	April 24-30	1	3.32	0.32	0	74.7 (f)
25.	May 1-7	0.7	2.49	0.27	0	59 (f)
26.	May 8-14	0.5	1.68	0.25	0	45.2 (f)
27.	May 15-21	0.3	1.4	0.15	0	33.9 (f)
	Seasonal mean	5.10	5.23	3.43	0.04	26.60

(s) = shoot infestation, (f) = fruit infestation

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

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

S. No.	Months and date	Lady bird beetle	Spider
1.	Nov 14-20	0.8	0
2.	Nov 21-27	1.2	0.9
3.	Nov 28-4	1.9	1.6
4.	Dec 5-11	2.6	1.5
5.	Dec 12-18	2.8	1.5
6.	Dec 19-25	3.1	1.7
7.	Dec 26-1	3.8	2.1
8.	Jan 2-8	4.3	2.9
9.	Jan 9-15	4.1	2.1
10.	Jan 16-22	2.2	2
11.	Jan 23-29	1.2	1.5
12.	Jan 30-5	0.4	1
13.	Feb 6-12	0.3	0.9
14.	Feb 13-19	0.2	0.8
15.	Feb 20-26	0.2	0.3
16.	Feb 27-5	0.4	0.4
17.	March 6-12	0.6	0.2
18.	March 13-19	0.8	0.5
19.	March 20-26	1.4	1.2
20.	March 27-2	1.9	1.2
21.	April 3-9	3.2	1.5
22.	April 10-16	3.9	2.5
23.	April 17-23	4.8	2.1
24.	April 24-30	3.9	2.1
25.	May 1-7	2.8	1.6
26.	May 8-14	1.5	1.2
27.	May 15-21	0	0
	Seasonal mean	2.01	1.30

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

Name of insect	**Scientific name**	**Population range/plant**	**Active period**	**Peak activity period**
Jassids	*Amrasca biguttula biguttula*	0.2-19.8	21^{th} November to 21^{th} May	Second week of March
Whitefly	*Bemisia tabaci*	0.88 -14.82	14^{th} November to 21^{th} May	Fourth week of February
Aphid	*Aphis gossypii*	0.15-21.92	14^{th} November to 21^{th} May	First week of February
Hadda beetle	*Epilacna vigintioctopunctata*	0.2-1.2	16^{th} January to 2 April	Second week of February
Brinjal shoot and fruit borer	*Leucinodes orbonalis*	0.25-76.4	2^{nd} January to 21^{th} May	Second week of April
Lady bird beetle	*Menochilus sexmuculata*	0.2-4.8	14^{th} November to 14^{th} May	Third week of April
Spider	*Lynx spp*	0.2-2.9	21^{th} November to 14^{th} May	First week of January

4.2. To study the correlationship between weather parameters and incidence of major insect pests on brinjal crop.

The data recorded on infestation of various pest populations were correlated with prevailing temperature, relative humidity, rainfall, wind velocity and sunshine hours obtained from observatory of the university.

4.2.1. Brinjal jassids

The activity of jassids was maximum observed during second week of March. The population of jassids showed positively and significant with wind velocity (r = 0.411). The positively and non significant with maximum (r = 0.148) and minimum (r = 0.147) temperatures, evening relative humidity (r = 0.007) and sunshine hours (r = 0.234). The negative and non significant with rainfall (r = -0.105) and morning relative humidity (r = -0.052).

In confirmation of the present findings Mahmood *et al*. (2002) reported that incidence of jassids showed positive and significant correlation with maximum and minimum temperatures and negative non significant correlation with morning and evening relative humidity. Vishwanathrao (2002) reported that jassids population had significant positive relationship with sunshine hours. Varma *et al*. (2011) reported that the leafhopper incidence showed positive correlation with maximum temperature, relative humidity, rainfall, wind speed and sunshine hours. On the contrary, Muthukumar and Kalyanasundaram (2003) observed jassids had negative association with minimum temperature and rainfall. Jain (2008) reported that jassids population had non significant relationship with all the weather parameters. Shaik (2012) noticed the jassids incidence showed positively non significant relation with maximum and minimum temperatures, maximum and minimum relative humidity, rainfall and sunshine hours.

4.2.2. Brinjal whitefly

The activity of jassids was maximum observed during last week February. The population of whitefly showed positive and non significant with morning relative humidity (r = 0.235), evening relative humidity (r = 0.194), wind velocity (r = 0.068) and Sunshine hours (r = 0.096). There was negative and non significant with maximum temperature (r = -0.239), minimum temperature (r = 0.262) and rainfall (r = -0.069).

Findings were observed by Vishwanathrao (2002) revealed that the population of whitefly had significant negative correlation with wind velocity and positive correlation with sunshine hours. Muthukumar and Kalyanasundaram (2003) reported whitefly had a positive association with relative humidity and negative association with minimum temperature and wind velocity. Jain (2008) revealed that the population of whitefly had positively non significant correlation with maximum and minimum temperatures, wind velocity and rainfall. Shaik (2012) revealed that whitefly population was correlated negatively non significant with maximum temperature (r = - 0.090) and positively non significant with minimum temperature (r = 0.016), sunshine hours (r = 0.287) and rainfall (r = 0.406). On the contrary, Prasad and Logiswaran (1997) reported that the *Bemisia tabaci* population was correlated positively significant with maximum temperature and wind velocity.

4.2.3. Brinjal aphid

The activity of aphid was maximum observed during second first week February. The population of aphid showed negative and significant with minimum temperature (r = -0.434). The positively and non significant with rainfall (r = 0.056), morning relative humidity (r = 0.330) and evening relative humidity (r = 0.201), (r = 0.007). The negative and non significant with maximum temperature (r = -0.379), wind velocity (r = -0.290) and sunshine hours (r = -0.074).

Ghosh *et al.* (2004) reported that aphid, *Aphis gossypii* showed significant positive correlation with average temperature, relative humidity and weekly rainfall.

4.2.4 Brinjal hadda beetle

The activity of hadda beetle was maximum noticed at the time second week of January. The population of hadda beetle showed positive and non significance with morning (r = 0.217) and evening (r = 0.178) relative humidity, wind velocity (r =

0.049) and sunshine hours (r = 0.121). There was negative and non significant with maximum (r = -0.164) and minimum (r = -0.185) temperature, rainfall (r = -0.025).

Haseeb *et al.* (2009) reported that the incidence of hadda beetle population incidence showed negative correlation with maximum and minimum temperatures and positive with minimum and maximum relative humidity.

4.2.5 Brinjal shoot and fruit borer

The activity of shoot and fruit borer was maximum recorded in the second week of April. The shoot and fruit borer infestation showed positive and significant correlated with maximum (r = 0.866) and minimum (r = 0.846) temperature, wind velocity (r = 0.579) and sunshine hours (r = 0.551). The shoot and fruit borer infestation showed negative and significant with morning (r = -0.834) and evening (r = -0.570) relative humidity. There was negative and non significant correlation with rainfall (r = -0.037). The regression equation for maximum [$y = 0.1837x + 27.7$; $R^2 = 0.7516$] and minimum [$y = 0.1848x + 12.249$; $R^2 = 0.7166$] temperature.

Similar findings were observed by Muthukumar and Kalyansundaram (2003) who reported that the maximum and minimum temperatures and sunshine hours showed positive correlation with shoot and fruit damage, while relative humidity had negative influence. Arvind (2007) noticed that the maximum temperature showed a positive correlation with shoot infestation. Mahesh and Men (2007) reported positive association of shoot and fruit borer infestation with maximum temperature and bright sunshine hours. Jain (2008) reported that brinjal shoot and fruit borer infestation was positively significant with maximum and minimum temperatures. Shukla and Khatri (2010) started that the maximum and minimum temperatures had a positive correlation with the abundance of pest on brinjal. Shaik (2012) reported brinjal shoot and fruit borer population had positively significant relation with maximum and minimum temperatures and negatively non significant relationship with morning and evening relative humidity, sunshine hours and rainfall.

Table 4.4: Coefficient correlation among major insect pests of brinjal and weather parameters.

Weather parameter	Insect pests				
	Jassids	Whitefly	Aphid	Hadda beetle	Shoot and fruit borer
Maximum Temperature (^{0}C)	0.148	-0.239	-0.379	-0.164	**0.866****
Minimum Temperature (^{0}C)	0.147	-0.262	**-0.434***	-0.185	**0.846****
Rainfall (mm)	-0.105	-0.069	0.056	-0.025	-0.037
Morning Relative humidity (%)	-0.052	0.235	0.330	0.217	**-0.834****
Evening Relative humidity (%)	0.007	0.194	0.201	0.178	**-0.570****
Wind velocity (km/h)	**0.411***	0.068	-0.290	0.049	**0.579****
Sunshine hours (hours)	0.234	0.096	-0.074	0.121	**0.551****

* Significant at 5% level of significance

** Significant at 1% level of significance

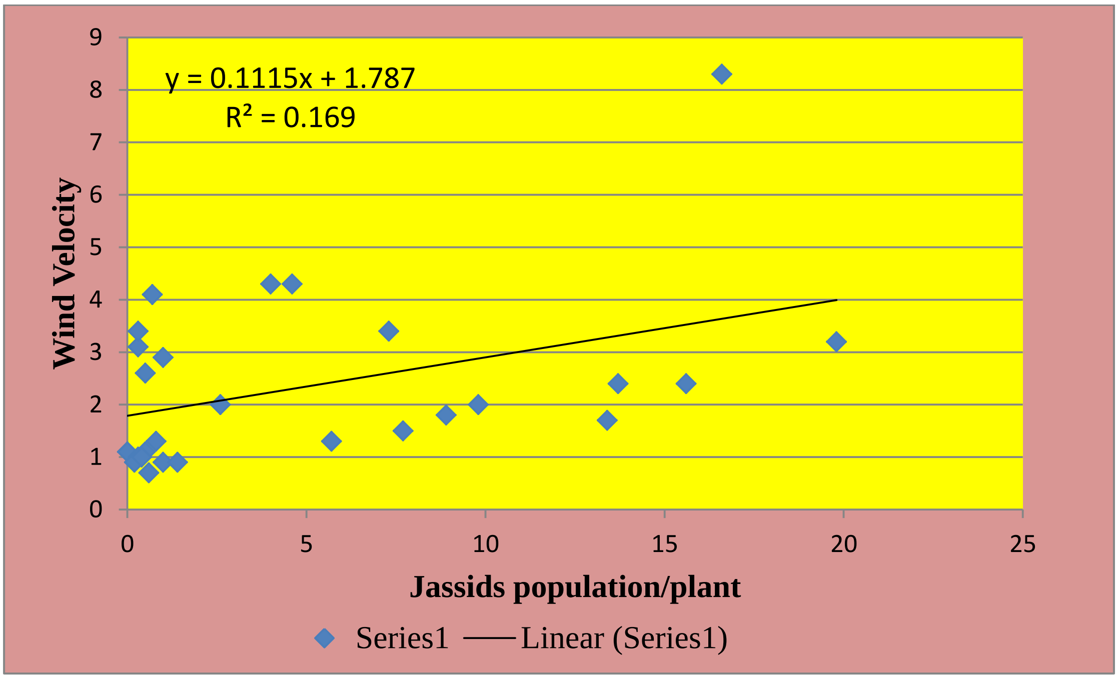

Fig. 4.1: Regression of Jassids population on wind velocity

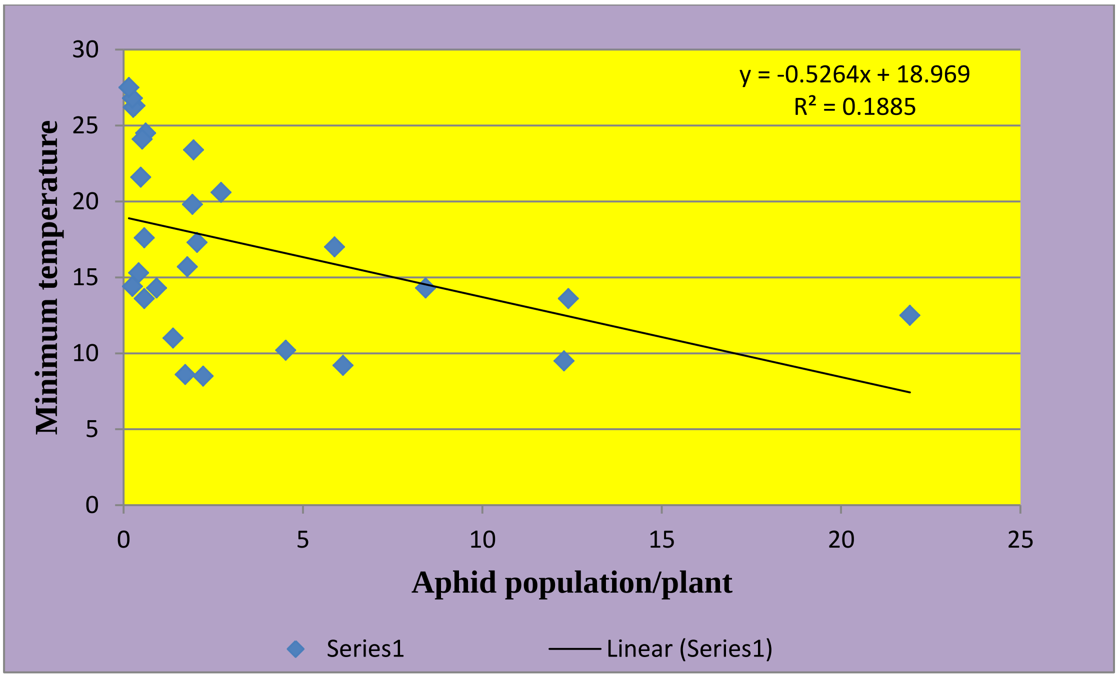

Fig. 4.2: Regression of Aphid population on minimum temperature

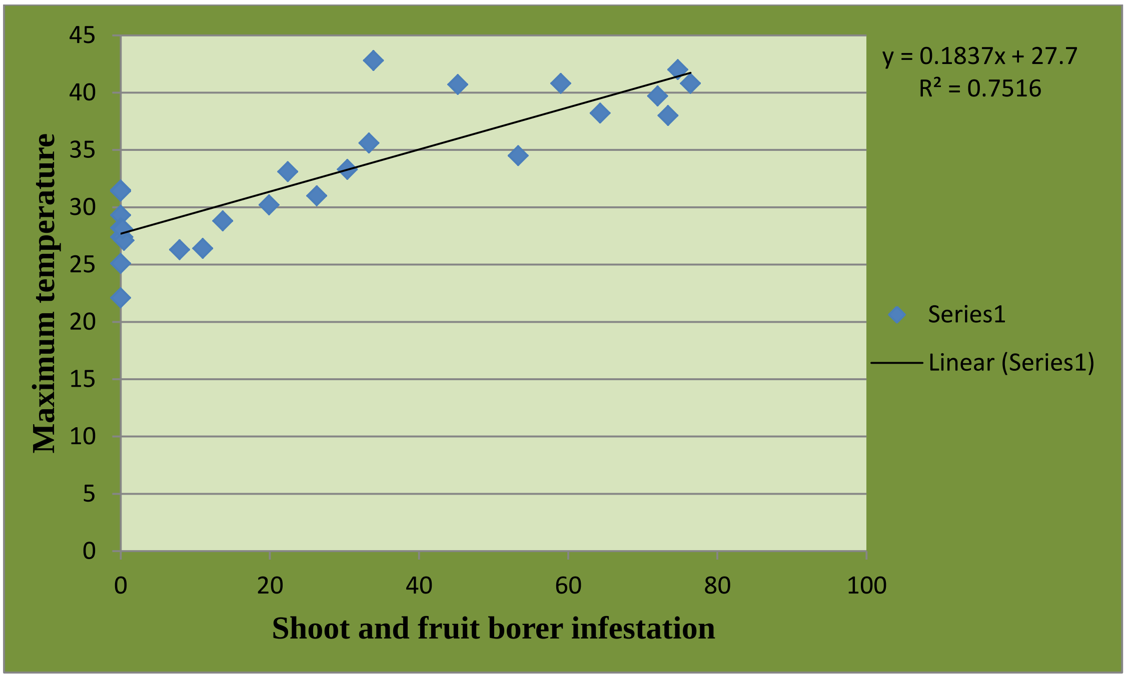

Fig. 4.3: Regression of Shoot and fruit borer infestation on maximum temperature

Fig. 4.4: Regression of Shoot and fruit borer infestation on minimum temperature

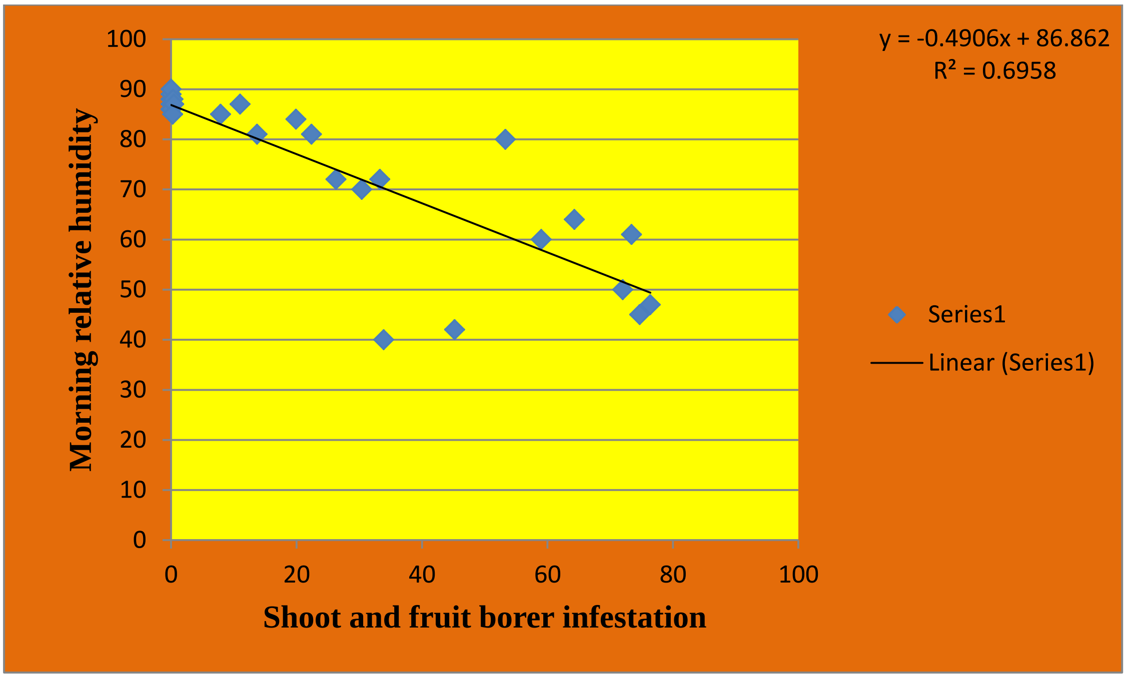

Fig. 4.5: Regression of Shoot and fruit borer infestation on morning relative humidity

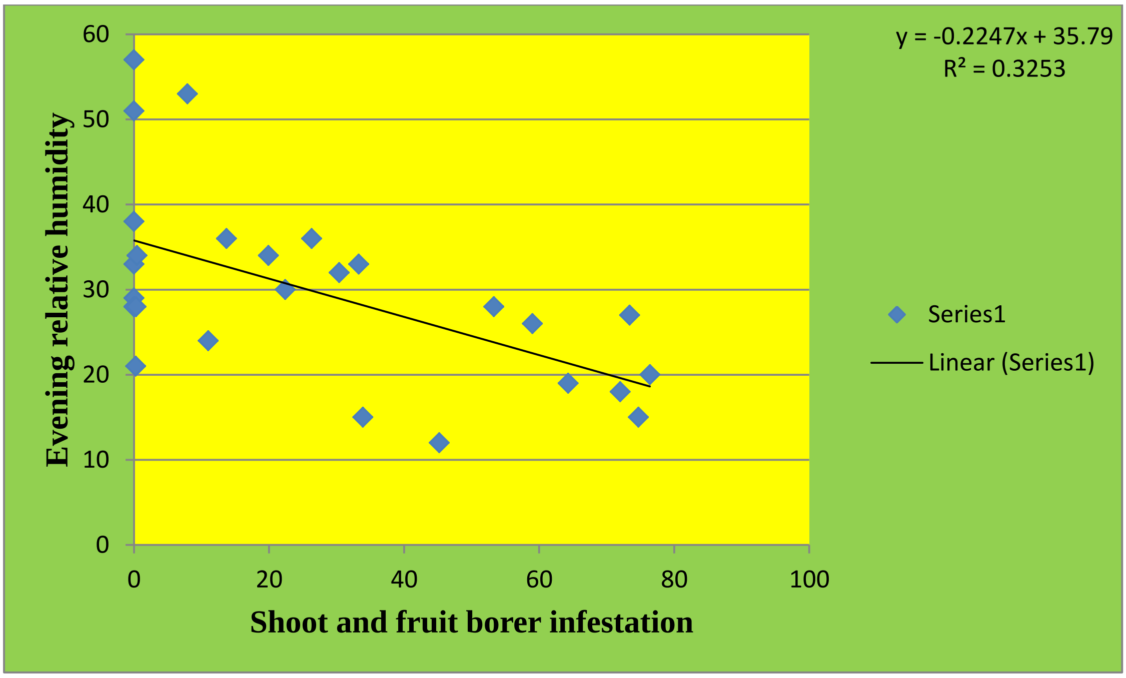

Fig. 4.6: Regression of Shoot and fruit borer infestation on evening relative humidity

