

**INSECT PEST SCENARIO AND SUCCESSION ON
SESAME, *SESAMUM INDICUM* L. CROP WITH
THEIR RELATIVE PREFERENCE ON DIFFERENT
GENOTYPES.**

M.sc.(Ag) Thesis

by

Santoshi Choudhary

**DEPARTMENT OF ENTOMOLOGY
COLLEGE OF AGRICULTURE
FACULTY OF AGRICULTURE
INDIRA GANDHI KRISHI VISHWAVIDYALAYA
RAIPUR (CHHATTISGARH)
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THEIR RELATIVE PREFERENCE ON DIFFERENT
GENOTYPES.**

Thesis

Submitted to the

Indira Gandhi Krishi Vishwavidyalaya, Raipur

by

Santoshi Choudhary

**IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE DEGREE OF**

Master of Science

in

Entomology

Roll No. 120117141

ID.No. 20131417001

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CERTIFICATE – I

This is to certify that the thesis entitled “Insect pest scenario and succession on sesame, *Sesamum indicum* L. crop with their relative preference on different genotypes” submitted in partial fulfilment of the requirements for the degree of **Master of science in Agriculture** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, is a record of the bonafide research work carried out by **Santoshi Choudhary** under my/our guidance and supervision. The subject of the thesis has been approved by the Student’s Advisory Committee and the Director of Instructions.

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

Date: 03/02/2020


Chairman

THESIS APPROVED BY THE STUDENT’S ADVISORY COMMITTEE

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Member (Dr. (Smt.) Gayatri Chandrakar)










CERTIFICATE – II

This is to certify that the thesis entitled entitled “**Insect pest scenario and succession on sesame, *Sesamum indicum* L. crop with their relative preference on different genotypes**” submitted by **Santoshi Choudhary** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur, 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 evaluator* and Student’s Advisory Committee after oral examination, *under the chairmanship of Head of the Department.*


Major Advisor

Date: 06/03/2020


Signature of Head of the Department

(Name. DY. D. K. Rana.)

Faculty Dean -----

Approved/Not approved

Director of Instructions-----

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Department of Entomology

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Santoshi Choudhary

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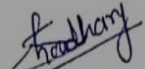
%	Per cent
>	More than
<	Less than
@	At the rate
°C	Degree Celsius
/	Per

LIST OF ABBREVIATIONS

CD	Critical Difference
CV	Co-Variance
Cm	Centimetre
<i>et al.</i>	co workers
Mm	Millimetre
i.e.	that is
NS	Non-Significant
S	Significant
S.No.	Serial Number
SEm	Standard Error of mean
SMW	Standard Meteorological Week
viz.	Namely
B:C ratio	Benefit cost ratio
Etc.	Etcetera
Fig.	Figure
Gm	Gram
Ha	Hectare
Kg	Kilogram
Cm ²	Square Centimetre

THESIS ABSTRACT

- a) Title of the Thesis : "Insect pest scenario and succession on sesame, *Sesamum indicum* L. crop with their relative preference on different genotypes."
- b) Full name of the Student : Santoshi Choudhary
- c) Major Subject : Entomology
- d) Name and Address : Dr.(Smt.)Sonali Deole, Associate professor, of the Major Department of Entomology, College of Agriculture, IGKV, Raipur (C.G.)
Advisor
- e) Degree to be Awarded : M.Sc.(Ag.)


Signature of the Student


Signature of Major Advisor

Date: 03/02/2020


Signature of Head of Department

ABSTRACT

The present investigation entitled "Insect pest scenario and succession on sesame, *Sesamum indicum* L. crop with their relative preference on different genotypes." was conducted in the Research Cum Instructional Farm at College of Agriculture, IGKV, Raipur (C.G.) during *kharif* 2018.

The insect pests like leaf hopper (*Orosius albicinctus*), green bug (*Nezara viridula*) and mirid bug (*Nesidiocoris tenuis*), defoliators leaf webber and capsule borer (*Antigastra catalaunalis*), til hawk moth (*Acherontia styx*) were reported as major insect pests on sesame crop. The highest number of hoppers

(3.25 hoppers / plant), mirid bug (4.86 bug / plant) and green bug (3.8 bug / plant) were seen during 41st SMW, 36th SMW and 39th SMW, respectively.

In the population dynamics studies the infestation of leaf webber or capsule borer, *Antigastra catalaunalis* started during 33rd standard meteorological week (SMW) *i.e.* 13th -19th August (2nd week) with mean population of 0.24 larva/plant. The population reached to its peak in the 38th SMW with a mean population of 1.68 larva/plant. After that, the population declined gradually and reached to a minimum level of 1 larva per plant observed during 42nd SMW *i.e.* 15th -21st October.

The correlation between leaf webber or capsule borer, *Antigastra catalaunalis* and weather parameters during *kharif* 2018 results indicated that the population demonstrated a significant positive correlation with maximum temperature ($r = 0.727$), significant positive correlation with sunshine hours ($r = 0.708$), while leaf webber population also showed significant negative correlation with rainfall (mm) ($r = -0.632$).

The til hawk moth appeared during 36th standard meteorological week (SMW) *i.e.* 3rd - 9th September (1st week) with a mean population of 0.08 til hawk moth / plant. The population build up gradually and reached to its peak in the 2nd week of October (41st SMW) with a mean population of 0.48 til hawk moth / plant. Then, the population declined and reached to its minimum levels of 0.36 til hawk moth / plant during 42nd SMW *i.e.* 15th -21st October.

The results indicated that the til hawk moth population showed significant positive correlation with maximum temperature ($r = 0.692$). The til hawk moth population also showed significant positive correlation with sunshine hours ($r = 0.757$), while til hawk moth population showed significant negative correlation with RH (%) Mor. ($r = -0.727$) and RH (%) Eve. ($r = -0.674$).

During the study period natural enemies viz. spiders (*Neoscona* sp.), lady bird beetle (*Micraspis* sp., *Cheilomenes sexmaculata* and *Coccinella transversalis*), and cantheconid bug were also observed in plants.

Out of twenty three genotypes of til it was seen that, based on overall mean leaf, flower and pod per cent infestation of leaf webber and capsule borer, none of the genotypes was found highly resistant, resistant and moderately resistant , one genotype was highly susceptible and twenty two were under susceptible categories against leaf webber and capsule borer on sesame.


With trichome density leaf webber and capsule borer, *Antigastra catalaunalis* showed negatively significant correlation ($r = -0.514$) and ($r = -0.741$) at 30DAS and 60DAS, respectively.

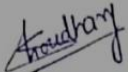
The biology study of leaf webber and capsule borer, *Antigastra catalaunalis* was recorded on sesame in the laboratory and it was seen that the incubation period of the eggs ranged between 2 to 3 days with an average of 2.34 days. The total larval period completed in 9-12 days with an average of 10.51 days. The pupation occurred inside the webbed leaves and the total pupal duration ranged between 5-7 days with an average of 6.33 days. The total life cycle (egg to adult emergence) varied from 21 to 29 days with an average of 25.40 days.

The biology study of til hawk moth, *Acherontia styx* were recorded on sesame and it was seen that the Egg period lasts for 3- 5 days with an average of 4.66 days. The total larval period completed in 17-22 days with an average of 19.50 days. The total pupal duration ranged between 17-26 days with an average of 21.66 days. The adult female period was 2-3 days and male period was 3-5 days, respectively with an average of 2.50 days and 4.50 days.

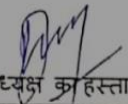
शोध सारांश

- अ) शोध का शीर्षक : "तिल (सीसेमम इंडिकम) पर कीट व्याधि परिदृश्य और अनुक्रमण तथा उनके विभिन्न जीनोटाइप के सापेक्ष वरीयता का अध्ययन"
- ब) छात्रा का पूरा नाम : संतोषी चौधरी
- स) मुख्य विषय : कीट विज्ञान
- द) मुख्य सलाहकार का नाम व पता : डॉ. सोनाली देवले, सह प्राध्यापक कीट विज्ञान विभाग,
कृषि महाविद्यालय रायपुर इंदिरा गाँधी कृषि विश्वविद्यालय रायपुर (छत्तीसगढ़) 492012
- इ) सम्मानित किये जाने वाली उपाधि : एम.एस.सी.(कृषि) कीट विज्ञान


प्रमुख सलाहकार का हस्ताक्षर


छात्रा का हस्ताक्षर

दिनांक 03/07/2020


विभागाध्यक्ष का हस्ताक्षर

सारांश

वर्तमान प्रयोग "तिल (सीसेमम इंडिकम) पर कीट व्याधि परिदृश्य और अनुक्रमण तथा उनके विभिन्न जीनोटाइप के सापेक्ष वरीयता का अध्ययन" का खरीफ 2018 के दौरान कालेज ऑफ एग्रीकल्चर इंदिरा गाँधी कृषि विश्वविद्यालय, रायपुर (छ.ग.) में रिसर्च कम इंस्ट्रक्शनल फार्म में किया गया था।

तिल में चूसने वाले जैसे फुदका (*ओरोसियस अलबिसिंकटस*), मिरिड बग (*नेसिडिओसोरिस तेनुइस*) तथा हरा बग (*नजारा विरिदुला*) और पत्ती खाने वाले कीटों में जैसे-पत्ती लपेटक तथा फली भेदक (*एंटीगोस्ट्रा केतेलउनालिस*), तिल हॉक मॉथ (*अचेरॉटिआ स्टिक्स*) आदि प्रमुख रूप से देखा गया।

फुदका 3.25/पौधा, मिरिड बग 4.86/पौधा तथा हरा बग का 3.8/पौधा प्रकोप क्रमशः उच्चतम 41st SMW, 36th SMW, तथा 39th SMW में देखा गया।

पत्ती लपेटक तथा फली भेदक का प्राथमिक प्रकोप 33rd SMW (0.24 लार्वा/पौधा /) के दौरान शुरू हुआ तथा धीरे-धीरे यह 38th SMW (1.68 लार्वा/पौधा /) के दौरान उच्चतम स्तर तक पहुँच गया तथा बाद में इसकी संख्या 42nd SMW (1 लार्वा/पौधा) के दौरान कम हो गयी।

अध्ययन के दौरान पत्ती लपेटक तथा फली भेदक और मौसम के मापदंडों के बीच सम्बन्ध ने संकेत दिया कि कीटसंख्या अधिकतम तापमान ($r=0.727$) तथा धूप के घंटे ($r=0.708$) थे तथा महत्वपूर्ण तथा सकारात्मक सम्बन्ध दिखाया जबकि वर्षा के साथ (0.632) महत्वपूर्ण तथा नकारात्मक सम्बन्ध दिखाया।

तिल हॉक मॉथ का प्राथमिक प्रकोप 36th SMW (0.08 लार्वा/पौधा) के दौरान शुरू हुआ तथा धीरे-धीरे यह 41st SMW (0.48 लार्वा/पौधा) के दौरान उच्चतम स्तर तक पहुँच गया तथा बाद में इसकी संख्या 42nd SMW (0.36 लार्वा/पौधा) के दौरान कम हो गई।

अध्ययन के दौरान तिल हॉक मॉथ और मौसम के मापदण्डों के बीच सम्बन्ध ने संकेत दिया कि कीटसंख्या धूप के घंटे ($r=0.757$) के साथ महत्वपूर्ण तथा सकारात्मक सम्बन्ध दिखाया जबकि सुबह और शाम की सापेक्ष आद्रता के साथ क्रमशः ($r= -0.727$) तथा ($r= -0.674$) महत्वपूर्ण तथा नकारात्मक सम्बन्ध दिखाया।