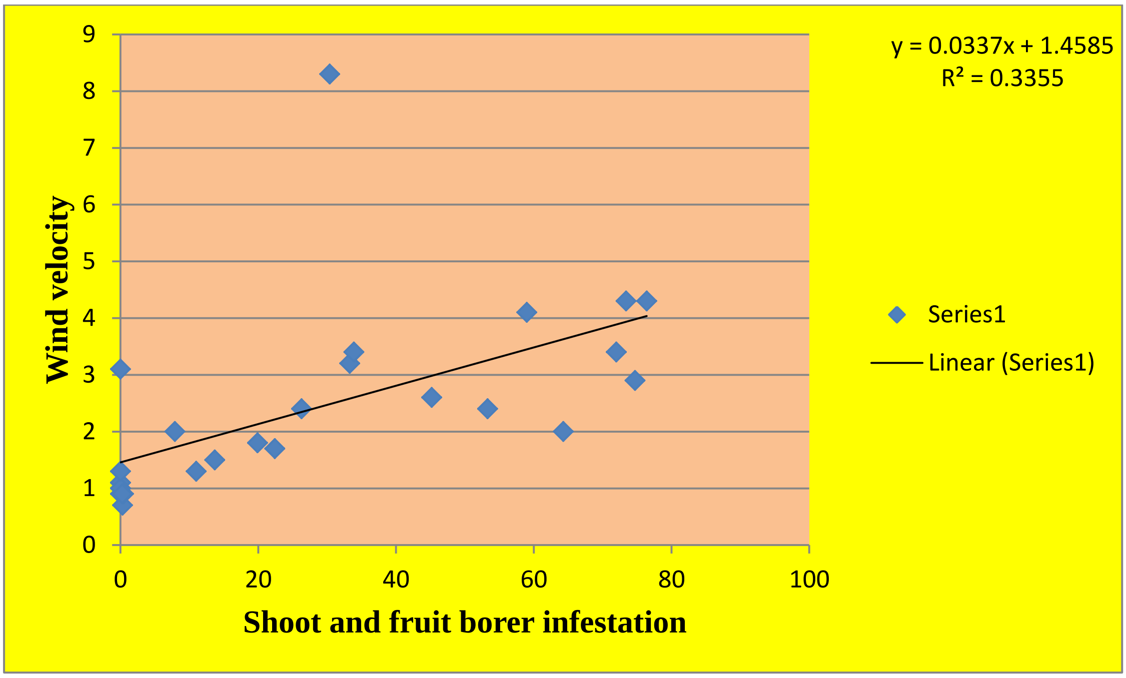

Fig. 4.7: Regression of Shoot and fruit borer infestation on Wind velocity

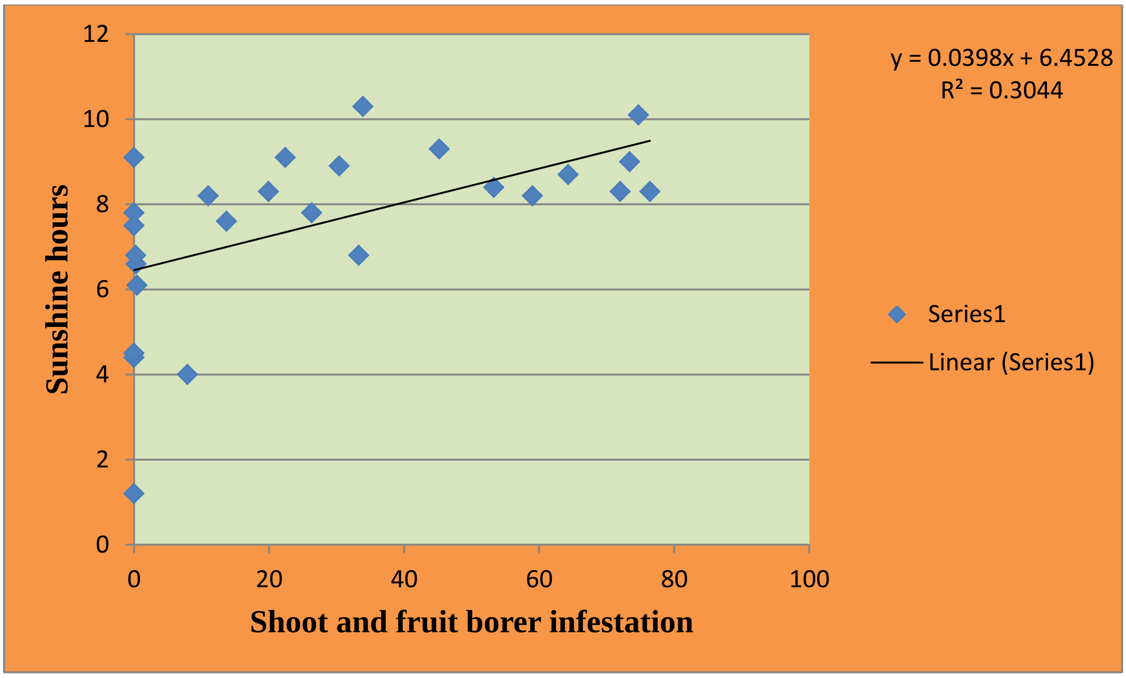

Fig. 4.8: Regression of Shoot and fruit borer infestation on Sunshine hours

4.2.6 Correlation between insect pests and their natural enemies.

The population of two predator *viz.*, lady bird beetle (*Menochilus sexmuculata*) and spider (*Lynx spp.*) were recorded quarried upon sucking pests on brinjal. The population of lady bird beetle, spider and the insect pests of brinjal *viz.*, jassids, whitefly and aphid were correlated. The level of highest population of lady bird beetle (4.8/plant) and spider (2.9/plant) were noticed during third week of April and first week of January, respectively.

Jassids population showed negative and significance correlated with lady bird beetle (r = -0.476) and spider (r = -0.493). The regression equation with lady bird beetle [y = -0.1175x + 2.6106; R^2 = 0.2272] and spider [y = -0.0627x + 1.6273; R^2 = 0.2437].

Whitefly population showed negative and significance correlated with lady bird beetle (r = -0.564) and spider (r = -0.401). The regression equation with lady bird beetle [y = -0.1854x + 2.981; R^2 = 0.3187] and spider [y = -0.068x + 1.663; R^2 = 0.1614].

Aphid population showed negative and significance correlated with lady bird beetle (r = -0.391), negative and non significant with spider (r = -0.115). The regression equation with lady bird beetle [y = -0.1151x + 2.4059; R^2 = 0.1531].

In confirmation of present findings Jain (2008) reported that the population of lady bird beetle and spider showed positively significant correlation with jassids, aphid and whitefly. Shaik (2012) noticed the positive significant correlation between insect pests (whitefly, jassids) and predatory population.

Table 4.5: Correlation between insect pests and natural enemies.

Insect pests	Natural enemies	
	Lady bird beetle	Spider
Jassids	-0.476*	-0.493*
Whitefly	-0.564*	-0.401*
Aphid	-0.391*	-0.115

* Significant at 5% level of significance
** Significant at 1% level of significance

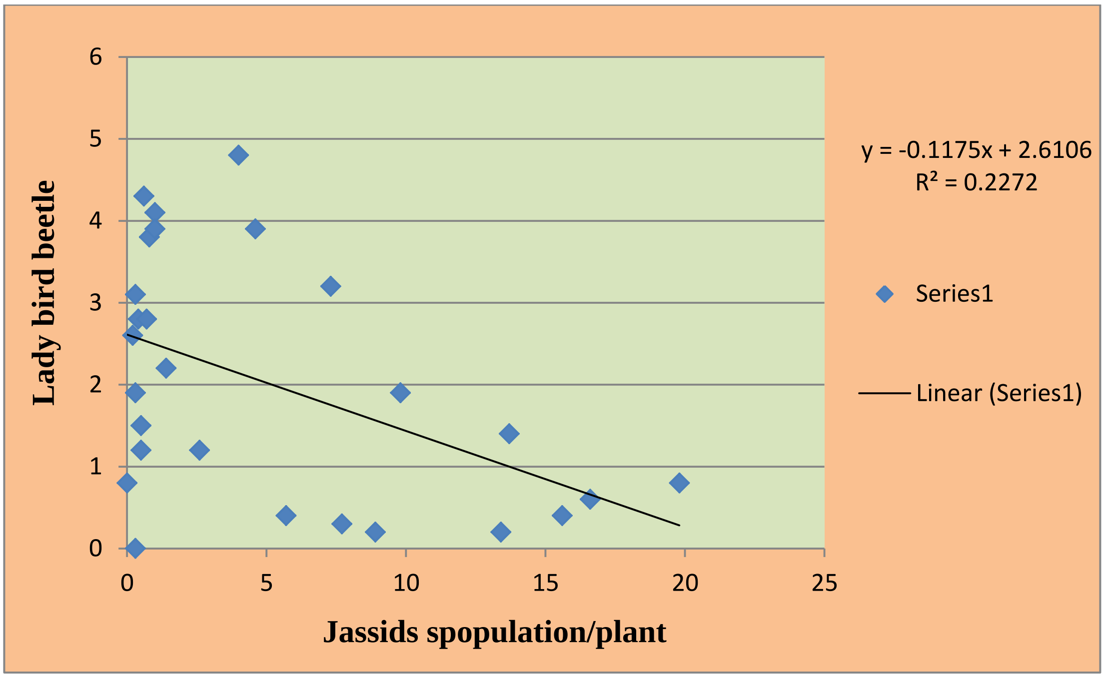

Fig. 4.9: Regression of jassids population on lady bird beetle

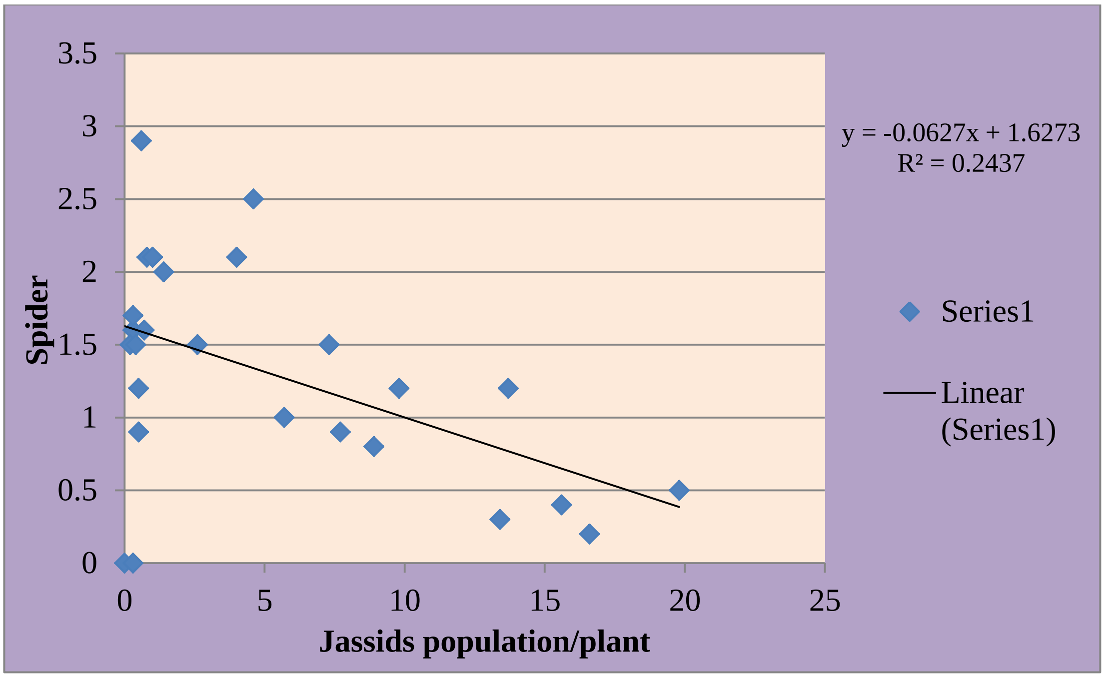

Fig. 4.10: Regression of jassids population on spider

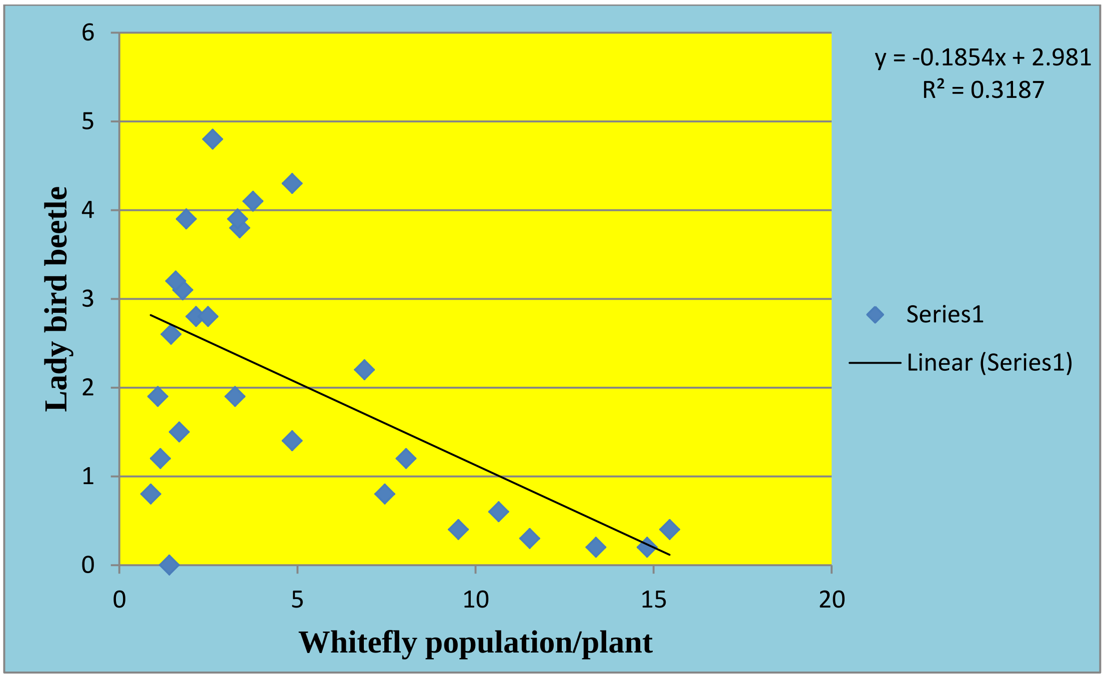

Fig. 4.11: Regression of whitefly population on lady bird beetle

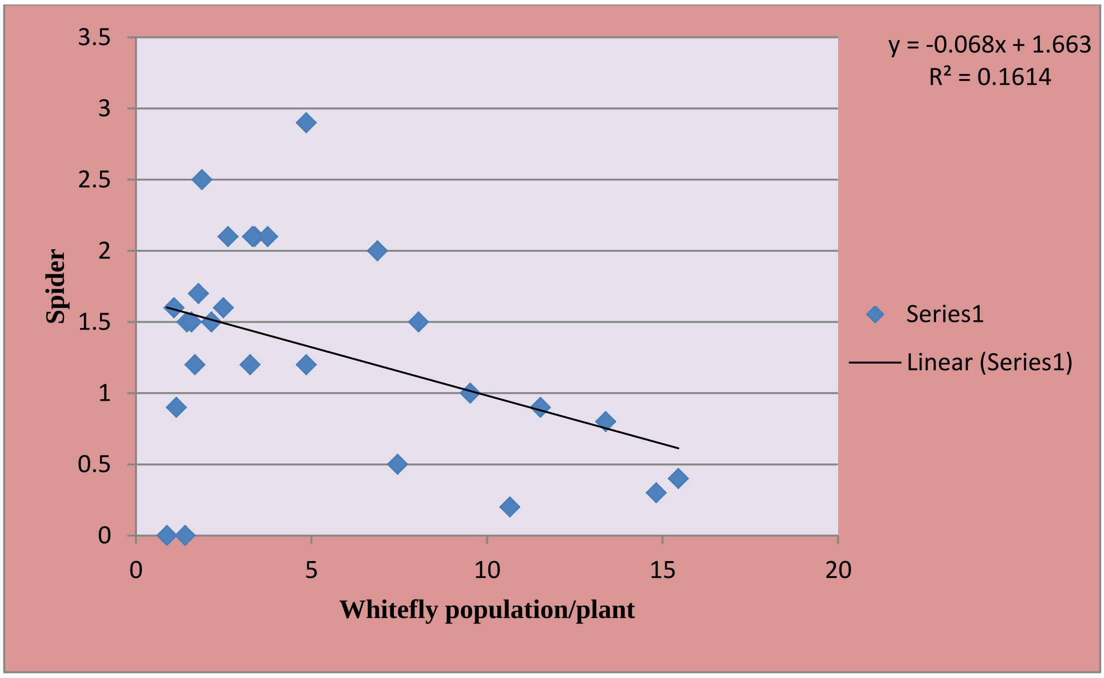

Fig. 4.12: Regression of whitefly population on spider

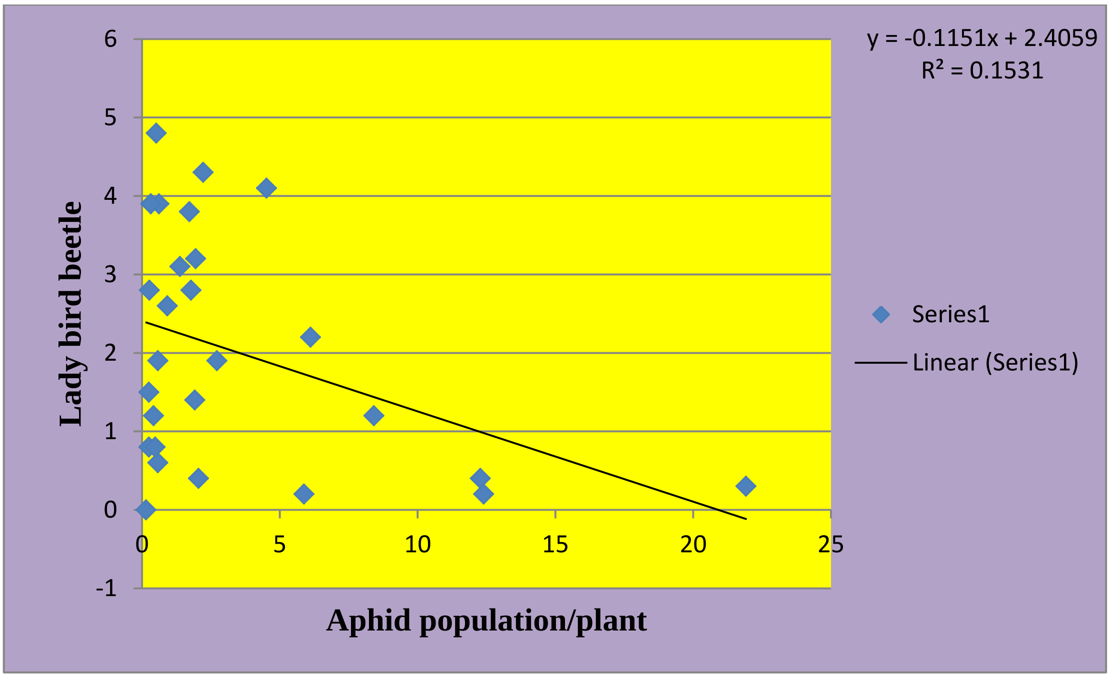

Fig. 4.13: Regression of aphid population on lady bird beetle

Plate 4.1. Aphid (*Aphis gossypii*)

Plate 4.2. Jassids (*Amrasca biguttula biguttula*)

Plate 4.3. Whitefly (*Bemisia tabaci*)

Plate 4.4. Brinjal shoot damaged by *Leucinodes orbonalis* Guenee

Plate 4.5. Brinjal fruit damaged by *Leucinodes orbonalis* Guenee

Plate 4.6. Grub of hadda beetle

Plate 4.7. Adult of hadda beetle

Plate 4.8. Grub and adult of lady bird beetle

Plate 4.9. Spider predator

4.3. Screening of the different brinjal germplasm against shoot and fruit borer (*Leucinodes orbonalis* Guenee).

The 124 brinjal germplasm screening was undertaken against brinjal shoot & fruit borer (*Leucinodes orbonalis*) during *kharif* season 2018-2019. Occurrence of shoot & fruit borer started from 30 days after transplanting (DAT). The population recorded of shoot & fruit borer on the basis of randomly selected five plants at weekly interval during kharif season. The overall mean population per plant of all 124 germplasms were undertaken and depicted on (table 4.7). The results obtained are being presented as below:

4.3.1. Screening against shoot and fruit borer (*L. orbonalis*)

On the basis of pest susceptibility grade formula on brinjal shoot and fruit borer infestation, formulated by subbaratnam and bhutani (1981), the overall mean percentage of shoot and fruit infestation due to *L. orbonalis* was recorded on all the 124 brinjal germplasm.

The overall per cent fruits infestation in different germplasm ranged from 22.29 to 79.73 per cent and 21.84 to 79.32 per cent on number and weight basis, respectively. Similarly, shoot infestation ranged from 1.11 to 7.45 per cent due to *L. orbonalis*. Accordingly the germplasm were categorized as per their reaction pattern (Table 4.7).

Out of the 124 germplasm none of the brinjal germplasm was resistant to brinjal shoot and fruit borer. Similarly, none of the germplasm was tolerant against shoot and fruit borer infestation in the category of 1.00 and 15.00 per cent.

Two germplasm *viz.* IGB-52 and IGB-53 were moderately tolerant under the category of 16.00 and 25.00 per cent infestation. The genotype IGB-52 (2.10 /plant) showed the least shoot borer incidence followed by IGB-53 (2.15 shoot borer /plant). In respect to the per cent infestation of fruit borer, the germplasm IGB-52 (22.29%) showed lowest fruit damage followed by IGB- 53 (24.41%).

While susceptible reaction *i.e.* infestation ranged from 26.00 to 40.00 per cent was exhibited by Twenty six germplasm, wherein the least shoot incidence was observed in the germplasm line IGB-31 (2.22), IGB-99 (2.22), IGB-12 (2.22) followed by IGB-61 (2.24), IGB-106 (2.29), IGB-73 (2.34), IGB-25 (2.34), IGB-111 (2.34),IGB-28 (2.40), IGB-23 (2.41) , IGB-71 (2.41), IGB-27 (2.42), IGB-72 (2.45) and IGB-18 (2.47), IGB-35 (2.54), IGB-123 (2.54), respectively.

However, the maximum shoot damage was observed in IGB-24 (3.18) followed by IGB-91 (3.12), IGB-70 (2.95), IGB-104 (2.86), IGB-120 (2.85), IGB-94 (2.73), IGB-46 (2.72), IGB-112 (2.67), IGB-34 (2.62), IGB-8 (2.55) respectively.

In respect to the per cent fruit borer infestation, the germplasm IGB-104 (26.49) showed lowest fruit incidence followed by IGB-91 (28.23),IGB-8 (29.10), IGB-120 (29.31), IGB-99 (30.41), IGB-71 (31.34), IGB-70 (31.85), IGB-111 (31.92), IGB-46 (32.81), IGB-23(32.91), IGB-34 (32.91), IGB-94 (33.38), IGB-106 (34.41), IGB-25 (34.42), IGB-123 (34.82), respectively. Whereas, highest per cent fruit damage was in IGB-73 (39.43) followed by IGB-28 (39.32), IGB-112 (37.95), IGB-72 (37.92), IGB-24(37.24), IGB-27 (37.09), IGB-35 (36.92), IGB-18 (36.71), IGB-61 (36.41), IGB-12 (36.15), IGB-31 (35.51), respectively.

The highly susceptible (above 40%) reaction was observed in rest of the 96 brinjal germplasm against shoot and fruit borer incidence.

The germplasm line IGB-43 (2.15) showed least shoot damage followed By IGB-109 (2.21), IGB-116 (2.21), IGB-36 (2.23), IGB-78 (2.23), IGB-39 (2.24), IGB-64 (2.29), IGB-60 (2.31), IGB-100 (2.31), IGB-56 (2.32), IGB-65 (2.32), IGB-90 (2.33), IGB-6 (2.34), IGB-54 (2.34), IGB-62 (2.34), IGB-33 (2.35), IGB-66 (2.38), IGB-63 (2.39), IGB-40 (2.41), IGB-57 (2.41), IGB-55 (2.42), IGB-105 (2.42), IGB-4 (2.45), respectively . Whereas, maximum shoot incidence was noticed in IGB-68 (7.45) followed by IGB-12 (6.74), IGB-97 (6.42), IGB-37 (6.41), IGB-13(6.34), IGB-29 (6.30), IGB-108 (6.22), IGB-83 (6.15), IGB-89 (5.84), IGB-15 (5.81), IGB-3 (5.58), IGB-79 (5.12), IGB-32 (5.12), respectively .

The germplasm IGB-78 (41.14) showed least fruit infestation due to fruit borer followed by IGB-62 (41.48), IGB-66 (41.62), IGB-93 (42.21), IGB-64 (42.71), IGB-109 (43.41), IGB-107 (43.45), IGB-76 (43.46), IGB-43 (44.31), IGB-95 (44.32), respectively. The highest fruit infestation on this category was found in IGB-121 (79.73) followed by IGB-13 (78.62), IGB-89 (78.31), IGB-68 (76.79), IGB-83 (76.39), IGB-108 (75.51), IGB-32 (75.41), IGB-97 (73.51), IGB-37 (72.13), IGB-3

(72.04), IGB-22 (71.54), IGB-117 (71.29), IGB-29 (71.29), IGB-114 (71.14), IGB-88 (71.12), IGB-124 (69.24), IGB-15 (69.12), IGB-14 (68.89), IGB-79 (68.75), respectively.

Table 4.6: Categorization of brinjal germplasms based on fruit infestation developed by Subbaratnam and Bhutani (1981)

Level of infestation (%)	Categories	Grade	No. of germplasm lines
1-15	Tolerant	T	0
16-25	Moderately tolerant	MT	2
26-40	Susceptible	S	26
Above 40	Highly susceptible	HS	96

Table 4.7: Overall mean population of shoot and fruit borer on brinjal germplasm.

Germplasm	Infestation percentage		
	Shoot borer /plant	Fruit borer/plant	
		On Number basis	On Weight basis
IGB-1	3.22	63.91	60.39
IGB-2	2.66	54.36	52.18
IGB-3	5.58	72.04	73.06
IGB-4	2.45	59.66	60.42
IGB-5	4.11	62.16	64.31
IGB-6	2.34	60.80	57.75
IGB-7	3.14	59.88	56.58
IGB-8	2.55	29.10	28.64
IGB-9	2.89	54.11	56.15
IGB-10	3.21	62.31	61.15
IGB-11	3.00	57.42	56.23
IGB-12	2.22	36.15	37.74
IGB-13	6.34	78.62	77.44
IGB-14	2.68	68.89	67.42
IGB-15	5.81	69.12	68.31
IGB-16	3.86	57.84	59.61
IGB-17	3.09	53.04	54.59
IGB-18	2.47	36.71	35.44
IGB-19	3.45	65.59	65.19
IGB-20	2.67	58.34	57.81
IGB-21	2.55	58.90	59.58

Germplasm	Infestation percentage		
	Shoot borer /plant	Fruit borer/plant	
		On Number basis	On Weight basis
IGB-22	4.15	71.45	65.18
IGB-23	2.41	32.91	31.04
IGB-24	3.18	37.24	38.75
IGB-25	2.34	34.42	35.61
IGB-26	3.11	52.63	53.54
IGB-27	2.42	37.09	36.65
IGB-28	2.40	39.32	41.31
IGB-29	6.30	71.29	73.87
IGB-30	2.73	61.11	64.59
IGB-31	2.22	35.51	34.62
IGB-32	5.12	75.41	74.74
IGB-33	2.35	52.16	51.53
IGB-34	2.62	32.91	33.75
IGB-35	2.54	36.92	37.61
IGB-36	2.23	51.38	47.54
IGB-37	6.41	72.13	67.51
IGB-38	3.14	65.47	61.35
IGB-39	2.24	57.61	55.51
IGB-40	2.41	61.29	60.04
IGB-41	3.41	51.47	52.54
IGB-42	2.47	48.22	46.58
IGB-43	2.15	44.31	43.26
IGB-44	2.74	51.74	45.14
IGB-45	2.91	47.52	57.34
IGB-46	2.72	32.81	28.63
IGB-47	2.81	68.27	70.64
IGB-48	2.64	64.23	60.81
IGB-49	4.09	48.69	49.64
IGB-50	2.75	60.55	58.17
IGB-51	2.71	64.13	62.85
IGB-52	2.10	22.29	21.84
IGB-53	2.15	24.41	24.26
IGB-54	2.34	48.47	50.61
IGB-55	2.42	56.71	54.95
IGB-56	2.32	61.18	66.84
IGB-57	2.41	65.83	63.43
IGB-58	2.49	61.19	59.44
IGB-59	3.22	64.93	61.85

Germplasm	Infestation percentage		
	Shoot borer /plant	Fruit borer/plant	
		On Number basis	On Weight basis
IGB-60	2.31	53.02	51.46
IGB-61	2.24	36.41	33.92
IGB-62	2.34	41.48	43.11
IGB-63	2.39	66.83	61.49
IGB-64	2.29	42.71	41.44
IGB-65	2.32	45.21	42.74
IGB-66	2.38	41.62	39.86
IGB-67	2.55	62.80	63.09
IGB-68	7.45	76.79	76.34
IGB-69	2.98	50.12	47.94
IGB-70	2.95	31.85	31.21
IGB-71	2.41	31.34	28.29
IGB-72	2.45	37.92	39.61
IGB-73	2.34	39.43	37.51
IGB-74	2.91	47.35	46.56
IGB-75	4.76	51.18	52.41
IGB-76	2.65	43.46	43.51
IGB-77	3.90	52.12	50.41
IGB-78	2.23	41.14	42.19
IGB-79	5.12	68.75	67.38
IGB-80	2.54	55.13	58.45
IGB-81	3.14	64.72	62.82
IGB-82	4.09	50.85	49.41
IGB-83	6.15	76.39	73.44
IGB-84	2.92	55.13	59.32
IGB-85	2.45	59.25	58.09
IGB-86	3.62	63.32	61.68
IGB-87	4.89	59.61	57.95
IGB-88	2.71	71.12	71.45
IGB-89	5.84	78.31	79.32
IGB-90	2.33	46.45	42.16
IGB-91	3.12	28.23	29.28
IGB-92	3.09	48.35	49.31
IGB-93	3.14	42.21	37.45
IGB-94	2.73	33.38	34.76
IGB-95	3.19	44.32	43.75
IGB-96	2.59	47.74	45.63
IGB-97	6.42	73.51	71.14

Germplasm	Infestation percentage		
	Shoot borer /plant	Fruit borer/plant	
		On Number basis	On Weight basis
IGB-98	4.55	61.85	63.78
IGB-99	2.22	30.41	27.61
IGB-100	2.31	51.17	52.75
IGB-101	3.31	56.29	57.39
IGB-102	2.45	45.12	44.89
IGB-103	2.68	47.56	45.43
IGB-104	2.86	26.49	28.19
IGB-105	2.42	50.24	48.26
IGB-106	2.29	34.41	35.32
IGB-107	3.81	43.45	45.17
IGB-108	6.22	75.51	74.62
IGB-109	2.21	43.41	45.71
IGB-110	4.15	62.16	61.53
IGB-111	2.34	31.92	33.76
IGB-112	2.67	37.95	38.64
IGB-113	3.23	51.38	47.56
IGB-114	4.41	71.14	72.53
IGB-115	3.75	67.48	65.34
IGB-116	2.21	57.43	55.54
IGB-117	5.11	71.29	70.04
IGB-118	3.32	51.46	52.49
IGB-119	2.92	47.28	48.59
IGB-120	2.85	29.31	28.25
IGB-121	6.74	79.73	78.81
IGB-122	2.95	45.51	51.35
IGB-123	2.54	34.82	31.67
IGB-124	4.81	69.24	68.69

Table 4.8. Shoot and fruit borer infestation per cent on brinjal germplasm

Level of infestation (%)	Germplasms	Categories	Grade
1-15	-	Tolerant	T
16-25	IGB-52, IGB-53	Moderately tolerant	MS
26-40	IGB-8, IGB-12, IGB-18, IGB-23, IGB-24, IGB-25, IGB-27, IGB-28, IGB-31, IGB-34, IGB-35, IGB-46, IGB-61, IGB-70, IGB-71, IGB-72, IGB-73, IGB-91, IGB-94, IGB-99, IGB-104, IGB-106, IGB-111, IGB-112, IGB-120, IGB-123	Susceptible	S
Above 40	IGB-1, IGB-2, IGB-3, IGB-4, IGB-5, IGB-6, IGB-7, IGB-9, IGB-10, IGB-11, IGB-13, IGB-14, IGB-15, IGB-16, IGB-17, IGB-19, IGB-20, IGB-21, IGB-22, IGB-26, IGB-29, IGB-30, IGB-32, IGB-33, IGB-36, IGB-37, IGB-38, IGB-39, IGB-40, IGB-41, IGB-42, IGB-43, IGB-44, IGB-45, IGB-47, IGB-48, IGB-49, IGB-50, IGB-51, IGB-54, IGB-55, IGB-56, IGB-57, IGB-58, IGB-59, IGB-60, IGB-62, IGB-63, IGB-64, IGB-65, IGB-66, IGB-67, IGB-68, IGB-69, IGB-74, IGB-75, IGB-76, IGB-77, IGB-78, IGB-79, IGB-80, IGB-81, IGB-82, IGB-83, IGB-84, IGB-85, IGB-86, IGB-87, IGB-88, IGB-89, IGB-90, IGB-92, IGB-93, IGB-95, IGB-96, IGB-97, IGB-98, IGB-100, IGB-101, IGB-102, IGB-103, IGB-105, IGB-107, IGB-108, IGB-109, IGB-110, IGB-113, IGB-114, IGB-115, IGB-116, IGB-117, IGB-118, IGB-119, IGB-121, IGB-122, IGB-124	Highly susceptible	HS

Grade formula given by subbaratnam and bhutani (1981).

Similar finding were revealed by Panda (1999) that, out of 174 brinjal genotype not any of the genotype was resistant to larval attack brinjal of shoots and fruit borer. The proportion invasion of shoot diverse from 1.61 to 44.11 per cent and fruit invasion ranged from 8.50 to 100 per cent, respectively.

Patnaik (2000) revealed the occurrence of shoot and fruit borer was frequently observed during September to October at 64-83 days after planting and the highest level of infestation were in the range of 59.2-75.5 percent.

Sridhar *et al.* (2001) evaluated fifty-four brinjal (aubergine) germplasms, including 5 wild species and some F1 crosses and none of the cultivated/wild species of brinjal was found resistant to *L. orbonalis*. Three wild species, *i.e. S. khasianum, S. viarum* and *S. incanum*, were found to be resistant with 0.5-10.0 per cent fruit infestation. Among the cultivated lines, CHB-103, 187 and 259 were identified as fairly resistant.

Mandal *et al.* (2005) evaluated thirty-one brinjal (aubergine) cultivars for resistance to *L. orbonalis*. None of the cultivar was highly resistant. Only three cultivars, *i.e.* BBS 103, BB 112 and Pusa purple cluster, were detected as moderately resistant, recorded fruit damage 11.28, 12.98 and 13.33% on number basis and 12.13, 13.36 and 13.86% on weight basis, respectively. These moderately resistant cultivars produced comparatively higher yield of 23.60, 16.19 and 17.51 t/ha, respectively.

Khan and Singh. (2014) observed the response of different brinjal genotypes against brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee) in *kharif* (rainy season). Among 192 genotypes of brinjal, two of them EC305163 and IC090132 were showed immune to shoot and fruit borer, three genotype namely IC545256, IC433625 and IC264470 found resistance, 21 fairly resistance, 38 tolerant, 52 susceptible and rest 76 genotypes were highly susceptible to brinjal shoot and fruit borer.

4.3.2: Morphological characteristics of the brinjal for screening against shoot and fruit borer.

(a) Fruit length

The fruit length of 124 brinjal germplasm lines ranged from 7.6 to 31.9 cm whereas the maximum length of fruit noticed in IGB-92 (31.9 cm) with fruit width (6 cm), shoot infestation (3.09 %) and fruit infestation (48.35 %), respectively. It was followed by IGB-93, IGB-104 with mean length (31.1 & 30.8 cm) and had fruit width (5.8 & 5.7 cm) and shoot infestation (3.14 & 2.86 %) with fruit infestation (42.21 & 26.49 %), respectively.

The minimum fruit length (7.6 cm) was recorded on IGB-121 possessed fruit width (3.9 cm) and shoots (6.74%) and fruit infestation (79.73 %), respectively. It was followed by IGB-13, IGB-89 with similar fruit length (8.6 cm), fruit width (2.9 and

4.9 cm), shoot infestation (6.34 and 5.84 %) and fruit infestation (78.62 & 78.31%), respectively.

(b) Fruit diameter

The fruit diameter of the 124 brinjal germplasm lines, ranged from 3 to 9.8 cm. The maximum fruit width was in IGB-118 (9.8 cm) with fruit length (20.4 cm), shoot infestation (3.32 %) and fruit infestation (51.46 %), respectively. Next effective germplasm line was IGB-88 recorded fruit width (9.7 cm), fruit length (13.4 cm), shoot infestation (2.71 %) and fruit infestation (71.12 %), respectively. Rest of the line showed the decreasing trend of fruit diameter.

The germplasm line IGB-76 showed minimum fruit width (3 cm) with fruit length of (23.4 cm), shoot infestation (2.65 %) and fruit infestation (43.46 %), respectively. Accordingly next germplasm line IGB-22, IGB-51 and IGB-108 recorded similar fruit width (3.1 cm), fruit length (12.6, 14.6 & 10.58 cm), shoot infestation (4.15, 2.71 & 6.22 %) and fruit infestation (71.45, 64.13 & 75.51%), respectively followed by the rest of germplasm lines in the increasing trend of fruit diameter.

(c) Fruit weight

The fruit weight of the 124 brinjal germplasm lines ranged from 17 to 476 g. The maximum fruit weight (476 g) was recorded in IGB-118 with shoot (3.32 %) and fruit infestation (51.46%), respectively. Next effective germplasm line was IGB-9 recorded fruit weight (437 g), fruit length (19.2 cm), shoot infestation (2.89 %) and fruit infestation (54.11%), respectively. Rest of the germplasm lines showed the decreasing trend of fruit weight.

The germplasm line IGB-51 showed minimum fruit weight (17 g) with shoot infestation (2.71 %) and fruit infestation (64.13%), respectively. Accordingly next germplasm line IGB-22 recorded fruit weight (23 g), shoot infestation (4.15 %) and fruit infestation (71.45 %), respectively. Rest of the germplasm lines were in the increasing trend of fruit weight.

(d) Calyx length

The calyx length of the 124 brinjal germplasm lines ranged from 1.3 to 5.5. The maximum calyx length (5.5 cm) was in IGB-12 with shoot infestation (2.22 %) and fruit infestation (36.15%), respectively. Next effective germplasm line was IGB-

18 recorded calyx length (5.24 cm), shoot infestation (2.47 %) and fruit infestation (36.71%), respectively. Rest of the germplasm line showed the decreasing trend of calyx length.

The germplasm line IGB-55 showed minimum calyx length (1.3 cm) with shoot infestation (4.42 %) and fruit infestation (56.71%), respectively. Accordingly next germplasm line IGB-4 recorded calyx length (1.42 cm), shoot (2.45 %) and fruit infestation (59.66%), followed by the rest of germplasm lines in the increasing trend of calyx length.