अध्ययन की अवधि के दौरान विभिन्न कीटों के प्राकृतिक दुश्मन जैसे- मकड़ी कीट, लेडी बर्ड बीटल तथा केंथोकोनिड बग देखे गये।

तिल के 23 जननद्रव्यों (जीनोटाइप) की कीट संवेदनशीलता के अध्ययन किस्मों में से यह देखा गया कि पत्ती, फूल और फली क्षति के आधार पर कोई भी किस्म अत्यधिक प्रतिरोधी नहीं पाई गई जबकि एक किस्म संवेदनशील तथा 22 किस्म अत्यधिक संवेदनशील पाई गई ।

ट्राईकोम घनत्व के साथ पत्ती लपेटक तथा फली भेदक कीट महत्वपूर्ण तथा नकारात्मक सहसम्बन्ध क्रमशः 30 DAS ($r = -0.514$) तथा 60 DAS ($r = -0.714$) पाया गया।

पत्ती लपेटक तथा फली भेदक के जीवन चक्र के अध्ययन के दौरान यह देखा गया कि अंडा अवस्था 2-3 दिनों की होती है तथा कुल इल्ली अवस्था 9-12 दिन तथा कुल प्यूपा अवस्था 5-7 की देखी गयी। कुल जीवन चक्र 21-29 दिन पायी गयी।

तिल हॉक मॉथ के जीवन चक्र के अध्ययन के दौरान अण्ड अवस्था 3-5 दिनों की होती है कुल इल्ली अवस्था 17-22 तथा प्यूपा अवस्था 17-26 दिनों में, मादा अवस्था कुल 2-3 दिन तथा नर अवस्था 3-5 में पूर्ण होते हुये अवलोकित की गई ।

CHAPTER- I

INTRODUCTION

Sesame (*Sesamum indicum* L.) is an important oilseed crop and has been under cultivation since classical times. It is also known as Til Gingely, Ajonjoli, Simsim, and Benniseed. Sesame belongs to family Pedaliaceae and commonly grown in the tropical and warm subtropical region (Bedigian and Harlan, 1986). The crop is highly tolerant to drought, grows well in most of the well-drained soils and is well adapted to different rotations. The plant genus consists of thirty seven species, of which *Sesamum indicum* L. is the predominant cultivated species. Sesame seeds are small and flattened and can vary in many colours.

Sesame is the “Queen of oil seeds” due to its high oil content (38-54%), protein (18-25%), calcium, phosphorous, oxalic acid and excellent qualities of the seed oil and meal (Prasad, 2002). The leaves of sesame are rich in a gummy substance and when mixed with water they form a rich bland mucilage which is used for the treatment of infant, cholera, diarrhoea, dysentery and bladder problems. Sesame cake is an excellent fodder for cattle and laying hens (Khan and Shaik, 1985). Sesame seed oil has a longer life due to the presence of lignin, which has remarkable antioxidant functions, which oppose oxidation (Brar and Ahuja, 1979).

Sesame is grown in more than 55 countries of the world. Asia contributes more than 68 percent of the area and 67 percent production in the world (Anonymous, 2016). In India, sesame currently lives in an area of about 1667 thousand hectares with an annual production of 747 thousand tonnes, with an average productivity of 448 kg/ha (Anonymous 2017). India ranks first in the area, production and export of sesame in the world region. In India the major sesame growing states are Gujarat, Rajasthan, Madhya Pradesh and Uttar Pradesh. It has also grown in Assam, Bihar, Haryana, Jammu and Kashmir, Kerala, Himachal Pradesh, North Eastern hill states and Pondicherry.

Sesame is mainly grown *in kharif* season under rainfed situation. Sesame productivity is low in India and the yield fluctuations are very wide. One of the

major obstacles in sesame production is the heavy damage caused by various insect pests. When all the components are placed in a production system, monitoring is needed to obtain information about plant growth, the status of pests and natural enemies as well as current and potential loss.

Biswas *et al.* (2006) recorded twenty nine insect species infesting sesame at different stages of plant growth. However, Ahuja and Bakhetia, (1995) recorded 65 insect species and one species of mite on sesame crop. Leaf webber and capsule borer, (*Antigastra catalaunalis* (Duponchel)), bihar hairy caterpillar, (*Spilosoma oblique* (Walker)), whitefly (*Bemisia tabaci* (Genadius)), and mirid bug (*Cryptopeltis tenuis* (Reuter)), green stink bug (*Nezara viridula* (Linnaeus)), til hawk moth (*Acherontia styx* (Westwood)) is considered a regular important pests of sesame (Ahirwar *et al.* 2009).

Leaf webber and capsule borer, *Antigastra catalaunalis* is one of the major pests of sesame. This can cause damage up to ninety per cent yield. It attacks all parts of the sesame plant except the root. In the early stage of the crop, the caterpillar feeds on the tender leaves by binding the top leaves. In the flowering stage, the larvae entered the bud and flower and feed inside the flowers. In the capsule stage, it bore and penetrates inside the capsule, feeding on developing capsule seeds and destroying the pod material partially or completely. If the infestation occurs at a very early stage, the plant dies without any branch or shoot. A single caterpillar can destroy 2 to 3 plants in an excessive week. If infestation occurs at a later stage, infected shoots persist without further growth.

Til hawk moth, *Acherontia styx* is a sporadic insect pest. However, at the larval stage it is the voracious feeder of sesame crop. This horny caterpillar is a defoliator and polyphagous, which is known to feed on 30 genera of plants. Only one larva is sufficient to denude the entire plant.

Some sucking insect pests viz., leaf hopper (*Orosius albicinctus* Distant), mirid bug (*Nesidiocoris tenuis* Rent.) and white fly (*Bemisia tabaci* Gennadius) suck the cell sap from leaves, flower, and pods. This damage causes the leaf margin downwards, stunted plant growth and ultimately reduce the yield. Leaf

hopper and white fly also transmit phyllody and leaf curl diseases in sesame severally.

Studies on the seasonal occurrence of insect pests and their natural enemies of sesame crop and their relationship with the weather parameters provide basic information about seasonal occurrence of insect pest and their predators. This provides an opportunity to develop important management strategies for the control of these pests. These studies will assist in designing pest monitoring system and ecological sound integrated pest management modules.

The studies on screening of genotypes for resistance against insect pests provide information on adopting resistant genotypes, providing management of insect pests without additional cost.

Different insects have different forms of life cycles. The knowledge of life cycle is important for the management of insect pest because the habitat, habits and appearance of the insect can change dramatically throughout the life cycle.

In view of the above information the present investigation is planned with the following objective.

Objectives:-

- 1. Seasonal incidence and scenario of insect pests and their natural enemies.**
- 2. Screening of sesame genotypes against major insect pests.**
- 3. Biology of leaf webber and capsule borer, *Antigastra catalaunalis* (Duponchel) and til hawk moth, *Acherontia styx* (Westwood).**

CHAPTER- II

REVIEW OF LITERATURE

This chapter deals with the previous work done by various research workers and their finding and based on which present research topic “**Insect pest scenario and succession on sesame, *Sesamum indicum* L. crop with their relative preference on different genotypes**” has been performed. The available literature pertaining to the different aspects of the objectives are presented under the following sub heads:-

2.1 Seasonal incidence and scenario of insect pests and their natural enemies.

Thakur and Kaistha (1994) were observed nine insect pests causing damage to sesame in Himachal Pradesh, during different stages of its growth. The pest incidence on the crop was overlapping. Hairy caterpillar attacked the crop at the vegetative growth to pod maturity stage from the 2nd week of August to 3rd week of September.

Bhadauria *et al.* (2000) recorded twenty-five species of insect pests on sesame, from germination till harvest, which includes 11 homopterans, 7 lepidopterous, 2 each of orthopterans, coleopterans and dipterans respectively. Out of these pests, 12 insect species were observed as regular and other 13 were sporadic pest.

Biswas *et al.* (2001) reported twenty-nine insect species to infest different growth stages of sesame plants. However only four, namely, til hawk moth, hairy caterpillar, mirid bug and leaf webber and capsule borer were considered as the major pests while the rest were of minor importance. Most of the insects infested the crop during vegetative to maturity stage (40-85 days after sowing) of the crop

Muzaffar *et al.*(2002) reported the leaf webber and capsule borer in highest number on sesame crop at early vegetative stage, while whitefly population was the lowest during flowering and the highest during vegetative phase. Thrips and aphids observed from the seedling stage remained active up to crop maturity.

Egonyu *et al.* (2005) studied that sesame is attacked by numerous pests and diseases that reduce its yield and lower the quality of the seed. Thirty eight insect pest species have been found to infest sesame in Uganda, of which the sesame leaf webber and capsule borer and the gall midge are considered most important.

Mishra *et al.* (2005) reported that bihar hairy caterpillar as the major pest of sesame. It attacked the flowers and buds. Leaf webber and capsule borer, was recorded from seedling to harvesting stage of crop growth while til hawk moth was found from capsule formation to capsule maturity stage of crop.

Thakur and Ghorpade (2006) reported leaf webber and capsule as one of the key pests of sesame in India and cause economic losses. This pest is active from seedling to harvest stage of the crop.

Pande *et al.* (2008) reported fourteen insect pests on sesame. The til hawk moth, bihar hairy caterpillar and sesame gallfly were identified as the major pests, while sesame leaf webber and capsule borer was the key pest of sesame crop.

Ahirwar *et al.* (2009) reported that among 67 insect pests damaging sesame crop, leaf insect pests viz. leaf webber and capsule borer, leaf hopper, whitefly and mind bug are considered to be key pests.

Kumar *et al.* (2009) studied pest succession on sesame and reported whitefly, leaf hopper and green stink bug, were active during vegetative stage of the crop while sesame gallfly and bihar hairy caterpillars were active from flowering to capsule formation stage and leaf webber and capsule borer were active from seedling to harvesting stage and til hawk moth from capsule formation to capsule maturity stage, respectively.

Patidar (2010) observed insect pests on sesame crop and found eight major insect pests, viz. white fly, leaf hopper, til hawk moth, hairy caterpillar and mirid bug in early stage to flowering, while thrips, leaf webber and capsule borer and gallfly were observed from 3rd week of August to 2nd week of September 2009,

respectively. In all 50 genotypes of sesame were observed for the incidence of insect pests to assess the plant tolerance (least susceptible) or highly susceptible.

Mahmoud (2012) conducted a survey of insects associated with sesame. A total of 31 insect species were collected and properly identified during the survey. Insects recorded on the plants were divided into four groups, true pollinators (Hymenoptera), other pollinators (Diptera, Coleoptera and Lepidoptera), pests (Orthoptera, Odonata, Hemiptera and Homoptera) and natural enemies (Coleoptera, Hymenoptera, Neuroptera and Dictyoptera).

Kinati (2017) conducted the survey on the insect pests of sesame. The study result showed that there are group of insects from Hemiptera, Lepidoptera, Orthoptera and Isoptera orders found attacking the crop. Among the recorded insects, the sesame leaf webber and capsule borer found the most serious pest feeding on the crop from the seedling up to the maturity stages.

Thangjam and Vastrad (2018) reported that sesame is attacked by numerous pests which reduce its yield both in quality and quantity. Altogether 55 species of arthropods were found to be associated with sesame, out of which 30 species were identified as pest and 25 as natural enemies including 2 strains of entomopathogen. Among the different insect pests recorded, highest number of species was obtained in Heteroptera followed by Homoptera, Lepidoptera, Coleoptera and Thysanoptera. Among the natural enemies recorded, 14 species were predators, 9 species were parasitoids and 2 strains were entomopathogen.

2.2 Screening of sesame genotypes against major insect pests.

Selvanarayanan and Baskaran (1996) studied the response of four varieties of sesame to leaf webber and capsule borer under field conditions in Tamil Nadu, India. Infestation on the branches, leaves, and capsules and the larval population was the maximum on the variety TSS-6, which recorded the lowest yield, while the variety TMV-3 recorded the highest yield and lower infestation.

Aponte *et al.* (1997) studied preference of sesame leaf webber and capsule borer for sesame varieties Piritu, Aceitera, Arawaca, Venezuela-44, Maporal,

Inamar, Acarigua and Fonusca at Turen, Venezuela. Leaf webber and capsule borer showed no preference for the varieties Arawaca and Maporal, whereas the most affected variety was Piritu.

Rath *et al.* (1997) screened twelve varieties of sesame for resistance to leaf webber and capsule borer at Chiplima, Orissa. Sesame variety OMT 30 showed the least damage while Bolangir local reported being highly susceptible.

Ahuja and Kalyan (2001) screened germplasm of sesame against leaf webber and capsule borer and gallfly. Seven lines, viz. ES-12, ES-22, SI-3315111, *Sesamum alatum*, SI-250, IS-210-1, and Zodge-3, whereas resistance to leaf webber and capsule borer and gallfly was observed in *Sesamum alatum*.

Muzaffar *et al.* (2002) tested the incidence and abundance of insects associated with sesame varieties S-17, PR-19/9, PR 28/88 and PR-37/88 and recorded insects viz. whitefly, and thrip and leaf webber and capsule borer. The varieties PR-1919 and S-17 showed relative resistance against these insects while PR-29/88 was relatively susceptible for these insect pest complex.

Singh (2002) screened thirteen genotypes of sesame for their reaction to leaf webber and capsule borer. The genotypes ES-22 and on SI-250, IS-23-1, KIS-305, and ES-12 and thus considered as being resistant to this pest.

Shrivastava *et al.* (2002) screened seven hundred and eighty-two germplasm lines of sesame against leaf webber and capsule borer. Revealed seven germplasm lines viz. SI-1729, SI-3239, IC-132246, IC-204137, IC-205071, IC-2050S2, and IC-205304 were found to be least susceptible.

Sridhar and Gopalan (2002) reported that the overall development of leaf webber and capsule borer was highly reduced in the resistant genotypes ES-22 and lower in SI-250 and good growth when the larvae fed with the susceptible check TC-25. The genotypes exhibited a resistant reaction to leaf webber and capsule borer.

Anonymous (2008 a) screened 24 sesame entries against leaf webber and capsule borer viz. MT-7-06, OSC-9-06, RT-354, Nirmala, PKDS-62, TKG-357, CST-2001, and ASS-9 found to be resistant to leaf webber and capsule borer.

Anonymous (2008 b) screened 150 germplasm accessions against leaf webber and capsule borer at reported, nine entries viz. KMR-30, KMR-41, KMR-55, KMR-5-358, KMR-5-370, SI-1930, SI-3282, KMR-8 and G-44 were found to be resistant to leaf webber and capsule borer.

Shrivastava *et al.* (2009) screened 150 germplasm lines against leaf webber and capsule borer and observed that twelve germplasm lines viz. KMR-5, KMR-13, KMR-37, KMR-75, KMR-77, KMR-71, G-19, G-9, KMR-80, KMR-67, G-22, and ST-3279-1 were found most promising to leaf webber and capsule borer.

Karuppaiah and Nadarajan (2013) screened to identify a resistance source against sesame leaf webber and capsule borer among 43 sesame genotypes under field and laboratory conditions. The reaction of genotypes was categorized using 0 to 9 scoring methodology. The genotypes KMR 14 and TKG 22 were found as moderately resistant with the score of 3 and grade 5 while SI 250, ES 22 and UMA were rated to be resistant with the score 1.6 and grade 3. Among 23 genotypes tested for biophysical (non-preference) and biochemical basis (antibiosis) of resistance three genotypes viz. ES 22, UMA, SI 250 and KMR 14 were identified as less preferred for oviposition with the lowest number of eggs laid on UMA.

Vijaykumar *et al.* (2017) were evaluated sixty sesame genotypes including 7 local cultivars during 2016 for resistance against sesame leaf webber and capsule borer. Among the 60 genotypes evaluated AVT-8, IVT-15, IVT 5-1, IVT-9 and Kanakapura local were reacted as highly resistant (HR) with mean pod damage of 1.15, 1.84, 1.86, 1.94 and 4.47%, respectively along with cumulative leaf, flower and pod damage score of 1.00 while, four genotypes viz. AVT-3, AVT-1, IVT- 23 and IVT-27 in which, the leaf, flower and pod damage were varied between 9.76 to 14.20%, 3.58 to 5.88%, and 1.42 to 1.65%, respectively and were rated as resistant (R) with a cumulative score of 1.66.

Choudhary *et al.* (2017 a) investigated host plant resistance in sesame genotypes against leaf webber and capsule borer. The infestation of leaf webber and capsule borer commenced in the third week of August and reached its peak in the last week of August during 2015 and 2016, respectively. Out of 15 varieties of sesame screened against leaf webber and capsule borer none was found immune. The varieties, RT-358 (4.63), RT-370 (4.38) and RT-371 (4.18) were ranked as least susceptible, while LT-8(7.93), TC-25 (6.78) and RT-46 (7.88) as highly susceptible. The morphological characters of these varieties viz. no. of leaves, no. of branches, no. of capsules and trichome density had negative correlation with the population of leaf webber and capsule borer.

Saravanaraman *et al.* (2017) were selected three promising accessions viz. IVTS-2001-7, KMR-102 and TMV-3 of sesame. To enhance resistance and yield traits, these three accessions in comparison with a susceptible check SVPR 1 were subjected to mutagenesis using gamma rays as physical mutagen; Ethyl Methane Sulphonate (EMS) and Diethyl Sulphate (DES) as chemical mutants. Leaf webber and capsule borer infestation was evaluated based on leaf, flower and capsule damage. Among the first mutant (M1) and second mutant (M2) generations, plants of the accessions namely IVTS 2001-7 and TMV-3 were rated as resistant and plants of SVPR-1 were highly susceptible to leaf webber and capsule borer.

2.3 Biology of leaf webber and capsule borer, *Antigastra catalaunalis* (Duponchel) and til hawk moth, *Acherontia styx* (Westwood).

Selvanarayanan and Baskaran (2000) noticed that the average incubation period of eggs of *A. catalaunalis* was 2.40 ± 0.49 days. There were five larval instars at 25- 30 °C temperature and 75- 80 per cent relative humidity. The larval period of *A. catalaunalis* lasted for 10.85 ± 1.03 days. The pupation of *A. catalaunalis* occurred inside the webbed leaves and the average pupal period was 4.50 ± 0.45 days. The average adult longevity of *A. catalaunalis* was 5.90 ± 0.44 days.

Singh (2003) studied the biology of leaf webber and capsule borer, *A. catalaunalis*, a most serious pest of sesame. The incubation (egg) period, larval period, pupal period, adult longevity, developmental (larval and pupal) period,

adult emergence, fecundity, total life cycle, and growth index recorded were 2-4 days, 8-11 days, 6-8 days, 6-10 days, 14-19 days, 65-95%, 20-30 eggs per female, 22-33 days and 4.64-5.00, respectively.

Ahirwar *et al.* (2010) studied the bioecology of *A. catalaunalis* on sesame variety, TKG-22 during 2006 and reported that eggs were conical in shape, white in colour with length and width varying from 0.35-0.43 mm and 0.18-0.24 mm, respectively. The incubation period of egg was 2-3 days and the neonate period was 17 minutes. There were five larval instars. Length of the completely developed larva was 16 mm and larval period was 10-15 days. The pre-pupal and pupal periods were 2-8 and 4-12 days, respectively and pupa was slender in shape. The mating was always in the morning within 0.89 seconds. The oviposition period was 3-4 days with fecundity of 30-90 eggs/ female. Life span of the adult was 4-12 days. Total life cycle was completed in 22-39 days. Mean adult emergence, sex ratio and growth index were 87 to 100 per cent, 1:1 and 7.22 to 3.15, respectively.

Ahirwar and Gupta (2010) studied the bioecology of til hawk moth, *Acherontia styx* on *Sesamum indicum* (Linn.) variety TKG-22 under field and lab condition during 2004-06. The eggs were globular in shape, yellow in colour with 0.70-0.95 mm in size. The incubation period of the eggs was 2-4 days with the neonate period of 10-15 minutes. There were five larval instars and length of the completely developed larva was 68-79 mm with larval period of 20-21 days. The pre-pupal and pupal periods were 3-4 and 14-23 days respectively, with pupae conical in shape. Life span of the adult was 3-5 days; total life cycle was completed in 39-52 days. Mean adult emergence (%), sex ratio and growth index were 95 to 100%, 1:1 and 2.64 to 2.27 respectively.

Suliman *et al.* (2013) conducted experiment during 2009-11 in Sudan to study the biology and webbing (spinning) behavior of *A. catalaunalis* under laboratory conditions and reported that incubation period of *A. catalaunalis* was 2.45 days, while larval period lasted for 10.2 ± 1.05 days, completing five larval instars. The pupation occurred both inside the webbed leaves as well as in the soil

and the average pupal period was 4.9 ± 0.21 days. The average adult longevity was 6.18 ± 0.2 days.

Karuppaiah (2014) Adult moths are small in size with orange brown forewings and pale yellow transparent hind wings. A female lay about 15-300 greenish minute eggs on the under surface of the apex of the tender leaves or on flowers. Egg stage lasted for 2 to 7 days depending upon the weather and larvae become fully grown in 10 to 11 days under going 5 instars. Pupation takes place within the webbing, under fallen leaves or in soil cervices in a thin transparent cocoon. The pupal period lasted for 4 to 19 days depending upon the weather. Adult longevity was 6 to 8 days. The total cycle was completed in 67 days during winter and 23 days in summer.

Jamuna and Ramaraju (2016) studied the biology of til hawk moth and recorded that the female moth laid egg singly on upper surface of leaves, spherical and shape and yellowish green in colour. Egg period lasts for 5 days. Neonate larva was pale green with black colour horn at the eighth abdominal segment. Larval period was 18-20 days. Larva measured about 4.0 mm on first day and it grew up to 90 mm with a tail horn length of 10 mm before pupation. Pupal period lasted for 20-25 days. It measured about 42-50 mm. Total life cycle ranged from 42-50 days.

Choudhary *et al.* (2017 b) observed that the total life cycle of *A. catalaunalis* varied from 21 to 39 days with an average of 28.1 days. The incubation period varied from 47- 73 hours with an average of 60.6 hours. The larva passed through five instars on sesame leaves under laboratory conditions. Duration of larva was 8.21-12.16 days. Duration of the pre-pupa ranged between 21-121 hours with an average of 100.7 hours and that of pupa 3.10-12.0 days with average 7.18 days. Longevity of adult male varied from 3-5 days with an average of 4.1 days, whereas females lived for 4 - 6 days with an average of 5.8 days.