(e) Pedicle Length

The pedicle length of the 124 brinjal germplasm lines ranged from 3.4 to 7.6 cm. The maximum pedicle length (7.6 cm) was in IGB-65, with the fruit length (22.6 cm), width (4.0cm), pedicle thickness (3.14 cm) and shoot (2.32 %) & fruit infestation (45.21%), respectively. Next effective germplasm lines were IGB- 76 and IGB-113 showed similar pedicle length (7.4 cm). IGB- 76 recorded fruit length (23.4 cm), fruit width (3 cm), pedicle thickness (2.7) and shoot (2.65 %) and fruit infestation (46.46 %), whereas Germplasm line IGB-113 showed fruit length (20.4 cm), fruit width (4.3 cm), pedicle thickness (3.32), shoot (3.23 %) and fruit infestation (51.38 %), respectively. Rest of the germplasm lines were in the decreasing trend of pedicle length.

The germplasm line IGB-22 and IGB-102 showed similar minimum pedicle length (3.4 cm). Germplasm line IGB-22 observed fruit length (12.6 cm), fruit width (3.1 cm), pedicle thickness (2.76 cm) and shoot (4.15 %) and fruit infestation (71.45 %), respectively. However germplasm line IGB-102 showed fruit length (22.8 cm), fruit width (4 cm), pedicle thickness (2.5 cm), shoot (2.45 %) and fruit infestation (45.12 %), respectively. Accordingly next germplasm line IGB-26 & IGB-96 recorded similar pedicle length (3.6 cm). Germplasm line IGB-26 showed fruit length (19.4 cm), fruit width (4.3 cm), pedicle thickness (2.2 cm) and shoot (3.11 %) and fruit infestation (52.63 %), whereas germplasm line IGB-96 showed fruit length (22 cm), fruit width (5.6 cm), pedicle thickness (2.6 cm), shoot (2.59 %) and fruit infestation (47.74 %), respectively. Rest of germplasm lines were in the increasing trend of pedicle length.

(f) Pedicle Thickness

The pedicle length of the 124 brinjal germplasm lines ranged from 1.1 to 3.92 cm. Germplasm line IGB-114 showed the maximum pedicle thickness (3.92 cm) with pedicle length (5.2 cm), fruit length (13.2 cm), fruit width (7.4 cm), shoot (4.41 %) and fruit infestation (71.41 %), respectively. Next effective germplasm line was IGB-48 recorded pedicle thickness (3.44 cm), pedicle length (5.4 cm), fruit length (14.4 cm), fruit width (4 cm), shoots infestation (2.64 %) and fruit infestation (64.23 %), respectively. Rest of germplasm lines were in the decreasing trend of pedicle thickness.

The germplasm line IGB-13 and IGB-73 showed minimum similar pedicle thickness (1.1 cm). Germplasm line IGB-13 showed pedicle length (4.6 cm), fruit length (8.6 cm), fruit width (2.9 cm), shoot (6.34 %) and fruit infestation (78.62 %), whereas germplasm line IGB-73 showed pedicle length (6.4 cm), fruit length (28 cm), fruit width (4.6 cm), shoot infestation (2.34 %) and fruit infestation (39.43 %), respectively. Accordingly next germplasm line IGB-33 observed, pedicle thickness (1.16 cm), pedicle length (5 cm), fruit length (19.8 cm), fruit width (4.1 cm), shoot infestation (2.35 %) and fruit infestation (52.16 %), respectively, followed by the rest of germplasm lines in the increasing trend of pedicle thickness.

(g) Fruit colour

Out of 124 brinjal germplasm lines, six different types of fruit colours of brinjal crop were observed viz. light green, green, greenish purple, dark purple, purple and white. According to the fruit colour, the per cent of fruit infestation was also assessed.

Brinjal fruits of light green colour consisting 2 germplasm line noticed 46.27 % infestation. Brinjal fruits of dark purple of 12 germplasm lines (47.94 %), greenish purple of 2 line (49.93%), green colour of 54 lines (53.54 %), purple colour of 45 lines (51.39 %) and white colour of 9 lines (60.78 %) were observed with fruit infestation, respectively.

Table 4.9. Measurement of fruits length, width, weight, calyx length and pedicle length and thickness on brinjal crop

Germplasm	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (gm)	Fruit calyx length (cm)	Pedicle length (cm)	Pedicle thickness (cm)
IGB-1	15.4	4.1	75	2.24	6.2	2.54
IGB-2	19.2	4.5	111	3.1	5.6	2.7
IGB-3	12.4	6.4	75	2.2	4.4	3.12
IGB-4	17.2	3.7	50	1.42	5.2	2.52
IGB-5	16	4.8	219	2.7	3.8	2.5
IGB-6	17	4.6	190	1.88	4.6	2.3
IGB-7	17.4	3.6	61	3.5	5	1.9
IGB-8	30	5.4	283	3.4	6.6	2.8
IGB-9	19.2	9.2	437	2.3	7.2	1.37
IGB-10	16	4.7	168	2.5	4.8	2.2
IGB-11	18.6	7.1	165	3.7	5.8	2.3
IGB-12	28.4	3.8	265	5.5	7	2.6
IGB-13	8.6	2.9	64	1.9	4.6	1.1
IGB-14	13.4	4.6	119	2.7	5.9	1.9
IGB-15	13.4	3.2	34.8	3.3	5.8	2.1
IGB-16	18.4	4.0	167	2.7	7	2.3
IGB-17	19.4	4.1	53	2.4	4.9	2.9
IGB-18	28.5	4.9	303	5.24	7.2	2.68
IGB-19	14.2	7.5	169	4.5	4.6	2.3
IGB-20	17.6	6.6	315	2.7	3.8	2.8
IGB-21	18	3.5	64	2.26	5.8	2.48
IGB-22	12.6	3.1	23	1.8	3.4	2.76
IGB-23	29.4	4.7	269	3.1	6.2	2.5
IGB-24	28.1	4.7	273.6	4.06	4.6	2.5
IGB-25	29	4.3	261	2.8	6.1	2.4
IGB-26	19.4	4.3	165	2.5	3.6	2.2
IGB-27	28.2	5.7	365	3.3	5.8	2.9
IGB-28	27.6	5.3	255	2.9	5.9	2.5
IGB-29	12.8	5.6	165	2.7	4.5	2.2
IGB-30	16.2	5.7	143	2.3	6	2.1
IGB-31	28.9	4.2	259	2.8	6	2.3
IGB-32	10.8	3.6	44	1.5	4.9	1.9
IGB-33	19.8	4.1	85	2.98	5	1.16
IGB-34	29.5	4.8	265	3.1	6.3	2.6
IGB-35	28.5	3.8	125.2	3.5	4.8	2.9
IGB-36	19.8	6.6	269	2.9	4.2	2.1
IGB-37	11	4.4	135	2.5	3.8	1.6
IGB-38	14.4	4.2	74	2.84	4.4	1.18
IGB-39	18.6	3.9	89	1.58	5.8	3.18
IGB-40	16.2	4.0	89	3.5	4.8	2.1
IGB-41	20	4.3	223	2.5	4.4	2

Germplasm	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (gm)	Fruit calyx length (cm)	Pedicle length (cm)	Pedicle thickness (cm)
IGB-42	20.8	3.7	60	1.7	7	1.92
IGB-43	23	4.5	143	3.5	4.4	2.3
IGB-44	20	5.0	123	2.34	6.2	2.5
IGB-45	21.4	4.0	93	2.1	4.6	2.7
IGB-46	29.5	4.9	273	3.2	6.4	2.6
IGB-47	14	3.7	209	2.3	4.4	1.6
IGB-48	14.4	4.0	61	1.76	5.4	3.44
IGB-49	21.4	4.5	156	2.18	5.8	2.34
IGB-50	17	3.6	63	3.56	5.2	2.4
IGB-51	14.6	3.1	17	1.7	3.8	2.1
IGB-52	21.4	4.1	79	2.14	4.8	1.18
IGB-53	24.6	4.2	176	2.3	4	1.18
IGB-54	21.4	4.2	113	2.5	6.6	3.24
IGB-55	19.1	4.1	85.2	1.3	4	3.1
IGB-56	16.4	3.4	46.6	2.5	4.8	2.1
IGB-57	14.4	4.3	65	2.28	5.6	2.64
IGB-58	16.8	3.6	67	2.7	6.8	2.3
IGB-59	15	3.8	45	2.22	6	2.24
IGB-60	19.4	3.4	62	2.5	6	2.62
IGB-61	28.6	4.1	257	2.7	6	2.3
IGB-62	24.6	3.6	68	3.7	4.8	2.1
IGB-63	14.2	5.0	110	2.26	5.8	2.4
IGB-64	24.6	7.7	414	4.92	6.8	1.7
IGB-65	22.6	4.0	325	2.74	7.6	3.14
IGB-66	25.2	5.5	331	4.3	6.6	2.7
IGB-67	16	6.1	133	3.1	4	2.28
IGB-68	9.6	4.8	120	2.5	4.2	2.3
IGB-69	20.4	7.3	333	3.7	4.4	2.3
IGB-70	29.6	5.0	275	3.2	6.4	2.6
IGB-71	29.8	5.1	277	3.2	6.4	2.7
IGB-72	28.3	5.9	177	2.4	4.2	2.16
IGB-73	28	4.6	131	4.08	6.4	1.1
IGB-74	21.6	4.0	130	2.5	6.8	2.9
IGB-75	20	4.0	169	2.3	4.6	2.7
IGB-76	23.4	3.0	41	1.82	7.4	2.7
IGB-77	19.8	3.3	70	3.3	6.4	2.64
IGB-78	25.6	4.8	140	3.1	7	2.42
IGB-79	14.2	5.6	132	2.2	3.8	2.9
IGB-80	19.2	3.4	66.6	2.5	4.8	2.3
IGB-81	15.2	6.3	125	2.7	6	2.3
IGB-82	20.6	6.3	30	2.5	4	2.1
IGB-83	9.8	5.1	136	2.3	4.2	1.9
IGB-84	19.2	6.8	111	2.5	7.2	1.2
IGB-85	17.4	4.9	218	2.7	4.6	2.3

Germplasm	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (gm)	Fruit calyx length (cm)	Pedicle length (cm)	Pedicle thickness (cm)
IGB-86	15.8	3.2	132	2.22	6.2	2.56
IGB-87	17.6	5.6	270	3.5	6.2	2.4
IGB-88	13.4	9.7	342	3.5	3.8	3.1
IGB-89	8.6	4.9	91	2.7	3.8	1.9
IGB-90	22	4.1	44	2.7	5.8	2.7
IGB-91	30.6	5.6	287	3.6	6.6	2.8
IGB-92	31.9	6.0	293	3.9	6.7	3
IGB-93	31.1	5.8	291	3.8	6.6	2.9
IGB-94	29.4	4.6	267	3	6.2	2.5
IGB-95	23.2	5.2	275	3.1	5.4	2.3
IGB-96	22	5.6	261	2.9	3.6	2.6
IGB-97	11	5.3	141	2.5	4.2	2.35
IGB-98	17	3.6	104	2.3	5	2.3
IGB-99	29.9	5.3	281	3.3	6.5	2.7
IGB-100	20.2	3.5	124.6	2.5	4.8	2.1
IGB-101	19	4.3	261	2.7	4.4	2.9
IGB-102	22.8	4.0	121.6	2.12	3.4	2.5
IGB-103	22	5.7	122	2.28	6.2	2.3
IGB-104	30.8	5.7	289	3.7	6.6	2.9
IGB-105	20.6	4.2	155	4.26	5.8	3.02
IGB-106	29.1	4.4	263	2.9	6.1	2.4
IGB-107	22.8	6.5	169	2.88	7	1.4
IGB-108	10.58	3.1	290	3.5	4.6	2.2
IGB-109	24.2	3.7	108	2.3	4.2	1.7
IGB-110	16	7.1	223	3.5	4.4	2.9
IGB-111	29.8	5.2	279	3.3	6.5	2.7
IGB-112	28.3	7.1	47.2	1.9	4	2.14
IGB-113	20.4	4.3	77	2.18	7.4	3.32
IGB-114	13.2	7.4	160	2.2	5.2	3.92
IGB-115	14.2	4.8	189	2.3	6.6	1.9
IGB-116	19	3.7	44	2.58	5.4	2.22
IGB-117	13	3.3	45	1.78	5	2.68
IGB-118	20.4	9.8	476	3.7	7	1.62
IGB-119	22	4.5	237	3.14	6.2	2.68
IGB-120	30.4	5.5	285	3.5	6.6	2.8
IGB-121	7.6	3.9	95	2.7	5.2	1.7
IGB-122	22.8	6.9	335	3.7	7.2	2.1
IGB-123	29.2	4.5	265	2.9	6.1	2.5
IGB-124	13.4	6.2	199	2.9	3.8	3

Table 4.10. Maximum and minimum value of fruits length, width, weight, calyx length, pedicle length and thickness of brinjal germplasm and infestation percentage of Shoot and fruit borer

Fruit length (cm)	Germplasm	Infestation percentage of Shoot and fruit borer of brinjal		
		Shoot borer/plant	fruit borer/plant	
			On number basis	On weight basis
31.9 (maximum)	IGB-92	3.09	48.35	49.31
7.6 (minimum)	IGB-121	6.74	79.73	78.81

Fruit diameter (cm)	Germplasm	Infestation percentage of Shoot and fruit borer of brinjal		
		Shoot borer/plant	fruit borer/plant	
			On number basis	On weight basis
9.8 (maximum)	IGB-118	3.32	51.46	52.49
3 (minimum)	IGB-76	2.65	43.46	43.51

Fruit weight (gm)	Germplasm	Infestation percentage of Shoot and fruit borer of brinjal		
		Shoot borer/plant	fruit borer/plant	
			On number basis	On weight basis
476 (maximum)	IGB-118	3.32	51.46	52.49
17 (minimum)	IGB-51	2.71	64.13	62.85

Fruit calyx length (cm)	Germplasm	Infestation percentage of Shoot and fruit borer of brinjal		
		Shoot borer/plant	fruit borer/plant	
			On number basis	On weight basis
5.5 (maximum)	IGB-12	2.22	36.15	37.74
1.3 (minimum)	IGB-55	2.42	56.71	54.95

Pedicle length (cm)	Germplasm	Infestation percentage of Shoot and fruit borer of brinjal		
		Shoot borer/plant	fruit borer/plant	
			On number basis	On weight basis
7.6 (maximum)	IGB-65	2.32	45.21	42.74
3.4 (minimum)	IGB-22	4.15	71.45	65.18
	IGB-102	2.45	45.12	44.89

Pedicle thickness (cm)	Germplasm	Infestation percentage of Shoot and fruit borer of brinjal		
		Shoot borer/plant	fruit borer/plant	
			On number basis	On weight basis
3.92 (maximum)	IGB-114	4.41	71.14	72.53
1.1 (minimum)	IGB-13	6.34	78.62	77.44
	IGB-73	2.34	39.43	37.51

Table 4.11. Incidence of shoot and fruit borer in related to fruit colours of brinjal germplasm lines.

No. Germplasm	Germplasm lines	Fruit colour	Mean fruit infestation % on number basis
1.	IGB-1,IGB-4, IGB-8 IGB-12, IGB-18, IGB-30, IGB-49,IGB-64, IGB-70, IGB-73, IGB-89, IGB-103	Dark purple	47.94
2.	IGB-2, IGB-5, IGB-6, IGB-10, IGB-13, IGB-14, IGB-17, IGB-20, IGB-21, IGB-25, IGB-28, IGB-29, IGB-32, IGB-34, IGB-41 IGB-46, IGB-48, IGB-51, IGB-55, IGB-58, IGB-60, IGB-61, IGB-63, IGB-65, IGB-69 IGB-71, IGB-74, IGB-77, IGB-78, IGB-82, IGB-85, IGB-88, IGB-91, IGB-94, IGB-100, IGB-102, IGB-106, IGB-107, IGB-110, IGB-111, IGB-113, IGB-116, IGB-119, IGB-122, IGB-123	Purple	51.39
3.	IGB-36, IGB-54	Greenish purple	49.93
4.	IGB-3, IGB-7, IGB-9, IGB-11, IGB-15, IGB-16, IGB-19, IGB-22, IGB-23, IGB-26, IGB-27, IGB-31, IGB-33, IGB-35, IGB-37, IGB-38, IGB-40, IGB-43, IGB-44, IGB-47, IGB-50, IGB-52, IGB-53, IGB-56, IGB-57, IGB-59, IGB-62, IGB-66, IGB-67, IGB-72, IGB-75,IGB-76, IGB-79, IGB-81, IGB-84, IGB-86, IGB-90, IGB-92, IGB-93, IGB-96, IGB-97, IGB-98, IGB-99, IGB-101, IGB-104, IGB-105, IGB-108, IGB-109, IGB-112, IGB-114, IGB-117, IGB-118, IGB-120, IGB-121	Green	53.54
5.	IGB-95, IGB-42	Light green	46.27
6.	IGB-24, IGB-39, IGB-45, IGB-68, IGB-80 IGB-83, IGB-87, IGB-115, IGB-124	White	60.78

Plate 4.10. Fruit infestation of shoot and fruit borer in fruit of different brinjal germplasm

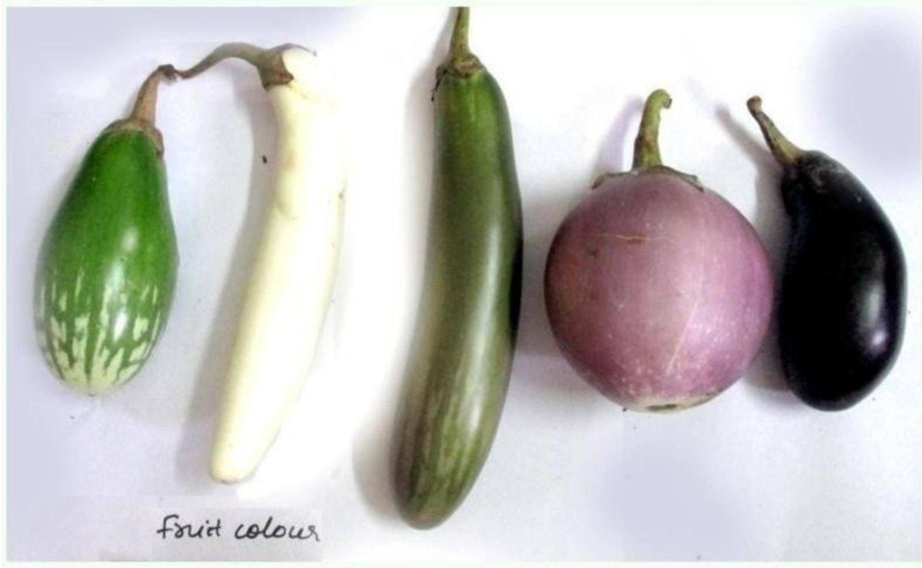

Plate 4.11. Different fruit colours of brinjal germplasm

Plate 4.12. Different fruit length of brinjal germplasm lines

Plate 4.13. Different fruit size of brinjal germplasm lines

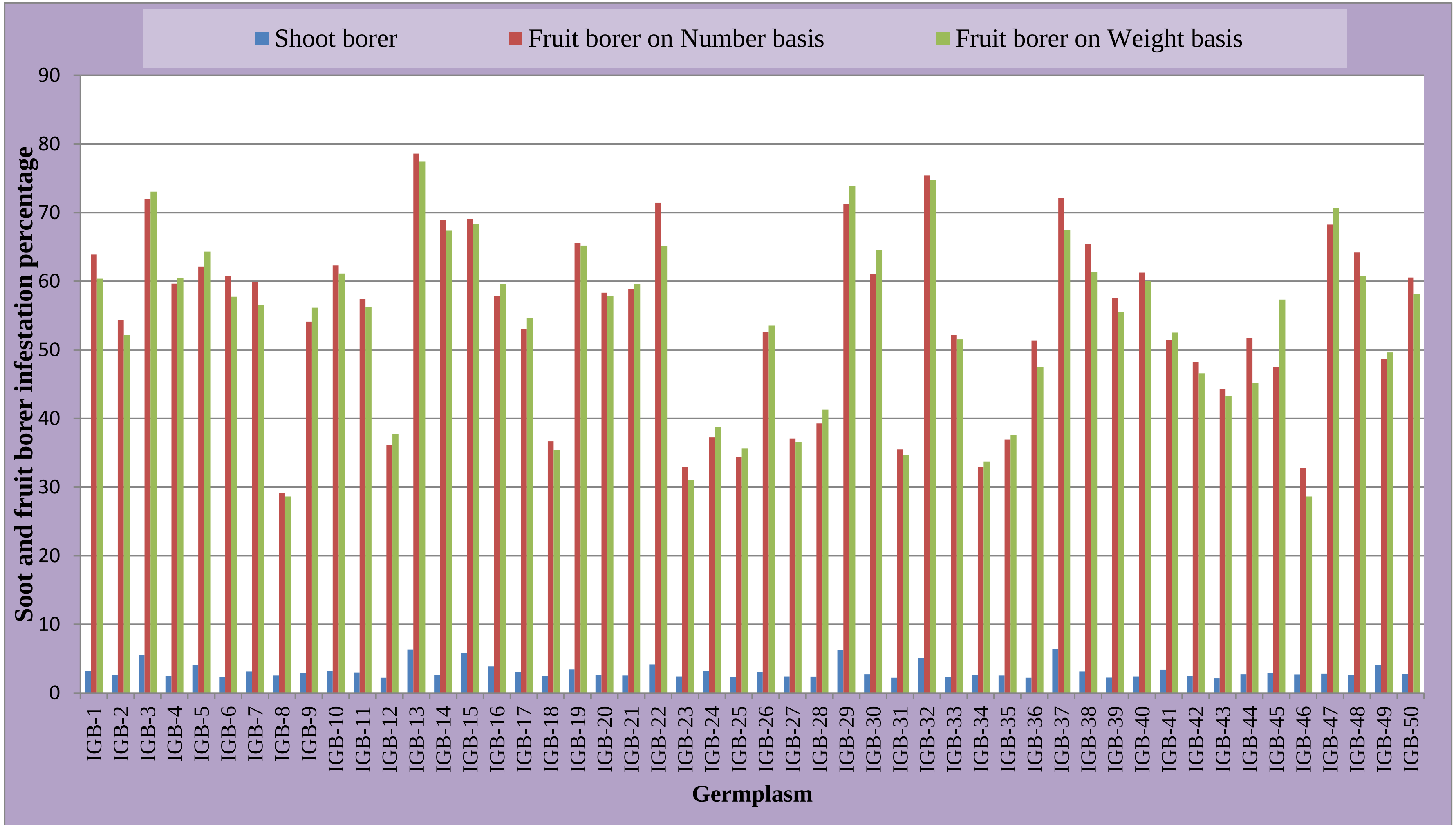

Fig. 4.14. Infestation percent of shoot and fruit borer in different germplasm (IGB-1 to IGB-50)