Pandey *et al.* (2018) studied the biology of leaf webber and capsule borer, *Antigastra catalaunalis*. Eggs laid singly, conical in shape and white in colour with length and width varied from 0.35-0.45 mm and 0.18-0.25 mm, respectively.

Incubation period varied from 2.32 to 2.42 days and viability of eggs varied from 73.34 - 90.00 percent. There were five larval instars and total larval period varied from 9.88 to 13.08 days. The pupal period lasted from 5.25 to 7.25 days. The average length and breadth of pupa was 7.29 ± 0.32 and 1.26 ± 0.29 mm. Percent adult emergence ranged from 70.00 to 85.00 with an average of 76.00 ± 6.51 . Adults were stout and medium in size. The colour varied from light reddish brown to dark reddish brown. The females lived slightly longer than the males. The oviposition period ranged from 2.50 to 4.00 days and fecundity varied from 53.00 to 92.00. Average male to female ratio was 1.0 to 1.09.

CHAPTER-III

MATERIALS AND METHODS

A brief description of the materials and the methods used as well as technique adopted during the course of investigation on the topic “**Insect pest scenario and succession on sesame, *Sesamum indicum* L. crop with their relative preference on different genotypes**” are presented in this chapter.

3.1 Site of work

Series of experiments comprising of (i) Seasonal incidence and scenario of insect pests and their natural enemies. (ii) Screening of sesame genotypes against major insect pests were conducted during *kharif* 2018 in Research Cum Instructional Farm at IGKV, Raipur (C.G.) while, *In vitro* studies on the biology of leaf webber and capsule borer, *Antigastra catalaunalis* (Duponchel) and til hawk moth, *Acherontia styx* (Westwood) on sesame were undertaken under the laboratory conditions during *kharif* 2018.

3.2 Geographical situation

Raipur falls under tropical region. It is situated in Central- Eastern part of Chhattisgarh and lies between at 21⁰6 North latitude and 81⁰36 East longitude which is at an altitude of 289.56 meters above the mean sea level.

3.3 Climate

The place of investigation Raipur comes under dry, sub-humid region under seventh agro-climatic zone of the country, i.e. eastern plateau and hills. The mean annual precipitation of the region is 1200-1400 mm and maximum rainfall is received from middle of June to September and very little during October to February. The weekly maximum temperature raises up to 46⁰C during summer and drop down as low as 10.1⁰C during winter season. The relative humidity is high from June to October. The weekly average meteorological data during the crop growth period was recorded at Meteorological Observatory, IGKV, Raipur, (Appendix-D).

3.4 Seasonal incidence and scenario of insect pests and their natural enemies.

Season : Kharif 2018

Variety : Tilak

Plot size : 20 m x 10 m

Plant spacing : 30 cm × 10cm

Methodology:- From the 200 m² crop area, five sites of the samples were randomly selected and from each site five sesame plants were observed throughout the cropping period, for the presence of insect pests at seven days interval. The population of different insect pests were recorded from germination to harvest of the crop. The population of lepidopterans insect pests (leaf webber and capsule borer, bihar hairy caterpillar and til hawk moth) were recorded by counting the number of larvae/plant. Population of sucking insect pests (leaf hopper, white fly, and mirid bug) were recorded by counting the number of nymphs and adults/three leaf leaves/plant (Top, middle and bottom). Observations of natural enemies were recorded at weekly interval on randomly selected five plants from five sites.

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

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

Where,

r = Simple correlation coefficient

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

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

N = Number of observations.

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

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

Where,

r= Correlation Coefficient

n= No. of observations

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

3.5 Screening of sesame genotypes against major insect pests.

Season : *Kharif* 2018
No. of Genotypes : 23
Plot size : 3 m x 2 m
Spacing : 30 cm × 10 cm
Design : Randomized Block Design
Replication : 3

Table 3.1: Treatment Details:

S.NO.	Genotype	S.NO.	Genotype
1	ACMS-14-007	13	TKG-22
2	DS-18-21	14	RT-385
3	RT-383	15	LT-15-28
4	JLS-706	16	SVT-333
5	AT-382	17	VS-15-014
6	LT-15-16	18	JCS-2420
7	GT-10	19	VS-15-007
8	DS-18-10	20	JCS-2696
9	RT-384	21	JTS-8
10	JLS-907	22	TBS-6
11	LT-15-26	23	TBS-11
12	DS-18-46		

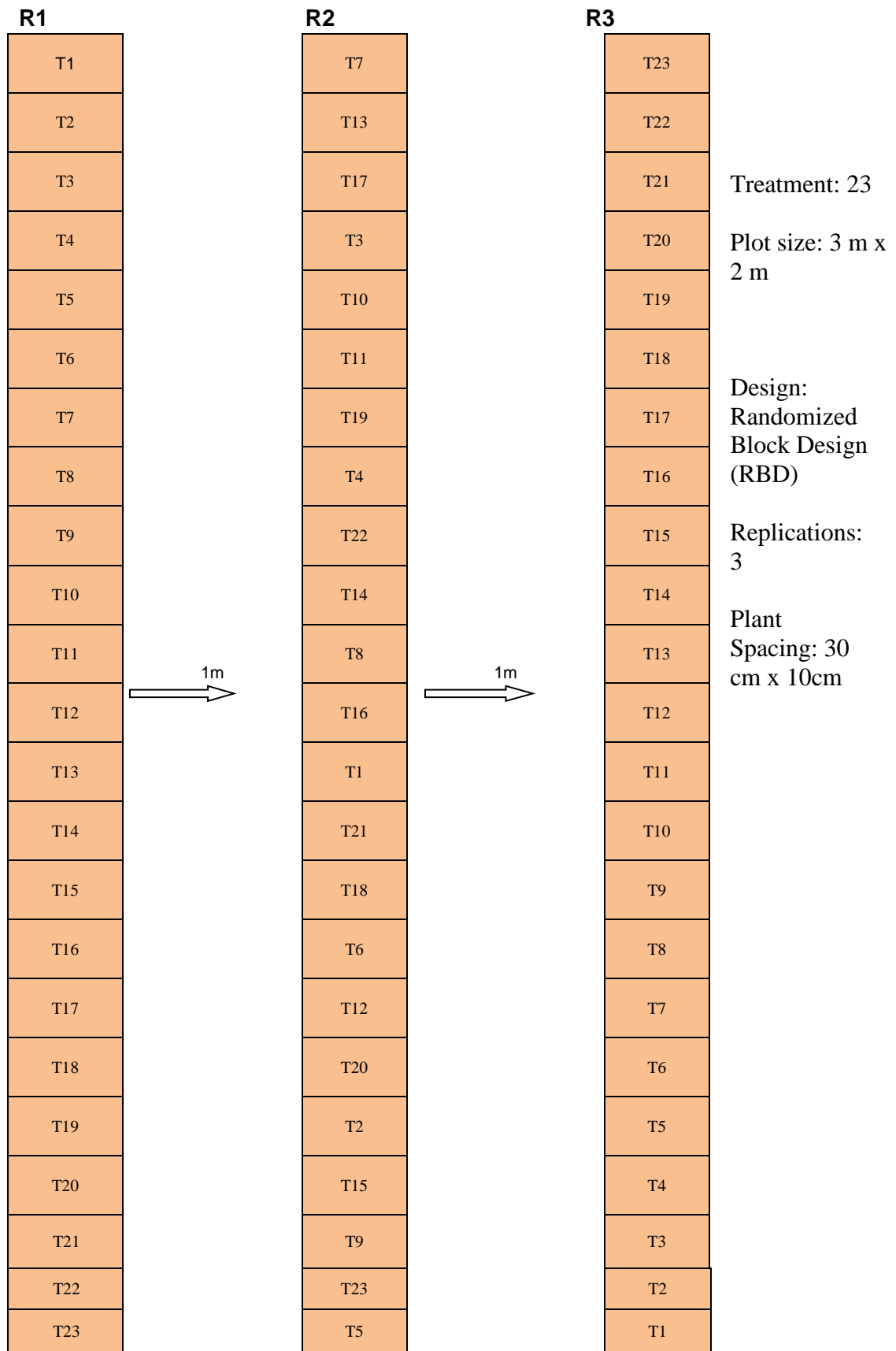


Fig. 3.1: Layout plan of different sesame genotypes screened against major insect pest

3.5.1:-Screening against sesame leaf webber and capsule borer, *Antigastra catalaunalis*

Methodology:-The screening was done in field conditions. Five plants were randomly selected from each replication and genotype for recording the data at weekly interval. Per cent leaf, flower and pod damage were calculated with the following formula.

$$\text{Per cent leaf/flower/pod damage} = \frac{\text{No. of leaf/flower/pod damage}}{\text{Total No. of leaf/flower/pod}} \times 100$$

Table 3.2: Scoring method for evaluation of sesame genotype against *Antigastra catalaunalis* (Sridhar and Gopalan 2002)

Percent damage			
Leaf(A)	Flower bud(B)	Pod(C)	Cumulative score (A+B+C)/3
0-10	0-5	0-2	1
>10-20	>5-10	>2-4	3
>20-30	>10-15	>4-6	5
>30-40	>15-20	>6-8	7
More than 40	More than 20	More than 8	9

Table 3.3: Grading method for evaluation of sesame genotype against *A. catalaunalis* –

Cumulative score	Grade	Degree of resistance
0-1	1	Highly Resistance(HR)
>1-2	3	Resistance(R)
>2-3	5	Moderately resistance(MR)
>3-5	7	Susceptible(S)
>5-9	9	Highly susceptible(HS)



Fig 3.2: View of sesame field for screening of sesame genotypes against major insect pests.

3.5.2 Morphological characters of sesame genotypes.

Morphological characters *viz.*, leaf colour, trichome density and plant height were recorded on five plants of 20 genotypes and data were correlated with population and damage of *A. catalaunalis*. At harvest other plant characteristics such as 100 grain weight (g) and yield (kg/ha.) were also recorded for different genotypes. The procedure adopted for these studies is described as under:

1. Leaf colour (30 DAS)

Leaf colour (light green, dark green) of each genotype was recorded by visual observations.

2. Trichome density (cm²) (30 and 60 DAS)

For trichome density, five leaves were collected randomly from each genotype, leaf was cut into bits of 1 cm² with the help of graph paper and counted the number of trichomes present on leaves under a stereomicroscope and expressed as number of trichomes per one cm².

3. Plant height (cm): (60 DAS)

Plant height was measured with the help of scale and expressed as cm.

4. 100-grain weight (gm)

A sample of 100 grains was randomly picked up from the samples and their weight was recorded.

5. Yield (kg/ha)

Pods obtained from the net area of the plant including the pods were sun dried to a constant weight and expressed in kg/ha.

3.6 Biology of leaf webber and capsule borer, *Antigastra catalaunalis* (Duponchel) and til hawk moth, *Acherontia styx* (Westwood).

The study was carried out in the laboratory at Department of Entomology IGKV, Raipur (C.G.) during 2018.

3.6.1. Insect culture: - The insect larvae of *A. catalaunalis* and *Acherontia styx* were collected from the sesame plants from the experimental field and kept in transparent glass jars covered with a fine muslin cloth secured with rubber band. The larvae were transferred to another clean jar containing fresh food for every 2-3 days till all the larvae pupated.