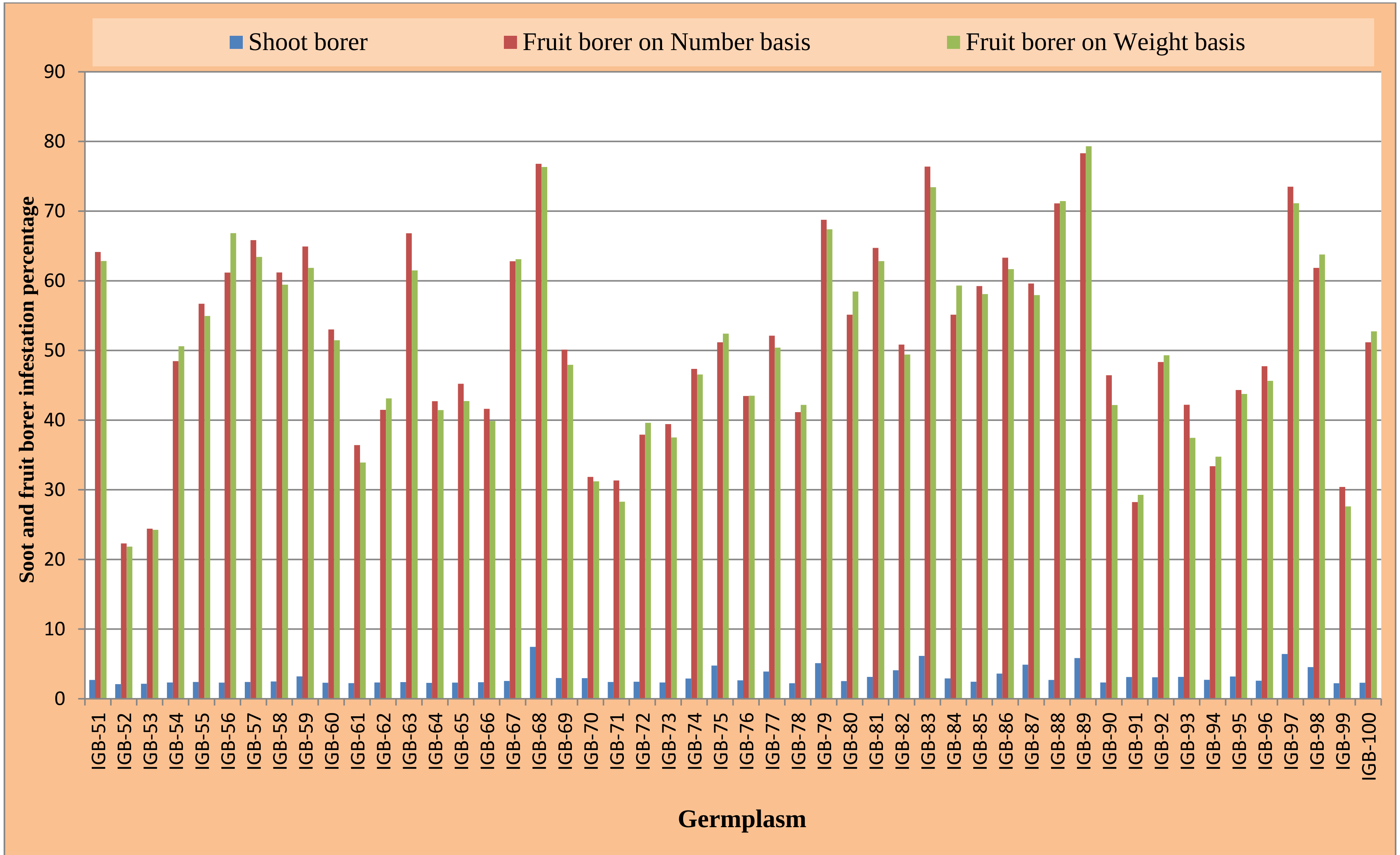

Fig. 4.15. Infestation percent of shoot and fruit borer in different germplasm (IGB-51 to IGB-100)

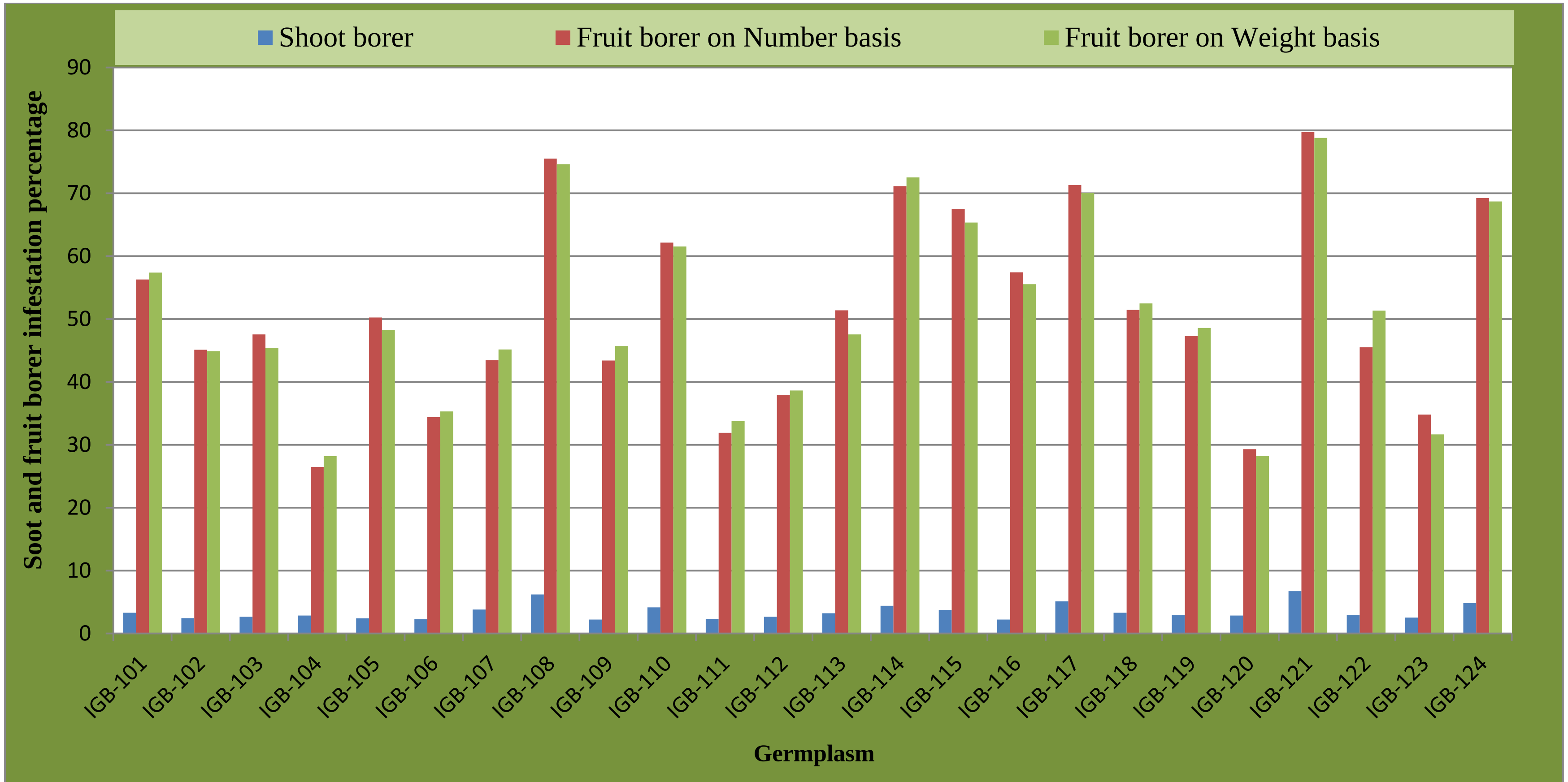

Fig. 4.16. Infestation percent of shoot and fruit borer in different germplasm (IGB-101 to IGB-124)

4.4. To evaluate the bio-efficacy of different combination of insecticides against major insect pests of brinjal crop.

Among the different pests those attacked brinjal, the brinjal shoot and fruit borers, jassids and epilachna beetles were appeared as the most damaging form, causing substantial yield loss. Brinjal shoot and fruit borer is most damaging that directly caused yield loss by boring the young apical twigs and petiole and in fruiting stage of the plant damage was mostly caused by boring the developing fruits. On the other hand, jassids causing damage by sucking the cell content from the leaves and severe infestation devitalised the growth of the plant. Both the adult and grub of the epilachna beetes caused devastating damage by feeding on leaf tissues in a characteristic fashion producing ladies' less like symptoms. Severe infestation of epilachna beetles causing death of the plants. All these three insect species appeared as a regular and major pest of brinjal causing significant crop loss and hence required intervention to manage them, using suitable pesticides.

Therefore, efficacy of Dimethoate 20% + Cypermethrin 3% EC at four different doses *viz.*, 114.8, 123.6, 132.5 and 141.3 g a.i./ha respectively has been tested against brinjal shoot and fruit borers, jassids and epilachna beetles along with single dose of Dimethoate 30% EC market sample (200g *a.i.*/ ha) and Cypermethrin 25% EC (50 g *a.i.*/ ha) were sprayed with an untreated control check.

4.4.1 Efficacy of insecticide molecules against brinjal shoot and fruit borer (*Leucinodes orbonalis* G.)

The results of the experiment revealed that lowest fruit infestation percentage of brinjal shoot and fruit borer, 12.66 % was recorded from the treatments of Dimethoate 20% + Cypermethrin 3% EC @ 141.3 g a.i./ha in 7 and 15 days after spraying which was found to be at par with other three doses of Dimethoate 20% + Cypermethrin 3% EC @ 114.8, 123.6 and 132.5 g a.i./ha against the brinjal shoot and fruit borer (Table 4.12). Comparatively high fruit infestation per cent of brinjal shoot and fruit borer was recorded from market sample of Dimethoate 30% EC and Cypermethrin 25% EC treated plots after 7 and 15 days after spraying and highest was observed in untreated check plots (Table 4.12). The population of brinjal shoot and fruit borer at 15 days after 1st spraying has been considered as the pre-treatment population for 2nd round of spraying which was found to be low and thus quite a significant fruit infestation reduction per cent has been recorded from all the treatments. It was observed that efficacy of Dimethoate 20% + Cypermethrin 3% EC of the test material was found to be more efficacious than the other treatments which was evidenced by the high recorded of the fruit infestation percentage in those treatments in comparison to the negligible recorded fruit infestation percentage in Dimethoate 20% + Cypermethrin 3% EC treated plots (Table 4.12).

4.4.2. Efficacy of insecticide molecules against *Amrasca biguttula biguttula* (Ishida)

The efficacy of Dimethoate 20% + Cypermethrin 3% EC against jassids, *Amrasca biguttula biguttula* or the leaf hoppers in brinjal has been presented in the table 4.13 which revealed that Dimethoate 20% + Cypermethrin 3% EC 141 g a.i/ha caused lowest population of jassids 3.74 per plant at 1, 3, 7 and 15 DAS was found to be at par with other three doses of Dimethoate 20% + Cypermethrin 3% EC @ 114.8, 123.6 and 132.5 g a.i./ha (Table-4.13) respectively. Comparatively high populations of jassids per plant has been recorded from market sample of Dimethoate 30% EC and Cypermethrin 25% EC treated plots after 1, 3, 7 and 15 days after spraying (Table 4.13).

The efficacy of different doses of Dimethoate 20% + Cypermethrin 3% EC during 2nd round of application has been presented in the table-3. It has been observed that like the 1st round application the lowest population of jassids per plant were recorded in Dimethoate 20% + Cypermethrin 3% EC @ 141.3 g a.i/ha treated plots which was statistically at par with the treatments of Dimethoate 20% + Cypermethrin 3% EC @ 114.8, 123.6 and 132.5 g a.i./ha at 1, 3, 7 and 15 days after spraying. (Table 4.13).

Table 4.12: Bio-efficacy evaluation of different combination of insecticides against shoot and fruit borer (*Leucinodes orbonalis*) on brinjal during *rabi* 2018-19.

S. No.	Insecticides	a.i./ha (gm)	Pretreatment fruit infestation (%)	Post treatment fruit infestation (%)				Overall mean
				I Spray		II Spray		
				7 DAS	15 DAS	7 DAS	15 DAS	
1.	Dimethoate 20% + Cypermethrin 3% EC	114.8	31.67 (34.23)	12.1 (20.31)	22.6 (28.34)	13.2 (21.22)	19.34 (26.04)	16.81
2.	Dimethoate 20% + Cypermethrin 3% EC	123.6	31.7 (34.25)	11.73 (19.92)	20.5 (26.89)	12.45 (20.56)	18.23 (25.22)	15.73
3.	Dimethoate 20% + Cypermethrin 3% EC	132.5	29.94 (33.16)	10.96 (19.28)	17.45 (24.63)	11.64 (19.84)	16.45 (23.89)	14.13
4.	Dimethoate 20% + Cypermethrin 3% EC	141.3	30.4 (32.44)	8.95 (17.33)	15.3 (22.99)	10.25 (18.61)	16.14 (23.62)	12.66
5.	Dimethoate 30% EC	200	29.82 (33.10)	13.73 (21.66)	23.3 (28.82)	13.89 (21.80)	20.4 (26.82)	17.83
6.	Cypermethrin 25% EC	50	30.43 (32.46)	14.36 (22.23)	25.93 (30.56)	15.6 (23.25)	22.24 (28.09)	19.53
7.	Control (Untreated)	-	31.2 (33.94)	31.35 (34.03)	33.16 (35.14)	36.42 (37.10)	38.52 (38.34)	34.86
	SEM		-	**1.103**	**0.907**	**1.129**	**0.915**	-
	CD at 5%		**NS**	**3.44**	**2.82**	**3.52**	**2.85**	-

( ) Figures in parentheses are angular transformed, NS= Non significant

Table 4.13: Bio-efficacy evaluation of different combination of insecticides against jassids on brinjal *during rabi* 2018-19.

S. No.	Insecticides	a.i./ha (gm)	Pre-treatment population/plant	Post treatment population of jassids/plant at different days after spray (DAS)								Overall mean
				I Spray				II Spray				
				1 DAS	3 DAS	7 DAS	15 DAS	1 DAS	3 DAS	7 DAS	15 DAS	
1.	Dimethoate 20% + Cypermethrin 3% EC	114.8	10.85 (3.44)	5.18 (2.86)	6.94 (3.04)	7.57 (2.84)	8.08 (2.92)	3.87 (2.06)	2.75 (1.77)	6.68 (2.66)	5.66 (2.46)	5.84
2.	Dimethoate 20% + Cypermethrin 3% EC	123.6	11.14 (3.48)	5.22 (2.93)	6.90 (3.05)	6.66 (2.66)	7.10 (2.75)	3.33 (1.94)	3.25 (1.93)	6.53 (2.61)	5.85 (2.50)	5.61
3.	Dimethoate 20% + Cypermethrin 3% EC	132.5	10.74 (3.42)	4.50 (2.83)	5.10 (2.97)	6.18 (2.84)	6.47 (2.62)	2.87 (1.76)	2.85 (1.83)	5.95 (2.54)	4.94 (2.31)	4.86
4.	Dimethoate 20% + Cypermethrin 3% EC	141.3	11.25 (3.50)	3.83 (2.46)	4.76 (2.65)	4.92 (2.32)	5.47 (2.43)	2.10 (1.61)	2.47 (1.72)	2.68 (1.77)	3.72 (2.24)	3.74
5.	Dimethoate 30% EC	200	10.55 (3.38)	6.65 (3.19)	7.77 (3.21)	7.92 (2.88)	6.73 (2.66)	3.80 (2.03)	3.57 (2.01)	6.97 (2.73)	5.93 (2.53)	6.17
6.	Cypermethrin 25% EC	50	10.62 (3.40)	7.95 (3.38)	8.15 (3.26)	9.01 (3.06)	9.2 (3.11)	5.25 (2.39)	4.50 (2.23)	8.35 (2.97)	7.31 (2.79)	7.47
7.	Control (Untreated)	-	10.92 (3.43)	11.95 (3.66)	11.28 (3.57)	12.03 (3.54)	12.10 (3.55)	11.35 (3.29)	11.10 (3.41)	8.15 (2.89)	8.6 (3.01)	10.82
	SEM		-	**0.223**	**0.212**	**0.345**	**0.322**	**0.39**	**0.26**	**0.214**	**0.26**	-
	CD at 5%		**NS**	**0.694**	**0.693**	**0.784**	**0.648**	**0.864**	**0.462**	**0.424**	**0.469**	-

( ) Figures in parentheses are angular transformed, NS= Non significant

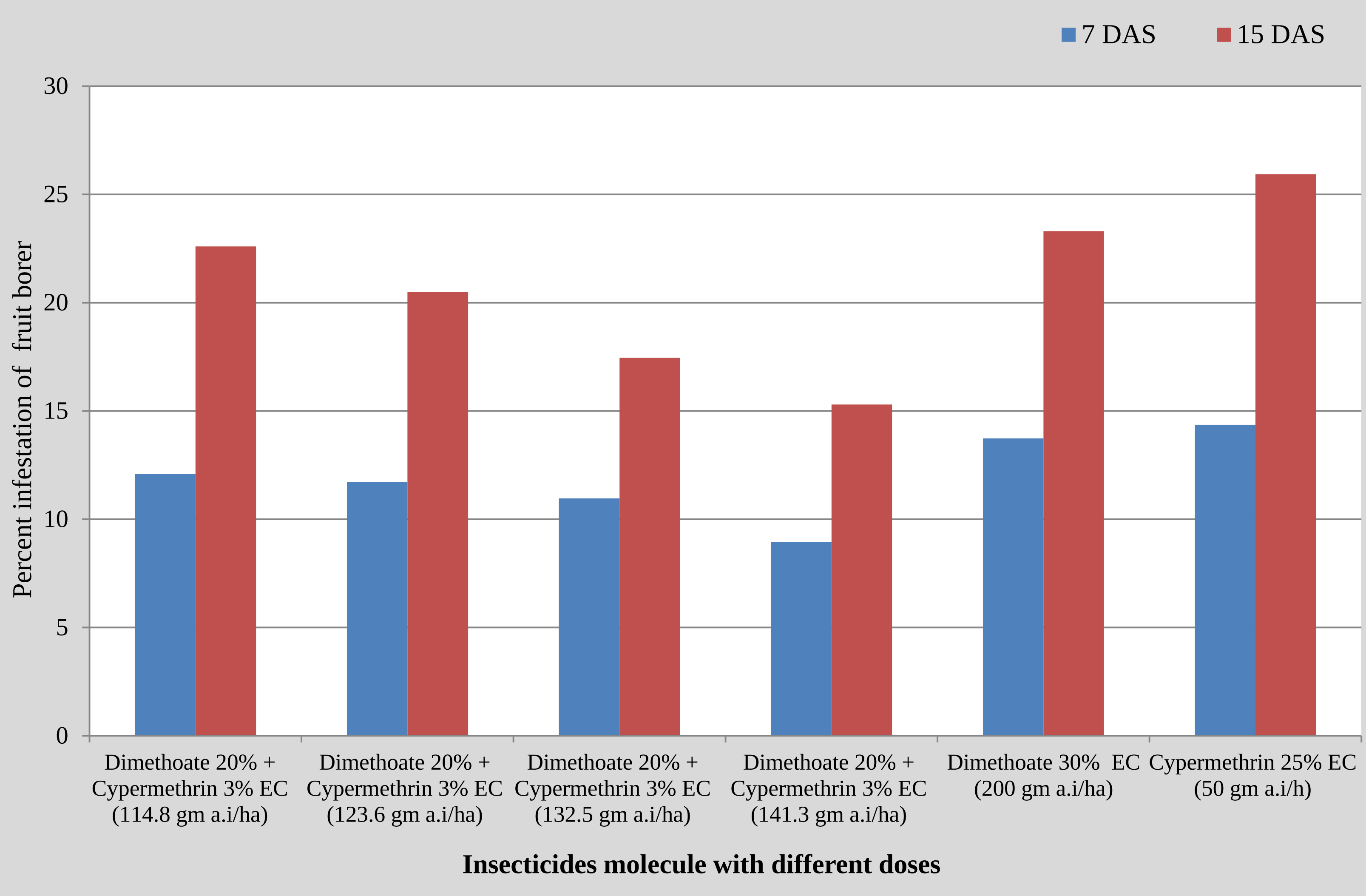

Fig. 4.17: Percent infestation of brinjal shoot and fruit borer at different days after spray (DAS) during 1st spray

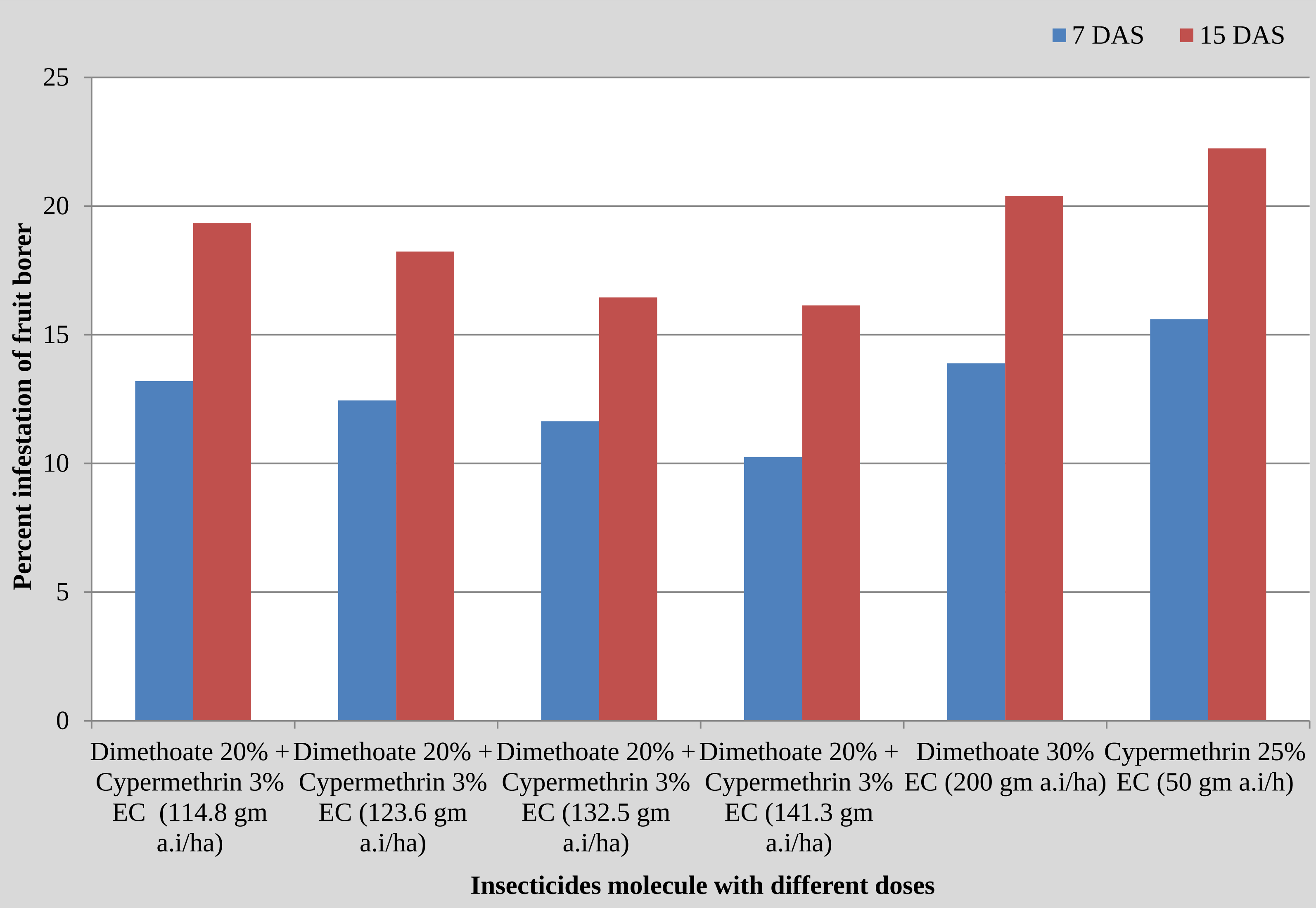

Fig. 4.18: Percent infestation of brinjal shoot and fruit borer at different days after spray (DAS) during 2nd spray

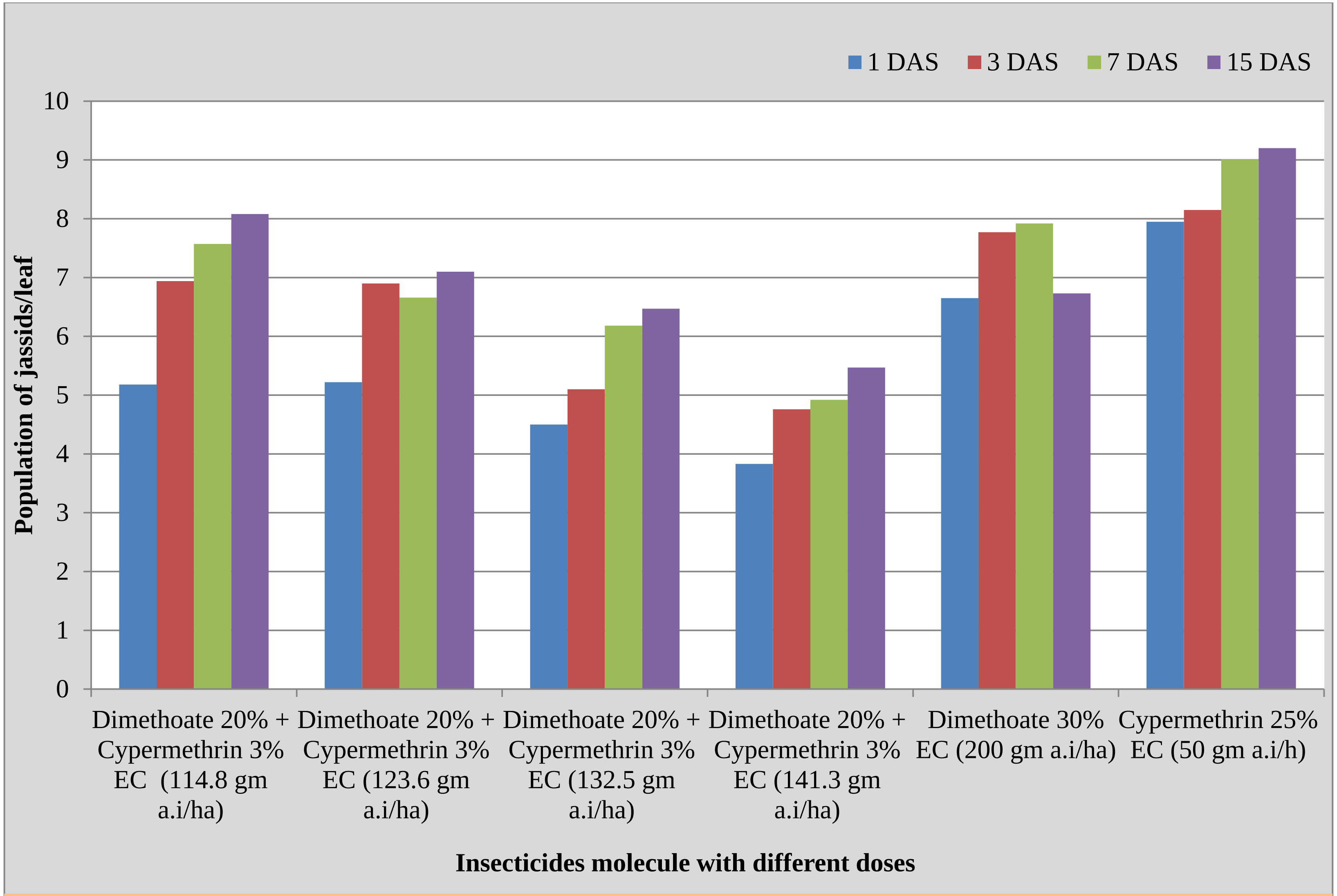

Fig. 4.19: Population of jassids/leaf at different days after spray (DAS) during 1st spray of insecticides

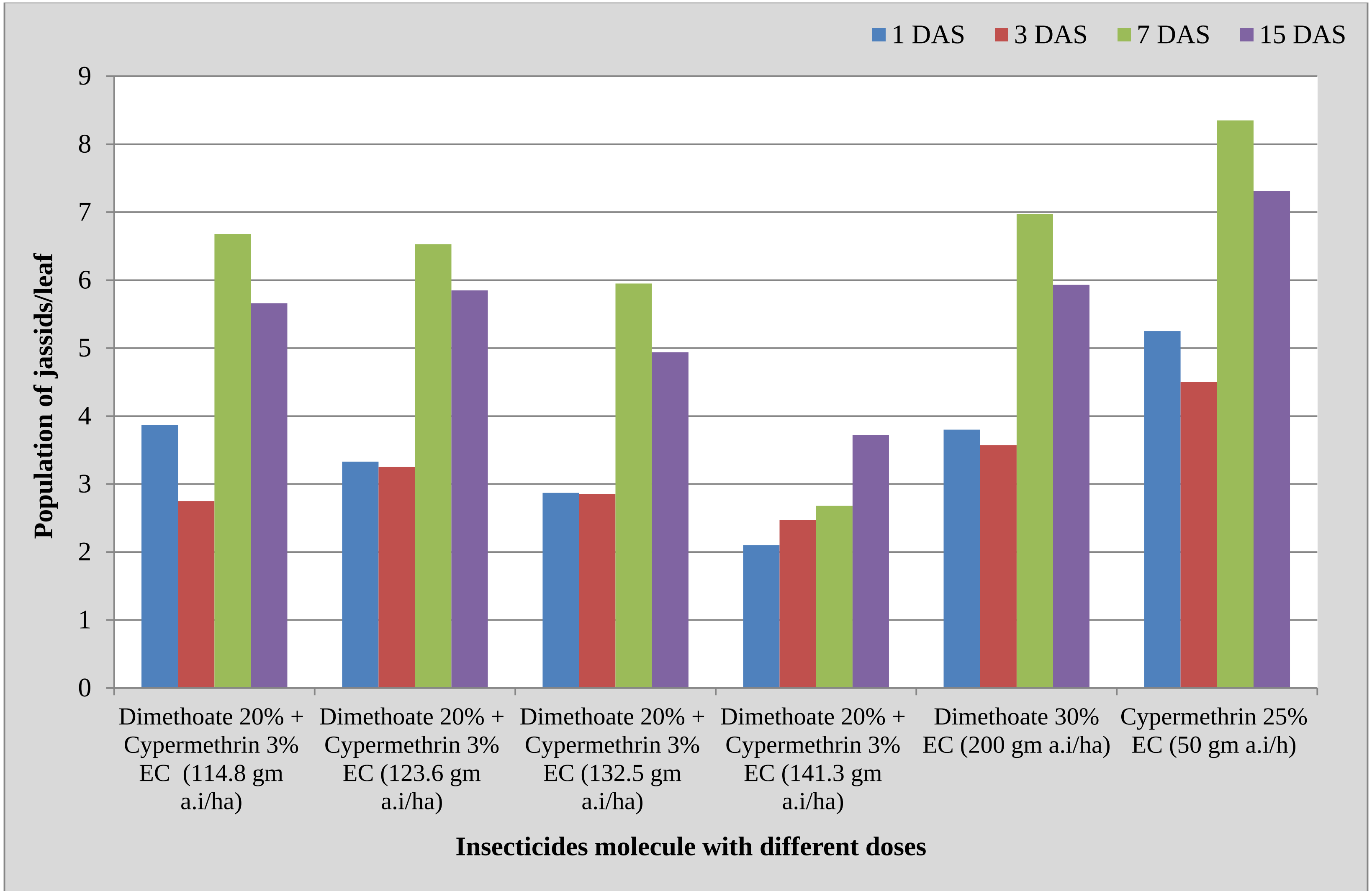

Fig. 4.20: Population of jassids/leaf at different days after spray (DAS) during 2nd spray of insecticides

4.4.3. Effect on natural enemies:

4.4.3.1 Impact of Dimethoate 20% + Cypermethrin 3% EC on the population of coccinellid predators

Both the grubs and adults of coccinellids were found to predate on the jassids, aphids, mealy bugs etc. The data on the mean population of coccinellid beetles per plant has been recorded and the impact of different doses of Dimethoate 20% + Cypermethrin 3% EC at different days after spray has been presented in table 4.14 and the same for 2nd round of application has been presented in table 4.14. It was observed that no significant impact on coccinellid population.

4.4.3.2 Impact of Dimethoate 20% + Cypermethrin 3% EC on spider population

The data on the mean population of spiders per plant has been recorded and the impact of different doses of Dimethoate 20% + Cypermethrin 3% EC at different days after spray has been presented in table 4.15 and the same for 2nd round of application has been presented in table 4.15. It was observed that no significant impact on spiders population.

4.4.4. Yield

The yield of brinjal fruits of different treatments have been presented in table-4.16 which revealed that the highest healthy fruit yield (220.00 qt/ha) were registered by Dimethoate 20% + Cypermethrin 3% EC 141.3 g a.i/ha, followed by Dimethoate 20% + Cypermethrin 3% EC @ 132.5 g a.i/ha (208.00 qt /ha), Dimethoate 20% + Cypermethrin 3% EC @ 201.00 g a.i/ha (201.00 qt /ha). The lowest yield was harvested from untreated check plots (137.67 qt /ha) (Table 4.16).

Table 4.14: Effect of different combination of insecticides on coccinellid predators during *rabi* 2018-19.

S. No.	Insecticides	a.i./ha (gm)	Pre-treatment population/ plant	Population of coccinellid predators per plant at different days after spray (DAS)								Overall mean
				I Spray				II Spray				
				1 DAS	3 DAS	7 DAS	15 DAS	1 DAS	3 DAS	7 DAS	15 DAS	
1.	Dimethoate 20% + Cypermethrin 3% EC	114.8	2.45 (1.84)	2.38 (1.72)	2.37 (1.74)	2.45 (1.84)	2.62 (1.92)	1.83 (1.42)	1.73 (1.41)	2.34 (1.64)	2.48 (1.88)	2.33
2.	Dimethoate 20% + Cypermethrin 3% EC	123.6	2.46 (1.85)	2.38 (1.72)	2.39 (1.78)	2.46 (1.84)	2.62 (1.92)	1.83 (1.42)	1.75 (1.42)	2.35 (1.64)	2.49 (1.84)	2.34
3.	Dimethoate 20% + Cypermethrin 3% EC	132.5	2.65 (1.90)	2.40 (1.73)	2.41 (1.71)	2.49 (1.88)	2.64 (1.93)	1.85 (1.52)	1.75 (1.42)	2.36 (1.69)	2.49 (1.84)	2.35
4.	Dimethoate 20% + Cypermethrin 3% EC	141.3	2.80 (1.94)	2.42 (1.74)	2.43 (1.82)	2.50 (1.87)	2.65 (1.94)	1.89 (1.62)	1.77 (1.47)	2.38 (1.70)	2.51 (1.87)	2.37
5.	Dimethoate 30% EC	200	2.76 (1.93)	2.35 (1.76)	2.37 (1.79)	2.44 (1.84)	2.60 (1.90)	1.82 (1.50)	1.72 (1.40)	2.32 (1.72)	2.53 (1.90)	2.32
6.	Cypermethrin 25% EC	50	2.65 (1.90)	2.34 (1.70)	2.36 (1.72)	2.41 (1.84)	2.59 (1.90)	1.81 (1.50)	1.70 (1.42)	2.30 (1.71)	2.4 (1.80)	2.30
7.	Control (Untreated)	-	2.60 (1.89)	2.37 (1.76)	2.44 (1.84)	2.50 (1.94)	2.66 (1.91)	1.90 (1.52)	1.79 (1.42)	2.39 (1.74)	2.46 (1.80)	2.35
	SEM		**0.009**	**0.004**	**0.014**	**0.018**	**0.013**	**0.019**	**0.015**	**0.025**	**0.017**	
	CD at 5%		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	

( ) Figures in parentheses are angular transformed, NS= Non significant

Table 4.15: Population of spiders per plant at different days after spray (DAS) during Pre and post treatment.