The pupae thus collected from each jar were kept separately in jars for the emergence of moth. The moths after emergence were kept in ovipositional glass jars. The inner surface of jars was lined with a black paper sheet, which provided clear visibility of eggs on the surface. 10% honey solution on a cotton swab was placed in each jar for moth feeding.

Eggs laid on the bottom were collected for further multiplication and study. These eggs were used as nucleus culture for mass rearing of *A. catalaunalis*. and *Acherontia styx*. The egg diameter was measured by means of a binocular micrometre.

3.6.2 Biology of *A. catalaunalis* and *Acherontia styx*

The biology of *A. catalaunalis* and *Acherontia styx* were studied under $26^{\circ}\text{C} \pm 2^{\circ}\text{C}$ temperature and 70 ± 5 per cent RH. Twenty five eggs were collected from stock and kept in petri dishes for hatching. The newly emerged larvae were fed on newly emerged leaves of sesame and later on food was changed daily. Observations regarding the duration and size of each larval instar, pupal period, adult longevity and fecundity were also recorded.



Fig 3.3: Jars containing larvae and pupae of *Antigastra catalaunalis*.

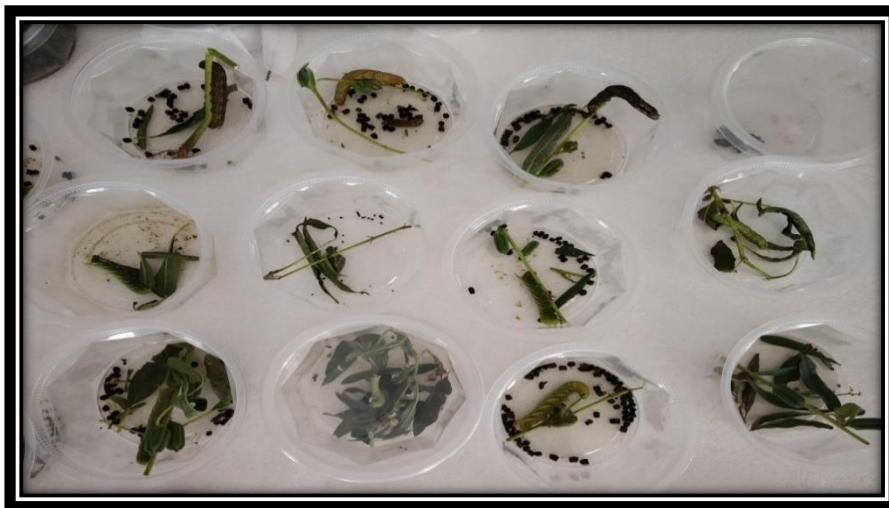


Fig 3.4: Jars containing larvae and pupae of *Acherontia styx*.

CHAPTER IV

RESULTS AND DISCUSSION

The chapter results and discussion deals with the brief description of findings obtained under various objectives under entitled, “**Insect pest scenario and succession on sesame, *Sesamum indicum* L. crop with their relative preference on different genotypes**”. The present results are compared with the previous findings of the relevant aspects in justified manner to draw an actual conclusion. The following sub headings of results and discussion are presented here:-

4.1 Seasonal incidence and scenario of insect pests and their natural enemies.

4.2 Screening of sesame genotypes against major insect pests.

4.3 Biology of leaf webber and capsule borer, *Antigastra catalaunalis* (Duponchel) and til hawk moth, *Acherontia styx* (Westwood).

4.1 Seasonal incidence and scenario of insect pests and their natural enemies

4.1.1 Seasonal incidence of leaf webber and capsule borer, *Antigastra catalaunalis* (Duponchel)

The leaf webber appeared during 33rd SMW *i.e.* 2nd week of August with a mean population of 0.24 leaf webber / plant. The population build up gradually and reached to its peak in the 3rd week of September (38th SMW) with a mean population of 1.68 leaf webber / plant, when the maximum and minimum temperature, rainfall and relative humidity (mor. and eve.) were 31°C, 24.1°C, 32.8 mm, 92 per cent and 68 per cent, respectively. The population declined and reached to its minimum levels of 1 leaf webber / plant during 3rd week of October (42nd SMW). The results indicated that the leaf webber population showed significant positive correlation with maximum temperature ($r = 0.727$). The regression equation being $y = 0.212x - 5.748$ indicating that with an increase in 1⁰C temperature there will be increase in population of leaf webber and capsule borer by 0.212/plant. The leaf webber population also showed significant positive correlation with sunshine hours ($r = 0.708$). The regression equation being

$y = 0.126x + 0.313$ indicating that with an increase in 1 hours of sunshine there will be increase in population of leaf webber and capsule borer by 0.126/plant, while leaf webber population also showed significant negative correlation with rainfall (mm) ($r = - 0.632$). The regression equation being $y = - 0.004x + 1.123$ indicating that with an increase in 1mm rainfall there will be decrease in population of leaf webber and capsule borer by 0.004/plant.(Table 4.1)

The present findings are in agreement with the Rakesh *et al.* (2012) who recorded the incidence of *A. catalaunalis* from the 1st week of August and continued till 4th week of October (vegetative to pod maturity stage). The population of *A. catalaunalis* was found significant and negatively correlated with maximum temperature and relative humidity. More or less these findings are in agreement with the Mishra *et al.* (2015) who found significant and negative correlation between *Antigastra* larval population and relative humidity. Ahirwar *et al.* (2009) and Kumar *et al.* (2012) also reported that relative humidity had significant negative correlation with *Antigastra*. Mishra *et al.* (2015) also observed that the incidence of *Antigastra* was started from 33rd SMW and continued up to 38th SMW and found that after heavy rainfall, when long dry spell occur *Antigastra* larvae population were increased.

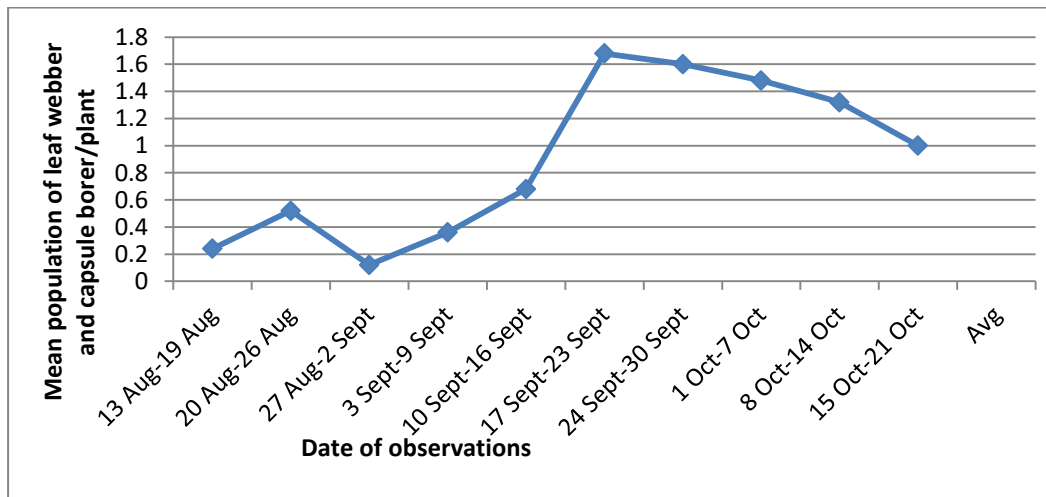


Fig.4.1: Mean population of leaf webber and capsule borer during *kharif* 2018

Table 4.1: Seasonal incidence of major insect pests infesting sesame crop and their correlation with abiotic parameters during *kharif* 2018

SMW	Average number of insect pests					Max. Temp. (°C)	Min. Temp. (°C)	Rain fall (mm)	RH (%) Mor.	RH (%) Eve.	Wind Velocity (Km/h)	Sun Shine (hours)
	Leaf webber and capsule borer larvae/plant	Til hawk moth larvae/plant	Leaf hopper/ top 3 leaves	Mirid bug/top 3 leaves	Green stink bug nymph and adult/plant							
33	0.24	0	0.62	0	0	30.3	25.3	101.2	94	79	4.1	2.9
34	0.52	0	1.66	1.2	0	29.0	24.6	60.4	93	79	5.5	0.6
35	0.12	0	0.28	0.8	0	28.3	24.1	275.0	96	86	6.8	0.2
36	0.36	0.08	2.24	4.86	1.08	29.2	23.9	30.2	93	57	0.5	1.1
37	0.68	0.08	2.64	4.52	3.56	32.6	25.1	0.0	90	55	2.2	6.4
38	1.68	0.28	2.38	4.28	3	31.0	24.1	32.8	92	68	3.5	3.6
39	1.6	0.36	2.76	3.18	3.8	32.9	25.0	11.0	93	59	1.2	7.8
40	1.48	0.2	2.64	3.04	3.4	34.0	23.8	0.0	91	44	0.7	8.0
41	1.32	0.48	3.25	3.42	2	32.4	22.8	0.0	87	51	2.8	7.1
42	1	0.36	1.8	2.4	0.96	33.4	21.3	0.0	89	40	1.0	8.5
Coefficient of correlation (r) for leaf webber and capsule borer population and abiotic factor						0.727*	-0.228	-0.632*	-0.517	-0.562	-0.491	0.708*
Coefficient of correlation (r) for til hawk moth population and abiotic factor						0.692*	-0.583	-0.576	-0.727*	-0.674*	-0.508	0.757*
Coefficient of correlation (r) for leaf hopper population and abiotic factor						0.658*	-0.172	-0.846**	-0.735*	-0.723*	-0.679*	0.641*
Coefficient of correlation (r) for mirid bug population and abiotic factor						0.367	-0.128	-0.632*	-0.473	-0.602	-0.662*	0.334
Coefficient of correlation (r) for green stink bug population and abiotic factor						0.727*	0.132	-0.612	-0.406	-0.565	-0.596	0.682*