Insecticides	a.i./ha (gm)	Dosage per ha	Pre-treatment population /plant	Population of spiders per plant at different days after spray (DAS)								Overall mean
				I Spray				II Spray				
				1 DAS	3 DAS	7 DAS	15 DAS	1 DAS	3 DAS	7 DAS	15 DAS	
Dimethoate 20% + Cypermethrin 3% EC	114.8	650	1.90 (1.52)	1.73 (1.41)	1.81 (1.47)	1.94 (1.56)	2.15 (1.61)	1.85 (1.46)	1.80 (1.45)	1.78 (1.42)	2.15 (1.61)	1.90
Dimethoate 20% + Cypermethrin 3% EC	123.6	700	1.91 (1.54)	1.74 (1.43)	1.86 (1.48)	1.94 (1.55)	2.15 (1.61)	1.86 (1.48)	1.82 (1.46)	1.79 (1.44)	2.16 (1.63)	1.92
Dimethoate 20% + Cypermethrin 3% EC	132.5	750	1.94 (1.56)	1.76 (1.45)	1.89 (1.49)	1.96 (1.57)	2.16 (1.63)	1.86 (1.48)	1.81 (1.46)	1.81 (1.46)	2.16 (1.63)	1.93
Dimethoate 20% + Cypermethrin 3% EC	141.3	800	1.96 (1.57)	1.78 (1.46)	1.90 (1.51)	1.97 (1.58)	2.18 (1.64)	1.91 (1.53)	1.84 (1.48)	1.82 (1.47)	2.20 (1.70)	1.95
Dimethoate 30 % EC	200	660	1.90 (1.51)	1.73 (1.42)	1.80 (1.47)	1.90 (1.51)	2.16 (1.63)	1.81 (1.42)	1.79 (1.44)	1.76 (1.42)	2.13 (1.60)	1.89
Cypermethrin 25% EC	50	200	1.89 (1.49)	1.70 (1.39)	1.78 (1.46)	1.89 (1.48)	2.10 (1.60)	1.80 (1.42)	1.77 (1.42)	1.77 (1.42)	2.10 (1.59)	1.86
Control (Untreated)	-	-	1.91 (1.53)	1.80 (1.47)	1.92 (1.54)	1.97 (1.57)	2.10 (1.63)	1.85 (1.46)	1.78 (1.42)	1.84 (1.48)	2.17 (1.64)	1.93
SEM			**0.008**	**0.006**	**0.018**	**0.014**	**0.014**	**0.005**	**0.006**	**0.016**	**0.012**	
CD at 5%			**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	

( ) Figures in parentheses are angular transformed , NS= Non significant

Table 4.16: Cumulative fruit yield of brinjal (q/ha) as influenced by different treatments during the experiment

Insecticides	Dosages per ha gm. *a.i.*/ha	Healthy fruit yield (q/ha)	Damaged fruit yield (q/ha)	Increase in healthy fruit yield over control(q/ha)	Cost benefit (C/B) ratio
Dimethoate 20% + Cypermethrin 3% EC	114.8	198.00	15. 65	60.33	1 : 1.96
Dimethoate 20% + Cypermethrin 3% EC	123.6	201.00	14.60	63.33	1 : 2.24
Dimethoate 20% + Cypermethrin 3% EC	132.5	208.00	13.30	70.33	1 : 2.44
Dimethoate 20% + Cypermethrin 3% EC	141.3	220.00	11.50	82.33	1 : 2.67
Dimethoate 30% EC	200	193.34	17.10	55.67	1 : 1.70
Cypermethrin 25% EC	50	188.34	19.25	50.67	1 : 1.63
Control (Untreated)	-	137.67	36.25	-	-
SEM	**-**	**3.327**	**-**	**-**	**-**
CD at 5%	**-**	**10.126**	**-**	**-**	**-**

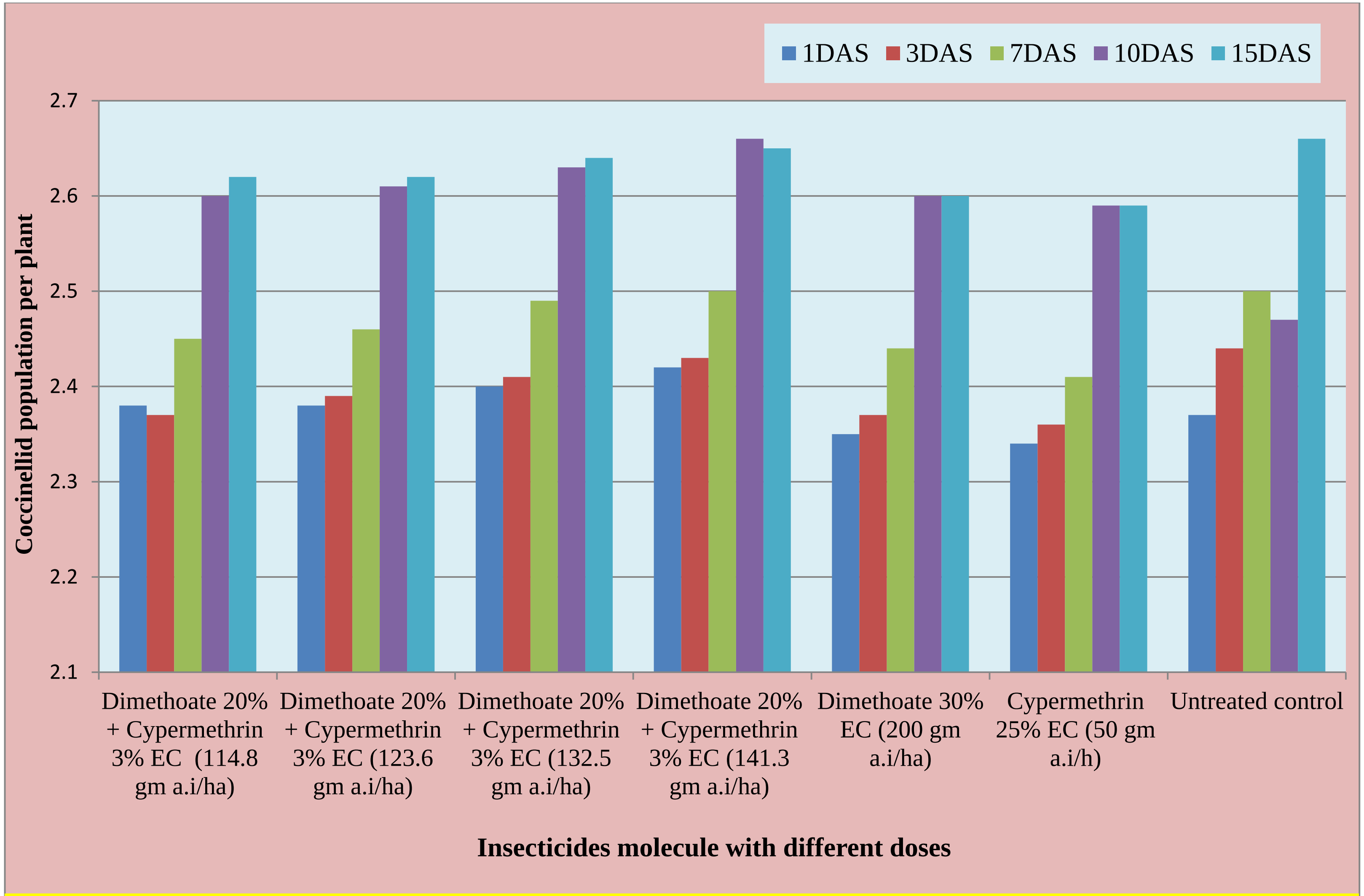

Fig. 4.21: Population of coccinellid predators per plant at different days after spray (DAS) during 1st spray of insecticides

Fig.4.22: Population of coccinellid predators per plant at different days after spray (DAS) during 2nd spray of

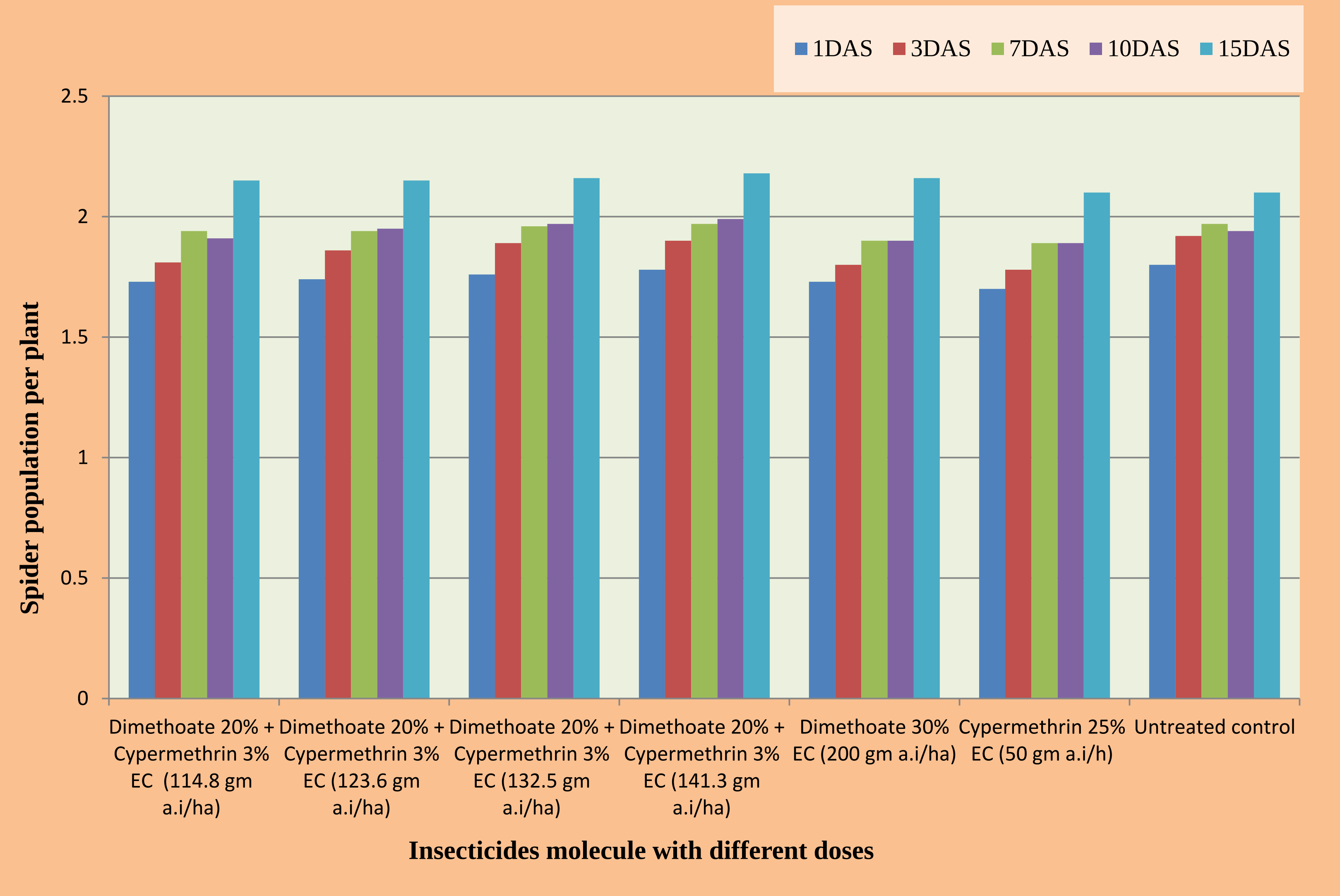

Fig.4.23: Population of spider predators per plant at different days after spray (DAS) during 1st spray of insecticides

Fig. 4.24: Population of spider predators per plant at different days after spray (DAS) during 2nd spray of insecticides

Plate. 4.14: Research field of bio-efficacy of insecticides on brinjal

CHAPTER-V

SUMMARY AND CONCLUSION

The investigation entitled **"Seasonal incidence, population dynamics, germplasm screening and bio-efficacy studies of insecticides against insect pests of brinjal''** was undertaken with following objectives:

5.1 Studies on seasonal incidence of major insect pests of brinjal and their natural enemies.

5.2 To study the correlationship between weather parameters and incidence of major insect pests on brinjal crop.

5.3 Screening of the different brinjal germplasm against shoot and fruit borer (*Leucinodes orbonalis* Guenee).

5.4 To evaluate the bio-efficacy of different combination of insecticides against major insect pests of brinjal crop.

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

5.1 Studies on seasonal incidence of major insect pests of brinjal and their natural enemies.

Studies on the seasonal incidence of insect pests of brinjal and their natural enemies revealed that jassids (*Amrasca biguttula biguttula*), whitefly (*Bemisia tabaci*), aphid (*Aphis gossypii*) as sucking pests while major pest on brinjal was recorded as shoot and fruit borer (*Leucinodes orbonalis*) and another important pest hadda beetle (*Epilacna vigintioctopunctata*) was recorded. Lady bird beetle and spider as natural enemies on sucking pests of brinjal were also recorded.

The population of jassids started from 21st November to 21st May. Its ranged from 0.2 to 19.8 jassids per plant and it was reached at peak point 19.8 jassids per plant during the period of second week of March. Activity of whitefly was recorded from 14th November to 21st May and its population ranged 0.88 to 14.82 per plant which was reached in peak point 14.82 per plant during the fourth week of February. Population of aphid ranged 0.15 to 21.92 per plant was observed during the active period from 14th November to 21st May and 21.92 per plant was recorded as peak point during the first week of February. The seasonal incidence of shoot and fruit borer was started on shoots (0.3% infested shoots/plant) in first week of January on vegetative stage and it to be continued on flowering and fruiting stage. Active period of shoot and fruit borer of brinjal was recorded from 2nd January to 21st May, ranged from 0.25 to 76.4 percentage shoot or fruit infestation and it was reached in peak at 76.4 percent fruit infestation per plant during the period of second week of April. Activity of hadda beetle was recorded from period of 16th January to 2nd April, population ranged from 0.2 to 1.2 per plant and peak activity 1.2 per plant was recorded during second week of February. Leady bird beetle population ranged from 0.2 to 4.8 per plant was recorded during the active period from 14th November to 14th May and it was reached in peak 4.8 per plant during third week of April of active period. Spider population ranged from 0.2 to 2.9 per plant was recorded during the active period from 21st November to 14th May and it was reached in peak 2.9 per plant during the first week of January of active period.

5.2 To study the correlationship between weather parameters and incidence of major insect pests on brinjal crop.

The population of jassids had positively and significant correlated with wind velocity (r = 0.411).Positive and non significant with maximum (r = 0.148) and minimum (r = 0.147) temperatures, evening relative humidity (r = 0.007) and sunshine hours (r = 0.234). The negative and non significant with rainfall (r = -0.105) and morning relative humidity (r = -0.052).

The population of whitefly had positive and non significant correlated with morning relative humidity (r = 0.235), evening relative humidity (r = 0.194), wind velocity (r = 0.068) and Sunshine hours (r = 0.096). There was negative and non significant with maximum temperature (r = -0.239), minimum temperature (r = -0.262) and rainfall (r = -0.069).

The population of aphid had negative and significant correlated with minimum temperature (r = -0.434). The positively and non significant with rainfall (r = 0.056), morning relative humidity (r = 0.330) and evening relative humidity (r = 0.201), (r = 0.007). The negative and non significant with maximum temperature (r = -0.379), wind velocity (r = -0.290) and sunshine hours (r = -0.074).

The population of hadda beetle had positive and non significance correlated with morning (r = 0.217) and evening (r = 0.178) relative humidity, wind velocity (r = 0.049) and sunshine hours (r = 0.121). There was negative and non significant with maximum (r = -0.164) and minimum (r = -0.185) temperature, rainfall (r = -0.025).

The population of shoot and fruit borer showed positive and significant correlated with maximum (r = 0.866) and minimum (r = 0.846) temperature, wind velocity (r = 0.579) and sunshine hours (r = 0.551). The population of shoot and fruit borer showed negative and significant with morning (r = -0.834) and evening (r = -0.570) relative humidity. There was negative and non significant correlation with rainfall (r = -0.037).

Jassids population had negative and significance correlated with lady bird beetle (r = -0.476) and spider (r = -0.493). The regression equation with lady bird beetle [y = -0.1175x + 2.6106; R^2 = 0.2272] and spider [y = -0.0627x + 1.6273; R^2 = 0.2437]. Whitefly population had negative and significance correlated with lady bird beetle (r = -0.564) and spider (r = -0.401). The regression equation with lady bird beetle [y = -0.1854x + 2.981; R^2 = 0.3187] and spider [y = -0.068x + 1.663; R^2 = 0.1614]. Aphid population had negative and significance correlated with lady bird beetle (r = -0.391), negative and non significant with spider (r = -0.115). The regression equation with lady bird beetle [y = -0.1151x + 2.4059; R^2 = 0.1531].

5.3 Screening of the different brinjal germplasm against shoot and fruit borer (*Leucinodes orbonalis* Guenee).

On the basis of pest susceptibility grade formula on brinjal shoot and fruit borer infestation, formulated by subbaratnam and bhutani (1981), the overall mean percentage of shoot and fruit infestation due to *L. orbonalis* was recorded on all the 124 brinjal germplasm.

The overall per cent fruits infestation in different germplasm ranged from 22.29 to 79.73 per cent and 21.84 to 79.32 per cent on number and weight basis, respectively. Similarly, shoot infestation ranged from 1.11 to 7.45 per cent due to *L. orbonalis*. Accordingly the germplasm were categorized as per their reaction pattern

Out of the 124 germplasm none of the brinjal germplasm was tolerant against shoot and fruit borer infestation in the category of 1.00 and 15.00 per cent. Two germplasm *viz.* IGB-52 and IGB-53 were moderately tolerant under the category of 16.00 and 25.00 per cent infestation. While susceptible reaction *i.e.* infestation ranged from 26.00 to 40.00 per cent was exhibited by 26 germplasm. The highly susceptible (above 40%) reaction was observed in rest of the 96 brinjal germplasm against shoot and fruit borer incidence.

The 124 brinjal germplasm lines fruit length ranged from 7.6 to 31.9 cm whereas the maximum length of fruit noticed in IGB-92 (31.9 cm) with shoot infestation (3.09 %) and fruit infestation (48.35 %). The minimum fruit length (7.6 cm) was recorded on IGB-121 possessed shoots infestation (6.74%) and fruit infestation (79.73 %). The fruit diameter ranged from 3 to 9.8 cm. The maximum fruit diameter was in IGB-118 (9.8 cm) with fruit length (20.4 cm), shoot infestation (3.32 %) and fruit infestation (51.46 %) and IGB-76 showed minimum fruit diameter (3 cm) with fruit length of (23.4 cm), shoot infestation (2.65 %) and fruit infestation (43.46 %). The maximum fruit weight (476 g) was recorded in IGB-118 and IGB-51 showed minimum fruit weight (17 g). Maximum calyx length (5.5 cm) was in IGB-12 and minimum in IGB-55 (1.3 cm). Maximum pedicle length (7.6 cm) was in IGB-65 and minimum in IGB-22 and IGB-102 showed similar (3.4 cm). IGB-114 showed the maximum pedicle thickness (3.92 cm) and two line IGB-13 and IGB-73 showed minimum (1.1 cm). Brinjal fruits of light green colour consisting 2 germplasm line noticed 46.27 % infestation. Brinjal fruits of dark purple of 12 germplasm lines (47.94 % mean fruit infestation), greenish purple of 2 line (49.93% mean fruit infestation), green colour of 54 lines (53.54 % mean fruit infestation), purple colour of 45 lines (51.39 % mean fruit infestation) and white colour of 9 lines (60.78 % mean fruit infestation) was observed.

5.4 To evaluate the bio-efficacy of different combination of insecticides against major insect pests of brinjal crop.

Efficacy of Dimethoate 20% + Cypermethrin 3% EC at four different doses *viz.*, 114.8, 123.6, 132.5 and 141.3 g a.i./ha respectively has been tested against brinjal shoot and fruit borers, jassids and epilachna beetles along with single dose of Dimethoate 30% EC market sample (200g *a.i.*/ ha) and Cypermethrin 25% EC (50 g *a.i.*/ ha) were sprayed with an untreated control check.

The results of the experiment revealed that lowest fruit infestation percentage of brinjal shoot and fruit borer, 12.66 % was recorded from the treatments of Dimethoate 20% + Cypermethrin 3% EC @ 141.3 g a.i./ha in 7 and 15 days after spraying which was found to be at par with other three doses of Dimethoate 20% + Cypermethrin 3% EC @ 114.8, 123.6 and 132.5 g a.i./ha against the brinjal shoot and fruit borer (Table-2). Comparatively high fruit infestation per cent of brinjal shoot and fruit borer was recorded from market sample of Dimethoate 30% EC and Cypermethrin 25% EC treated plots.

Dimethoate 20% + Cypermethrin 3% EC 141 g a.i/ha caused lowest population of jassids 3.74 per plant at 1,3,7 and 15 DAS was found to be at par with other three doses of Dimethoate 20% + Cypermethrin 3% EC @ 114.8, 123.6 and 132.5 g a.i./ha respectively. Comparatively high populations of jassids per plant has been recorded from market sample of Dimethoate 30% EC and Cypermethrin 25% EC treated plots after 1, 3, 7 and 15 days after spraying.

Impact of different doses of Dimethoate 20% + Cypermethrin 3% EC at different days after spray was observed that no significant impact on natural enemies, coccinellid and spider population.

Suggestions for future research work

1. Life table studies of shoot and fruit borer of brinjal should be carried out.

2. Natural enemies of different insect pests, mainly the parasitic fauna of major insect pests should be identified.

3. Looking to high cost of insecticide and hazards to environment, different suitable integrated insect pest management strategies for the region needed to be worked out.

4. Further studies on the residual periods of insecticides on the crop and development of insecticide resistance in insect pests should be carried out.

REFERENCES

Alam, S. N., Rashid, M. A., Rouf, F. M. A., Jhala, R. C., Patel J. R., Satpathy S., Shivalingaswamy T. M., Rai S.; Wahundeniya I., Cork A., Ammaranan C. and Talekar N. S. 2003. Development of an integrated pest management strategy for eggplant fruit and shoot borer in south Asia. Technical Bulletin 28, AVRDC-The World Vegetable Center, Shanhua, Taiwan.

Anil and Sharma, P. C. 2010. Bioefficacy of insecticides against *Leucinodes orbonalis* on brinjal. *Journal. of Environmental Biology* 31(4): 399-402.

Anonymous, 1999. Guide to Agriculture Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola pp-139.

Arvind, K. Ishar., Bhagat, R. M., Arora, R. K. and Monobrullan, Md. 2007. Effect of abiotic factors on *Leucinodes orbonalis* in brinjal. *Annals of Plant Protection. Science* 15(2): 469-539.

Ashraf, M., Khaliq, A. and Ahmad, K. F. 1993. Control of brinjal fruit borer, *Leucinodes orbonalis* Guen with some insecticides. *Pakistan J. Sci. and industrial Res.* 36 (6-7): 264- 266.