SMW: Standard Meteorological Week

*Significant at 5% level of significance

** Significant at 1% level of significance

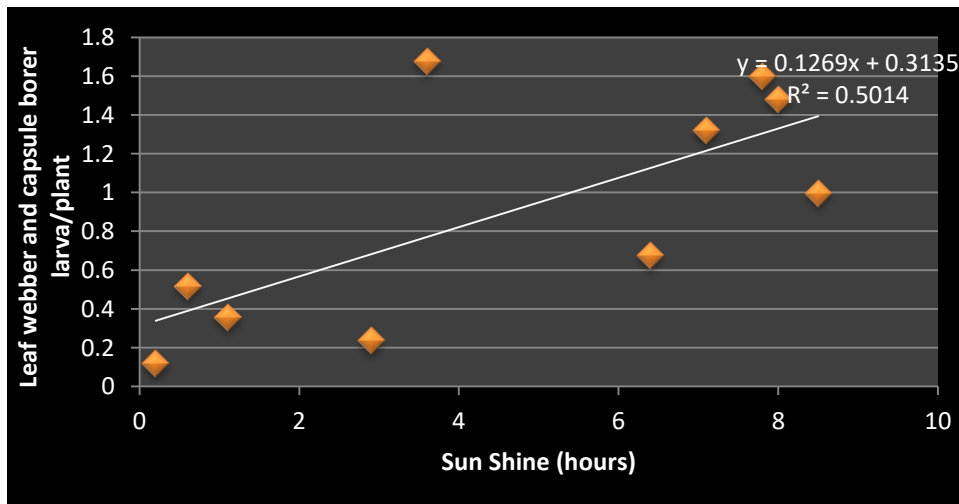
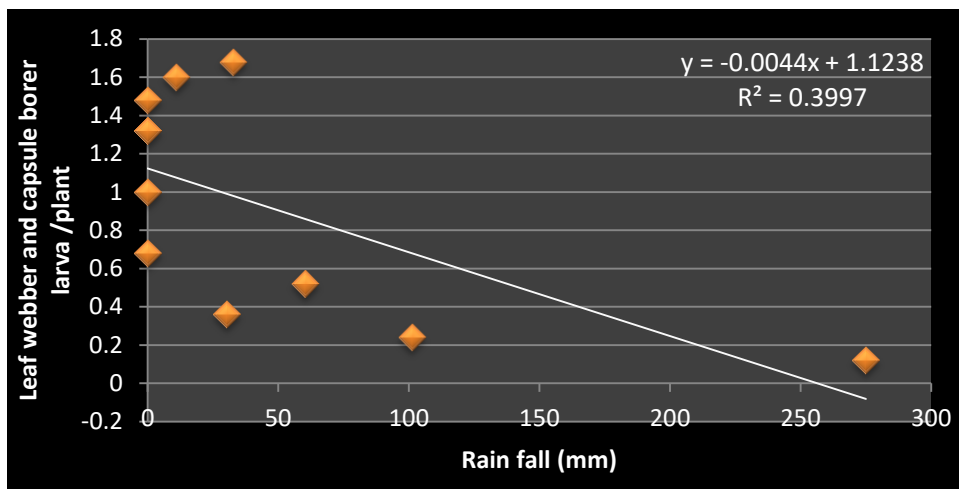
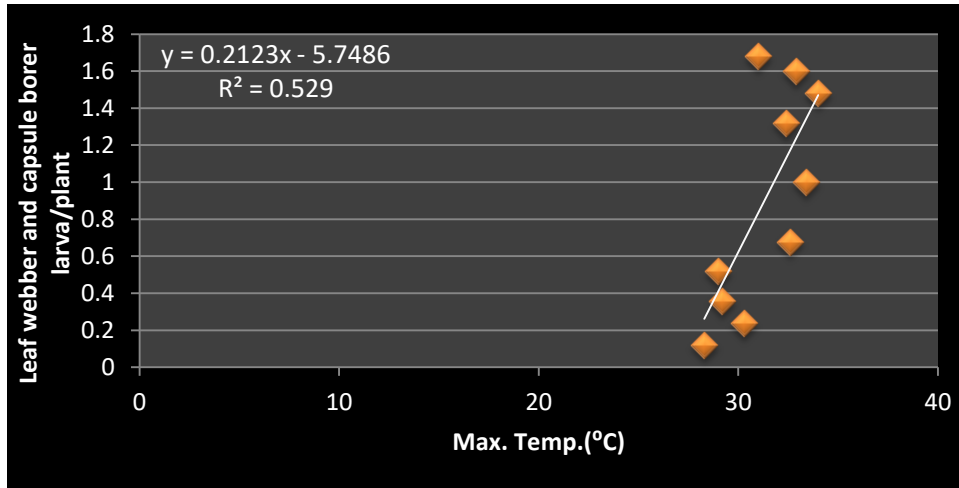


Fig.4.2: Regression equation between weather parameters and population buildup of leaf webber and capsule borer.

4.1.2 Seasonal incidence of til hawk moth, *Acherontia styx* (Westwood)

The til hawk moth appeared during 36th SMW *i.e.* 1st week of September with a mean population of 0.08 til hawk moth / plant. The population build up gradually and reached to its peak in the 2nd week of October (41st SMW) with a mean population of 0.48 til hawk moth / plant, when the maximum and minimum temperature, rainfall and relative humidity (mor. and eve.) were 32.4°C, 22.8°C, 0 mm, 87 per cent and 51 per cent, respectively. Then, the population declined and reached to its minimum levels of 0.36 til hawk moth / plant during 3rd week of October (42nd SMW). The results indicated that the til hawk moth population showed significant positive correlation with maximum temperature ($r = 0.692$). The regression equation being $y = 0.060x - 1.708$ indicating that with an increase in 1^oC temperature there will be increase in population of til hawk moth by 0.060/plant. The til hawk moth population also showed significant positive correlation with sunshine hours ($r = 0.757$). The regression equation being $y = 0.040x - 0.003$ indicating that with an increase in 1 hours of sunshine there will be increase in population of til hawk moth by 0.040/plant, while til hawk moth population showed significant negative correlation with morning relative humidity ($r = - 0.727$). The regression equation being $y = - 0.049x + 4.702$ indicating that with an increase in 1 per cent relative humidity there will be decrease in population of til hawk moth by 0.049/plant. Til Hawk moth population showed significant negative correlation with evening relative humidity ($r = - 0.674$). The regression equation being $y = - 0.007x + 0.655$ indicating that with an increase in 1 per cent relative humidity there will be decrease in population of til hawk moth by 0.007/plant. (Table 4.1)

Bondre (2014) studied that til hawk moth appeared during the flowering, and damage the crop till maturity stage at the crop age of 13 to 76 days. The pest attack on the flowers as well as capsule also. Thangjam and Vastrad (2018) were recorded 30 major insect pests species including, *Acherontia styx*, *Spilarctia oblique*, *Nezara viridula*, *Dolycoris indicus*, *Orosius albicinctus* and *Bemisia tabaci*.

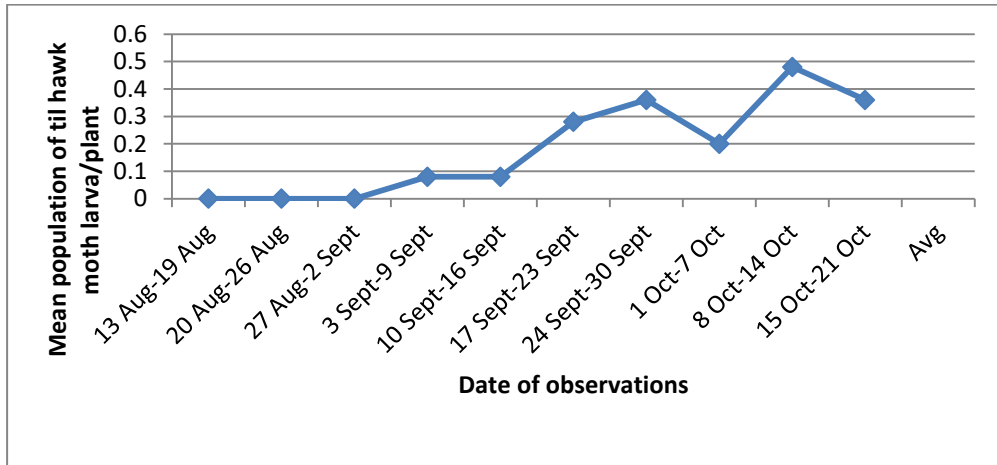


Fig.4.3: Mean population of til hawk moth during kharif 2018

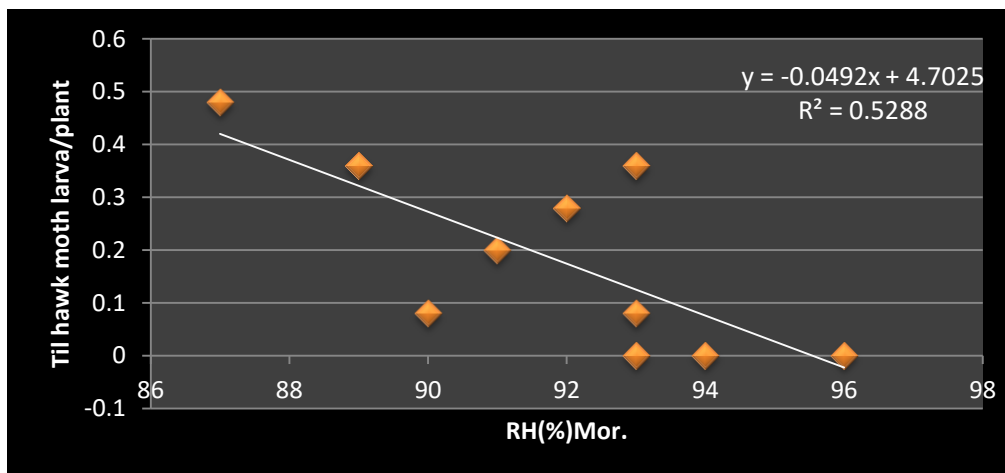
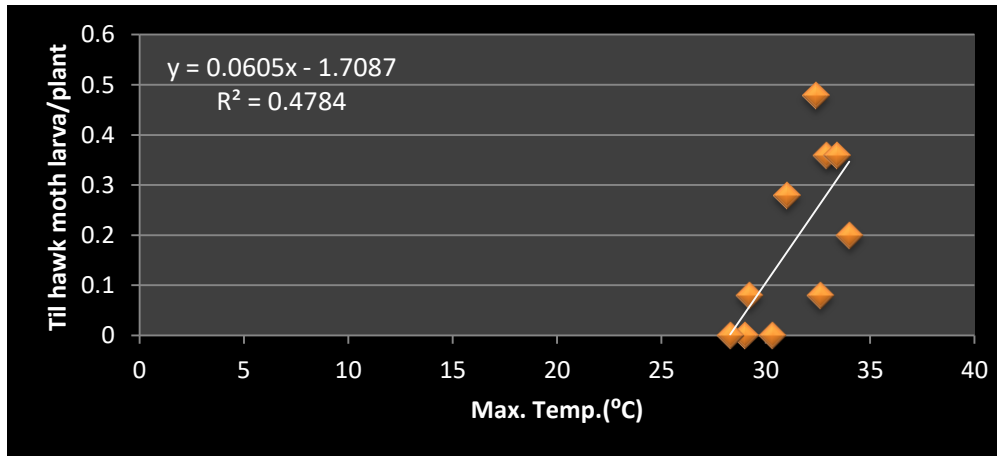


Fig.4.4: Regression equation between weather parameters and population buildup of til hawk moth

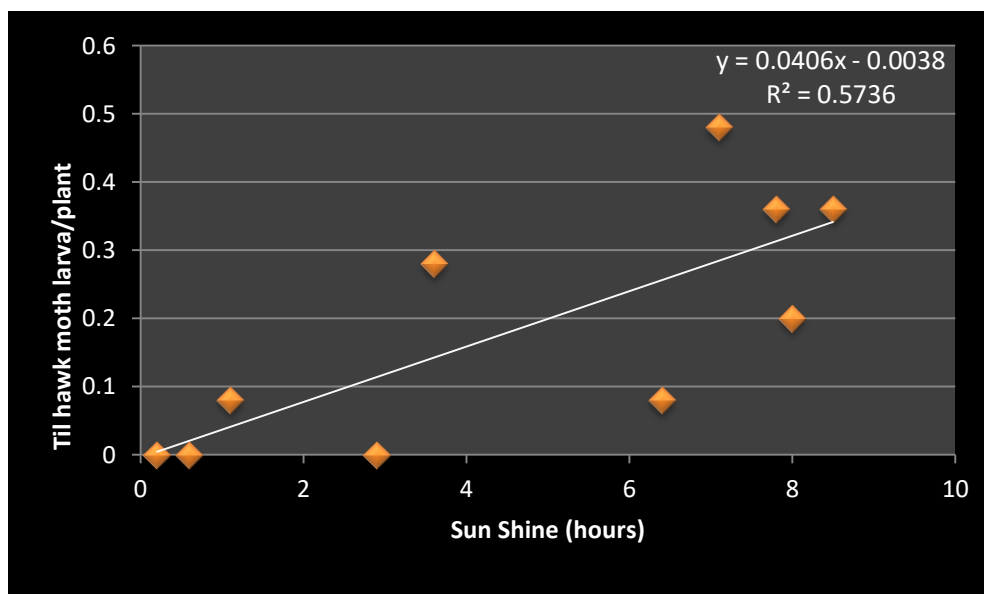
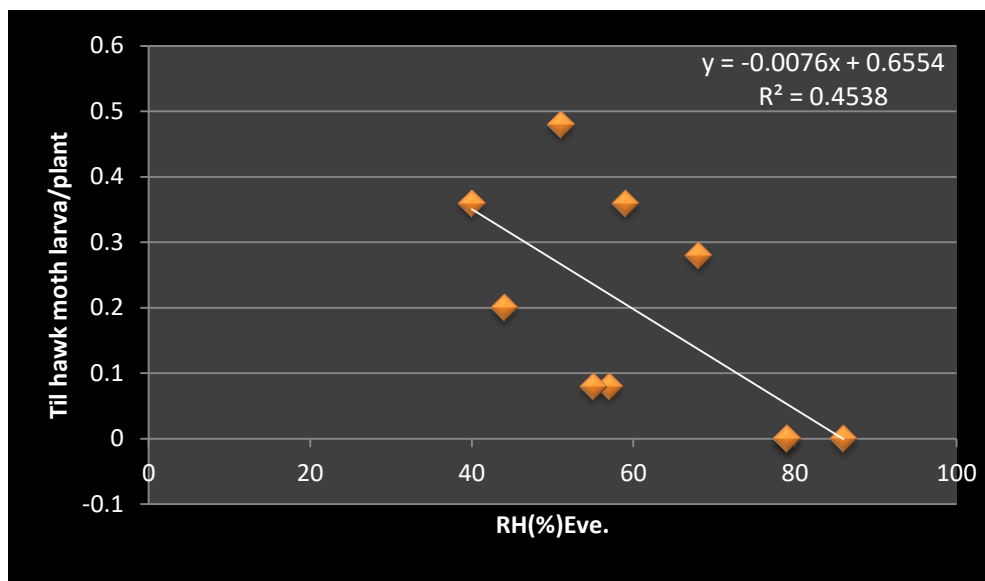


Fig.4.5: Regression equation between weather parameters and population buildup of til hawk moth.

4.1.3 Seasonal incidence of leaf hopper, *Orosius albicinctus*

The leaf hopper appeared during 33rd SMW *i.e.* 2nd week of August with a mean population of 0.62 leaf hopper / plant. The population build up gradually and reached to its peak in the 2nd week of October (41st SMW) with a mean population of 3.25 leaf hoppers / plant, when the maximum and minimum temperature, rainfall and relative humidity (mor. and eve.) were 32.4°C, 22.8°C, 0 mm, 87 per cent and 51 per cent, respectively. Then, the population declined and reached to its minimum levels of 1.8 leaf hoppers / plant during 3rd week of October (42nd SMW). The results indicated that the leaf hopper population showed significant positive correlation with maximum temperature ($r = 0.658$). The regression equation being $y = 0.309x - 7.660$ indicating that with an increase in 1°C temperature there will be increase in population of leaf hopper by 0.309/plant. The leaf hopper population also showed significant negative correlation with rainfall (mm) ($r = - 0.846$). The regression equation being $y = -0.009x + 2.509$ indicating that with an increase in 1mm rainfall there will be decrease in population of leaf hopper by 0.009/plant. The leaf hopper population also showed significant positive correlation with sunshine hours ($r = 0.641$). The regression equation being $y = 0.185x + 1.171$ indicating that with an increase in 1hours of sunshine there will be increase in population of leaf hopper by 0.185/plant, while leaf hopper population showed significant negative correlation with morning relative humidity ($r = - 0.735$). The regression equation being $y = -0.267x + 26.61$ indicating that with an increase in 1per cent relative humidity there will be decrease in population of leaf hopper by 0.267/plant. Leaf hopper population showed significant negative correlation with evening relative humidity ($r = - 0.723$). The regression equation being $y = -4.750 + 0.044x$ indicating that with an increase in 1 per cent relative humidity there will be decrease in population of leaf hopper by 0.044/plant. The leaf hopper population also showed significant negative correlation with wind velocity (km/h) ($r = - 0.679$). The regression equation being $y = - 0.301x + 2.881$ indicating that with an increase in 1km/h of wind velocity there will be decrease in population of leaf hoppers by 0.301/plant.(Table 4.1)

Bondre *et al.* (2016) were recorded the peak activity of leaf webber and capsule borer was during 3rd week of October, and peak activity of hopper were recorded during 1st week of October, and the peak activity of til hawk moth and whitefly were recorded during 2nd week of October. Mean population of nymph and adult of hoppers (1.80) were recorded at higher level and considered as key pests of sesame. Correlation of meteorological parameters i.e maximum and minimum temperature, relative humidity, vapour pressure, evaporation etc. with the population of insect pests viz. whitefly, leaf hopper, gallfly, til leaf webber and til hawk moth were found significant.

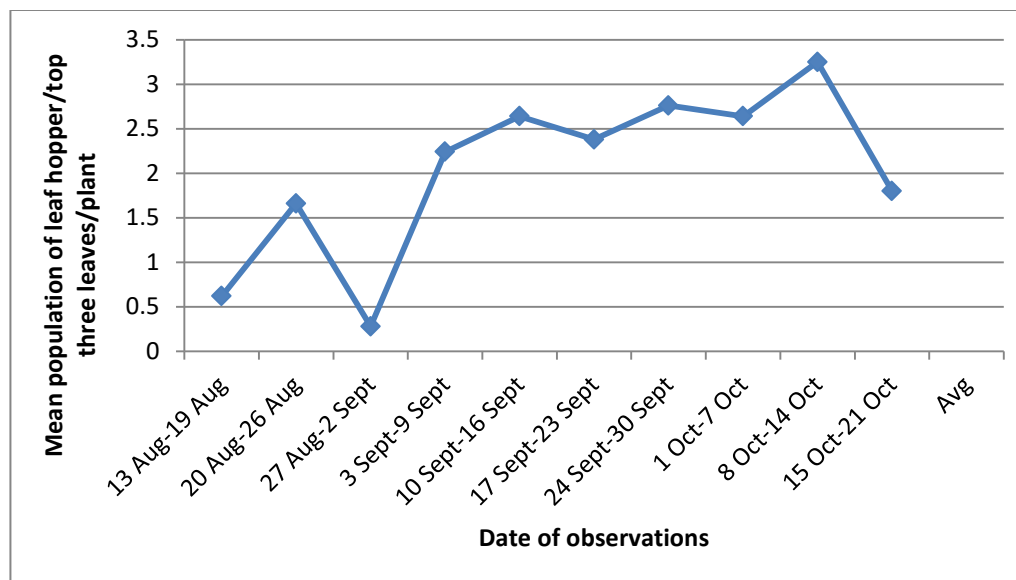


Fig.4.6: Mean population of leaf hopper during *kharif* 2018

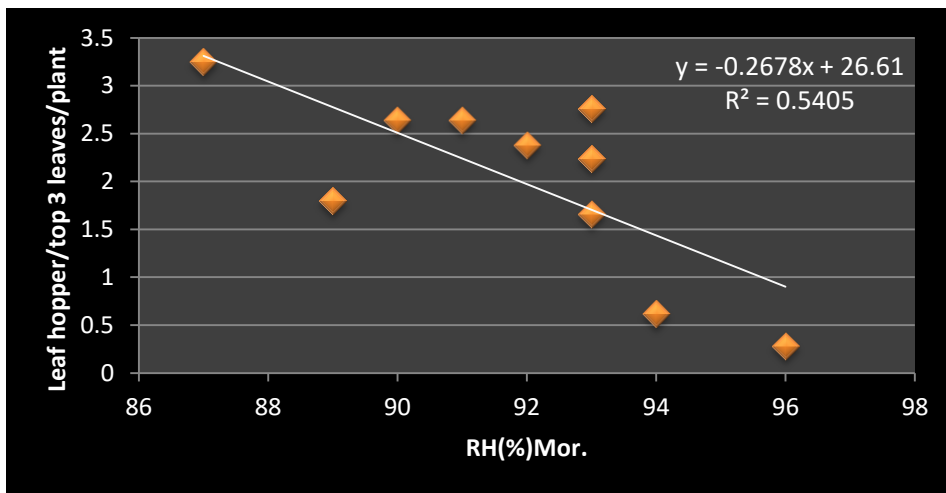
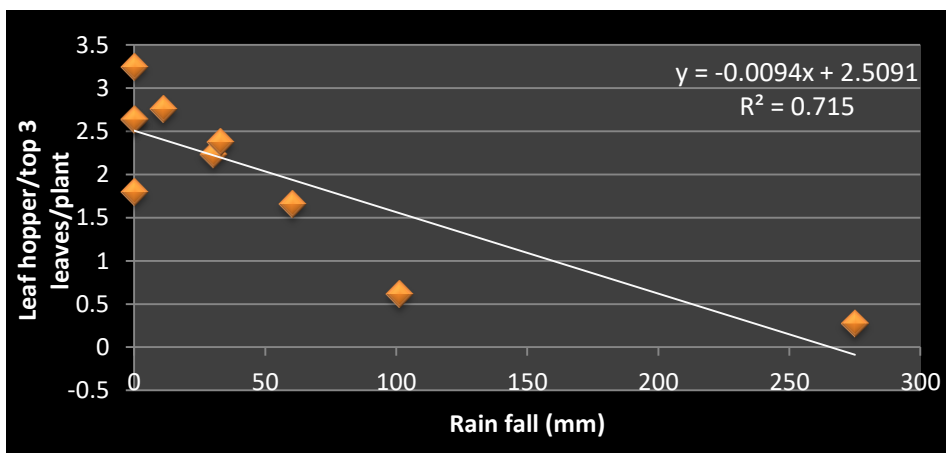
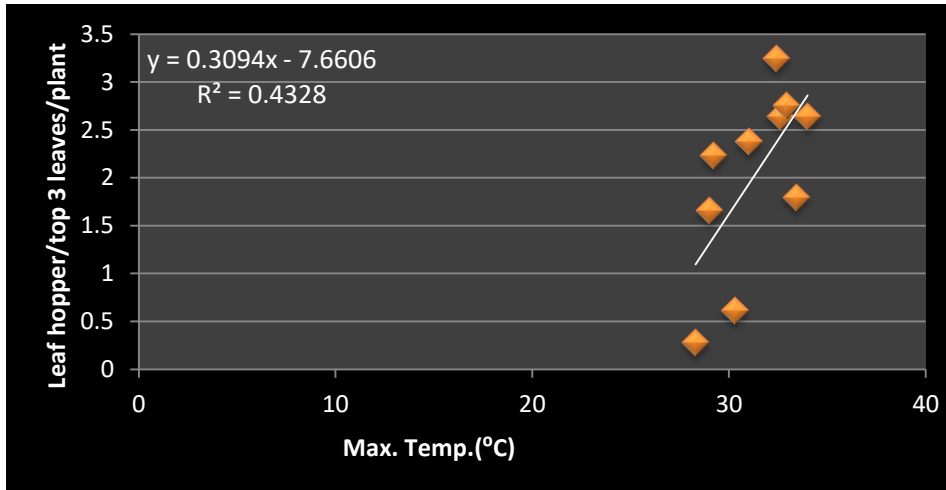