Biswas, K., Mallikarjunappa, S. and Bhat, U. G. 2009. Takumi an ultimate new generation product for the management of most problematic insect pest, shoot and fruit borer, *Leucinodes orbonalis* (Guen) of brinjal. *Pestology* 33(10): 23-26.

Bharadiya, A. M. and Patel, B. R. 2005. Succession of insect pests of brinjal in north Gujarat. *Pest Management and Economic Zoology* 13(1): 159-161.

Bheemanna, M., Patil, B. V., Hanchinal, S. G., Hosamani, A. C. and Kengegowda, N. 2005. Bio-efficacy of emamectin benzoate (Proclaim) 5SG against cotton bollworm complex. *Pestology* 26: 31-34.

Borah, R. K. 1995. Insect pest complex in brinjal (*Solanum melongena* L.) *Annals of Agricultural Research* 16(1): 93-94.

Daniel, A.K., Enoch, A.O., Nicholas G.B., Emmanuel, N.A. 2013. *Agriculture and Healthcare. Journal of Biology*, Vol.3 (18).

Das, A N. and Singh, B.R. 1990. Field reaction of brinjal varieties against shoot and fruit borer, (*Leucinodes orbonalis* Guen). *Environment and Ecology* 8(2): 761-762.

Deshmukh, R. M. and Bhamare, V. K. 2006. Field evaluation of some insecticides against brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen. *International Journal Agricultur Science* 2(1): 247-249.

Devi, M. N., Singh, T. K. and Devi, C. 2002. Field density of *Aphis gossypii* Glover on brinjal in relation to predatory and biotic factors. *Uttar Pradesh Journal Zool*. 22(1): 67-71.

Devi, P., Gawde, P. and Koshta, V. K. 2015. Screening of some brinjal cultivars for resistance to shoot and fruit borer (*Leucinodes orbonalis* Guenee). *The bioscan, An International Journal of Life Science* 10(1): 247-251.

Dhamdhere, S., Dhamdhere, S. N. and Mathur, R. 1995. Occurrence and succession of pests of brinjal *Solanum melongena* Linn. at Gwalior (Madhya Pradesh). *Indian Journal of Entomological Research* 19(1): 71-77.

Dunbar, D. M., Lawson, D. S., White, S. M., Ngo, N., Dugger, P. and Richter, D. 1998. Emamectin benzoate: Control of the *Heliothis* complex and impact on beneficial arthropods. *In*: *Proceedings Beltwide Cotton Conferences, Sandiego, California*, UAS. 2: 1116-1118.

Frary A., Doganlar S., Daunay M. C. 2007. Eggplant, in Vegetables SE - 9, Genome Mapping and Molecular Breeding in Plants, ed Kole C., editor. (Berlin: Springer;), 287–313. 10.1007/978-3-540-34536-7_9 [CrossRef]

Ghosh, S.K. and Senapati, S.K. 2001. Biology and seasonal fluctuation of *Henosepilachna vigintioctopunctata*. Fab. on brinjal under terai region of West Bengal. Ind. J. Agric. Res. 35 (3): 149-154

Ghosh, S. K. and Senapati, S. K. 2003. Biology and seasonal abundance of jassid infesting brinjal in Terai Region of West Bengal. *Environment and Ecology* 21(3): 716-719.

Ghosh, S. K., Laskar, N. and Senapati, S. K. 2004. Seasonal fluctuation of *Aphis gossypii* Glov. on brinjal and field evaluation of some pesticides against *A. gossypii* under terai region of West Bengal. *Indian Journal of Agricultural Research* 38(3): 171-177.

Gomez, K. A. and Gomez A. A. 1984. Statistical Procedure for Agricultural Research, *John Wiley and sons publication* 2nd edition.

Grewal, R. S. and Singh, D. B. 1995. Fruit character of brinjal in relation to infestation by *Leucinodes orbonalis* Guen. *Indian Journal of Entomology* 57: 336-343.

Gumbek, M. 1986. Control of fruit and shoot borer in brinjal. *Annual report of the research branch, Department of Agriculture, Kuching, Sarawak* pp. 134-135.

Harish, D. K., Agasimani, A. K., Imamsaheb, S. J.and Patil, Satish S. 2011. Growth and yield parameters in brinjal as influenced by organic nutrient management and plant protection conditions. *Research Journals of Agricultural Sciences* 2(2): 221-225.

Haseeb, M., Qamar, M. and Sharma, D.K. 2009. Seasonal incidence of brinjal hadda beetle, *Henosepilachna vigintioctopunctata* (F.) (Coleoptera: Coccinellidae) in Aligarh, Uttar Pradesh. M.Sc. thesis Department of Plant Protection, Faculty of Agricultural Sciences, Aligarh Muslim University, Aligarh.

Hirekurubar, R.B. and Ambekar, J. S. 2008. Bio-efficacy of newer insecticides against shoot and fruit borer of okra and their impact on natural enemies. *Crop Research* (Hisar) 36(1/3): 302-307.

Ishaaya, I. and Ohsawa, K. 2002. Emamectin a novel insecticide for controlling field crop pests. *Pest Management Science* 58(11): 1091-1095.

Jain, S. K. 2008. Insect pest succession on hybrid brinjal with particular reference to shoot and fruit borer (*Leucinodes orbonalis* Guen.) infestation status and its management through plant products. M.Sc. thesis IGKV, Raipur. pp. 28.

Khaire, V.A. and Lawande, K.E. 1986. Screening of promising germplasm of brinjal against shoot and fruit borer (*Leucinodes orbonalis* Guen), aphid (*Myzus persicae* S.) and jassid (*Amrasca biguttula*) current Research Reporter, Mahatma phule Agricultural University 2(1): 112-115.

Khan, R. and Singh, Y.V. 2014. Screening For Shoot And Fruit Borer (*Leucinodes Orbonalis* Guenee.) Resistance In Brinjal (*SolanumMelongena* L.) Genotypes. *An International Quarterly Journal of Environmental Sciences,* Vol.6: 41-45.

Kumar, B. V., Boomathi, N., Kumaran, N. and Kuttalam, S. 2010. Combination of flubendiamide+thiacloprid 480 SC (RM) against bollworms and sucking pests of cotton. *Madras Agricultural Journal* 97(4/6): 157-160.

Kumar, P. and Devappa, V. 2006. Bioefficacy of emamectin benzoate 5% SG (Proclaim) against brinjal shoot and fruit borer. *Pestology* 30: 17-19.

Latif, M. A., Rahman, M. M. and Alam, M. Z. 2010. Efficacy of nine insecticides against shoot and fruit borer, *Leucinodes orbonalis* Guenee (Lepidoptera – Pyralidae) in eggplant. *Journal Pest Science* 83: 391-397.

Mahesh, P. and Men, U. B. 2007. Seasonal incidence of *Leucinodes orbonalis* on brinjal. *Annals of Plant Protection Science* 15(2): 469-539.

Mahmood, T., Hussain, S., Khokhar, K. M., Jeelani, G. and Ahmad, M. 2002. Population dynamics of leafhopper, *A. bigguttula biguttula* on brinjal and effects of abiotic factors on its dynamics. *Asian Journal of Plant Science* 1(4): 403-404.

Mandal, S.M.A., Dash, D. and Mishra, P.R. 2005. Performance of brinjal cultivars against fruit and shoot borer, *Leucinodes orbonalis* Guen. J. Appl. Zool. Res., 16(2):195-197.

Mannan, M. A., Begam, A., Rahman, M. M. and Hossain M. M. 2003. Screening of local and exotic varieties/cultivars for resistance to shoot and fruit borer *Leucinodes orbonalis* Guen. *Pakistan Journal of Biological Sciences* 6(5): 488-492.

Mathur, A., Singh, N.P., Mahesh, M. and Singh, S. 2012. Seasonal incidence and effect of abiotic factors on population dynamics of major insect pests on brinjal crop. *Journal of Environmental Research and Development* 7(1): 431-435.

Mehta, D.N., Singh, K.M. and Singh, R.N. 1979. Note on extent of damage by *Leucinodes omonalis* Guenee. *Bulletin of Entomology* 20: 115-116.

Mehta, P. K., Vaidya, D. N. and Kashyap, N. P. 1998. Bioefficacy of some insecticides against brinjal shoot and fruit borer, *Leucinodes orbonalis* (Guen.). *Journal Insect Science* 11(1): 80-81

Misra, H. P. 2008. New promising insecticides for the management of brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee. *Pest Management in Horticultural Ecosystems* 14(2): 140-147.

Misra, H. P. 2011. Bio-eficacy of chlorantraniliprole against shoot and fruit borer of brinjal, *Leucinodes orbonalis* Guenee. *Journal Insect Science* 24(1): 60-64.

Mohan, N. J. and Prasad, V.G. 1986. Role of synthetic pyrethroids in the control of brinjal pest, *Indian Journal of Entomology* 46: 179-182.

Mote, U.N. and Bhavikatti, S. 2001. Comparative efficacy of chemical pesticides with biopesticides against major pests of brinjal in *kharif* season, Proceeding of Second National Symposium on Integrated Pest Management (IPM) in Horticulture Crops: *New Molecules, Biopesticides and Environment,* Bangalore, 17-19 October, 2001, pp. 56.

Mote, U. N. 1976. Seasonal incidence and chemical control of brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee. *Vegetable Science* 3: 128-130.

Muthukumar, M. and Kalyanasundaram. 2003. Influence of biotic factors ont he incidence of major insect pests in brinjal (*Solanum melongena* L.). *South Indian Horticulture* 51(1/6): 214-218.

Naik, V. C. B., Rao, P. A., Krishnayya, P. V. and Rao, V. S. 2008. Seasonal incidence and management of *Leucinodes orbonalis* Guenee on brinjal. *Annals of Plant Protection Science* 16(2): 329-332.

Netam, M., Lakra, R., Koshta, V. K., Sharma, D. and Deole, S. 2018. Screening of Shoot and Fruit Borer (*Leucinodes orbonalis* Guenee.), for Resistance in Brinjal (*Solanum melongena* L.) Germplasm Lines. *Int. J. Curr. Microbiol. App. Sci* 5(8): 3700-3706

Nonita, M., Hemchandra, O., Bijaya, P. and Singh, T. K. 2006. Seasonal incidence and spatial distribution of the cotton aphid and its coccinellid predators on brinjal. *Uttar Pradesh J. Zool*. 26(3): 265-270.

Pal, A. 1999. Screening of brinjal cultivars cultivars against major insect pests and their insecticide management. M.Sc. thesis IGKV, Raipur. pp : 69-70.

Panda, H.K. 1999. Screening of brinjal cultivars for resistance to *Leucinodes orbonalis* Guen. Ins. Environ., 4(4): 145-146.

Pareet, J. D. and Basvanagoud, K. 2009. Evaluation of bio-pesticides against brinjal shoot and fruit borer and sucking pests. *Annals of Plant Protection Science* 17(2): 463-464.

Patnaik, H.P. 2000. Flower and fruit infestation by brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen. Damage potential vs weather. *Vegetable Science* 27(1): 82 – 83.

Patra, S., Chatterrjee, M. L., Mondal, S. and Samanta, A. 2009. Field evaluation of some new insecticides against brinjal shoot and fruit borer, *Leucinodes orbonalis* (Guen.). *Pest. Res. J*. 21(1): 56-60.

Pradhan, S. (1969). Insect pest of crops. National Book Trust of India. pp: 208.

Prasad, G .S. and Logiswaran, G. 1997. Seasonal pattern of leafhopper and cotton aphid, occurrence on brinjal in terms of day of degree. *Journal of Andaman Science Association* 13(1-2): 99-101.

Prempong, E. and Buahim. 1977. Studies on the insect pest of egg plant, *Solanum melongena* Linn. in Ghana. *Bulletin de institute fundamental de Afrigue Neire seria* A. 39(3): 627-641.

Radhika, S., Dharma Reddy, K. and Subbaratathnam, G. V. 1997. Management of brinjal shoot and fruit borer *Leucinodes orbonalis* Guenee with insecticides. *Journal of Research ANGRAU* 25: 10-14.

Rahman, M.A., Prodhan, M.D.H. and Maula, A.K.M. 2008. Effect of botanical and synthetic pesticides in controlling epilachna beetle and the yield of bitter gourds. Int. J. of Sustainable Crop Products, 3(5): 23-26.

Ratanpara, H .C., Shekh, A. M., Patel, J. R. and Patel, N. M. 1994. Effect of weather parameters on brinjal jassids, *Amrasca biguttula biguttula* Ishida. *Gujarat Agril. Uni. Research Journal* 19(2): 39-43.

Roy, D. C. and Pande, Y. D. 1994. Damage to brinjal by brinjal shoot and fruit borer (Lepidoptera: pyralidae) and economics of its insecticidal control. *Indian Journal of Agricultural Research* 28(2): 110-120.

Sahu, B. B., Senapati, B. and Mohapatra, L. N. 2004. Bioefficacy of certain insecticides against brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen. *Orissa Journal Hort*. 32(2): 81-86.

Sardana, H. R. 2006. Conservation of natural enemies through IPM in brinjal (*Solanum melongena* L.) fields. *Indian Journal of Entomology* 31(2): 83-88.

Shaik, S. 2012. Studies on seasonal incidence of major insect pests and efficacy of new insecticide molecules against shoot and fruit borer (*Leucinodes orbonalis* Guenee) on brinjal (*Solanum melongena* L.). M.Sc. thesis IGKV, Raipur. pp : 78.

Sharma, S. S and Kaushik, H. D. 2010. Effect of spinosad (a bioinsecticide) and other insecticides against pest complex and natural enemies on eggplant (*Solanum melongena* L.). *Journal of Entomological Research* 34(1): 39-44.

Shinde, B. D., Sarkate, M. B., More, S. A. and Sable, Y. R. 2007. Evalution of different pesticides for safetyness to predators on okra. *Pestology* 31(5): 25-28.

Shukla, A. and Khatri, S. N. 2010. Incidence and abundance of brinjal shoot and fruit borer *Leucinodes orbonalis* Guenee. *The Bioscan* 5(2): 305-308.

Shukla, R. P. 1989. Population fluctuation of *L.orbonalis* and *A. biguttula biguttula* on brinjal (*Solanum melongena*) in relation to abiotic factors in Megalaya. *Indian Journal of Agriculture Science* 59(4): 260-264.

Singhal, V. 2003. *Indian Agriculture*. Indian Economic Data Research Centre, New Delhi.

Singh, D. K., Singh, R., Datta, S. D. and Singh, S. K. 2009. Seasonal incidence and insecticidal management of shoot and fruit borer (*Leucinodes orbonalis* Guenee) in brinjal. *Annals of Horticulture*. 2(2): 187-190

Singh, J. P. and Vishwanath. 2007. Field evaluation of insecticides and neem formulations for management of shoot and fruit borer, *Leucinodes orbonalis* Guenee in brinjal. *Indian Journal of Entomology* 69(4): 341-344.

Singh, R. K. R., Singh, T. K. and Shah, M. A. S. 2011. Population incidence of brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen. in Manipur. *Journal of Experimental Zoology, India* 14(1): 229-232.

Singh, S., Kumar, A. and Awasthi, B. K. 2005. Study of sucking and leaf feeding insect in relation to weather parameters on the brinjal crop. *Vegetable Science* 32(2): 210-212.

Singh, T. H. and Kalda, T. S. 1997. Source of resistance to shoot and fruit borer in eggplant eggplant (*Solanum melongena* L.). PKV *Res. J.* 21(2): 126-128.

Sinha, S. R., and Vishwanath. 2011. Management of insect pests through insecticides and mixture in brinjal. *Annals of Plant Protection Science* 19(2): 318-320.

Sridhar, V., Vijay, O.P. and Naik, G. 2001. Field evaluation of brinjal (*Solanum* spp.) germplasm against shoot and fruit borer, *Leucinodes orbonalis* Guen. *Ins. Environ.,* 6(4): 155-156.

Subbaratnam, G.V. and Butani, D.K. 1981. Screening of eggplant varieties for resistant to insect pest complex. Vegetable Science, 8:149-153.

Subbaratnam, G. V. 1982. Studies on the internal characters of shoot and fruit of brinjal governing resistance to shoot and fruit borer, *Leucinodes orbonalis* Guen. *South India Horticulture*. 30: 217-220

Suresh, M., Bijaya, P., Prasad, B. and Singh, T. K. 1996. Seasonal incidence of insect pests of brinjal and a note on the biology of *L. orbonalis* in Manipur. U.P. *J. Zool*. 16(3): 151-155.

Suroshe, S. S., Reddy, K. D. and Reddy, K. N. 2004. Bio-efficacy of certain insecticides against major insect pests of brinjal. *Journal of Research ANGRAU*. 32(4): 18-24.

Tatwadi, S. 1999. Bioefficacy of lindane formulation and screening of brinjal cultivars for resistance against shoot and fruit borer (*L. orbonalis* Guen) and other pests. M.Sc. thesis IGAU, Raipur.

Thanki, K.V. and Patel, J. R. 1988. Seasonal incidence of shoot and fruit borer *(Leucinodes orbonalis* Guenee) on eggplant *(Solanum melongena)* in Gujarat.*Indian Journal of Agricultural Sciences* 58: 867-868.

Tripathy, M. K., and Senapathi, B. 1998. Seasonal incidence *Leucinodes orbonalis* in relation to weather parameters and crop growth stage of brinjal at Bhubaneswar, Orissa. *Orissa J. Hort*. 26(2): 37-41.

Udikeri, S. S., Patil, S. B., Rachappa, V. and Khadi, B. M. 2004. Emamectin benzoate 5 SG A safe and promising biorational against cotton bollworms. *Pestology* 28(6): 78-81.

Varma, S., Anandhi, P. and Singh, R. K. 2009. Seasonal incidence and management of brinjal shoot and fruit borer, *Leucinodes orbonalis*. *Journals of Entomological Research* 33(4): 323-329.

Varma, S., Anandhi, P., Srivastava, D. S. and Singh, Y. 2011. Population dynamics and evaluation of certain bio-products against brinjal leafhopper, *Amrasca biguttula biguttula* in Allahabad condition. *Journals of Entomological Research* 35(3): 215-220.

Veeraval, R. and Baskaran, P. 1995. Succession of insect pests of brinjal (*Solanum melongena*) under unsprayed conditions. *Bull. Ent*. 36(1-2): 49-56.

Vishwanath and sinha, S. R. (2011). Efficacy of insecticides and their mixture for management of insect pest of brinjal. *Indian Journal of Entomology* 73(4): 308-311.

Vishwanathrao, J. M. 2002. Relative susceptibility of different cultivars and insecticidal management against sucking insect pest complex of brinjal. M.Sc. Thesis, IGKV. Raipur. pp. 107.

Walunj, A.R., Pawar, S. A. and Darekar, K. S. 1998. Bioefficacy of new combinations insecticides against shoot and fruit borer of brinjal. *Pestology* 22: 5-6.

Wankhede, S. M., Kale, V. D. and Gangurde, S. M. 2009. Evalution of bio-efficacy and persistence toxicity of some novel insecticides against larvae of the brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee. *Pest Management and Economic Zoology* 17(1): 77-83.

Yadav, D. K., Singh, N. N., Mishra, V. K. and Singh, S. K. 2015. Bioefficacy of certain newer insecticides against brinjal shoot and fruit borer, (*Leucinodes orbonalis* Guen.). *J. ent. Res.*, 39 (1) : 25-30 (2015).

RESUME

Name	:	Harshal Kumar Chandrakar
Date of birth	:	19/09/1995
Present Address	:	Room No.03, Maharshi Arvind Boys Hostel, College of Agriculture, Raipur (C.G.)
Phones	:	8889096240, 7000231288
E. mail	:	harshalchandrakar1995@gmail.com
Permanent address	:	Ward no. 17, jagnathi chowk, Purani basti, Kurmi para, Mahasamund, District-Mahasamund (Chhattisgarh)

Academic Qualification:

Degree	Year	Board/University
Higher Secondary	2013	C.G.B.S.E., Raipur (C.G.)
B.Sc. (Ag.)	2017	I.G.K.V. Raipur (C.G.)
M.Sc. (Ag.)	2019 (cont.)	I.G.K.V. Raipur (C.G.)

Professional Experience (If any)	:	Rural Agricultural Work Experience Programme (RAWEP)
Membership of professional Societies (If any)	:	Nil
Awards/ Recognitions (If any)	:	Nil
Publications (If any) : In number only	:	Nil

Harshal

Signature

Gmail

harshal chandrakar <harshalchandrakar1995@gmail.com>

Manuscript Accepted: (Ref: Chemi-7-6-198).

Chemistry Journal <chemi.journal@gmail.com> Mon, Nov 18, 2019 at 12:35 AM
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