Fig.4.7: Regression equation between weather parameters and population buildup of leaf hopper

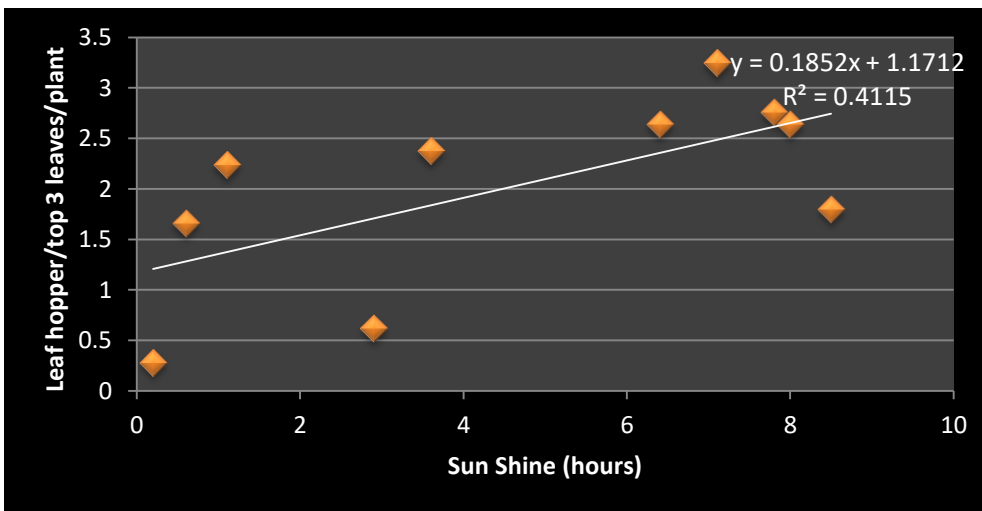
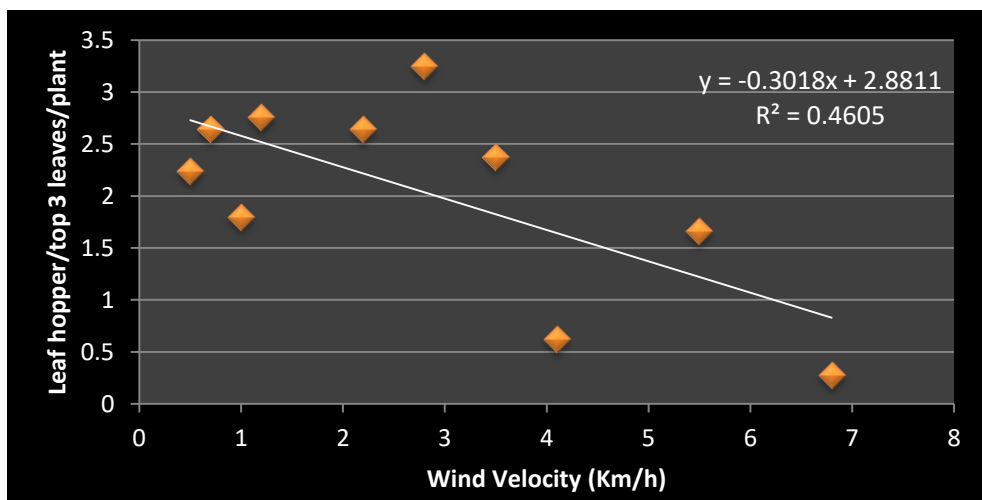
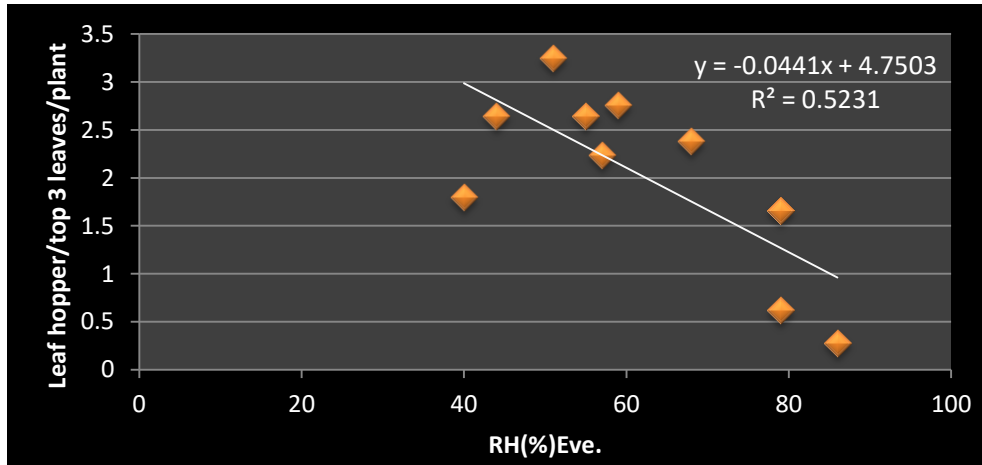


Fig.4.8: Regression equation between weather parameters and population buildup of leaf hopper

4.1.4 Seasonal incidence of mirid bug, *Nesidiocoris tenuis*

The mirid bug appeared during 34th SMW *i.e.* 3rd week of August with a mean population of 1.2 mirid bugs / plant. The population build up gradually and reached to its peak in the 1st week of September (36th SMW) with a mean population of 4.86 mirid bugs / plant, when the maximum and minimum temperature, rainfall and relative humidity (mor. and eve.) were 29.2°C, 23.9°C, 30.2 mm 93 per cent and 57 per cent, respectively. Then, the population declined and reached to its minimum levels of 2.4 mirid bugs / plant during 3rd week of October (42nd SMW). The results indicated that the mirid bug population showed significant negative correlation with wind velocity (km/h) ($r = - 0.662$). The regression equation being $y = - 0.510x + 4.213$ indicating that with an increase in 1km/h of wind velocity there will be decrease in population of mirid bugs by 0.510/plant. The mirid bug population also showed significant negative correlation with rainfall (mm) ($r = -0.632$). The regression equation being $y = - 0.012x + 3.398$ indicating that with an increase in 1mm of rain fall there will be decrease in population of mirid bugs by 0.012/plant. (Table 4.1)

The present findings are contrary with the Mishra *et al.* (2015) incidence of white fly and mirid bug population had significant and positive correlation with maximum temperate.

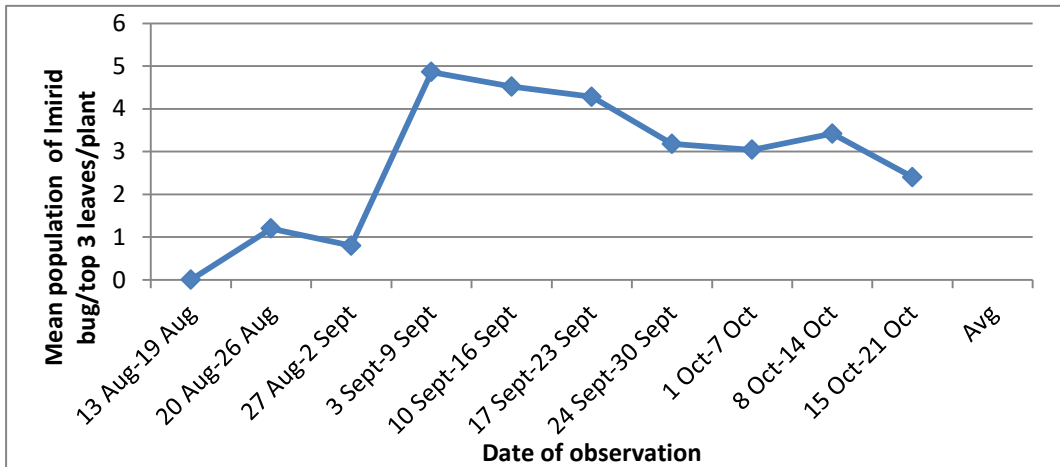


Fig.4.9: Mean population of mirid bug during kharif 2018

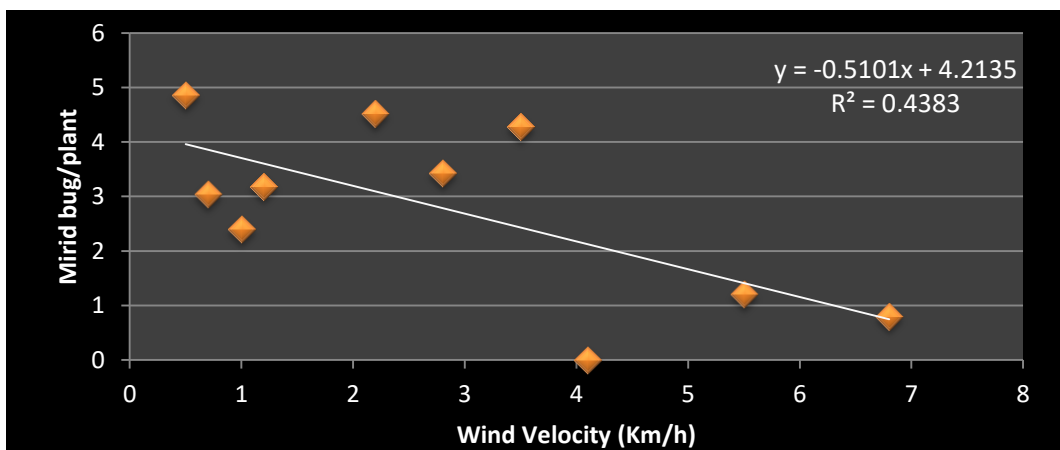
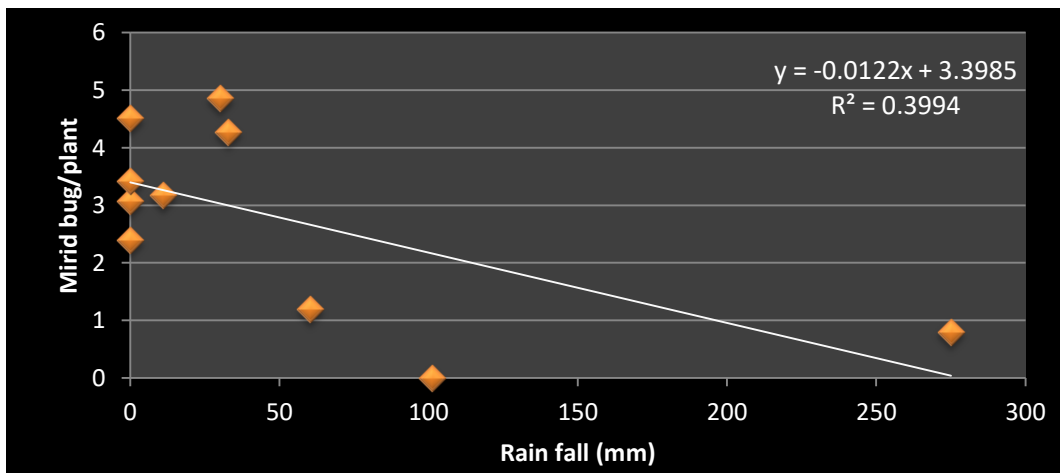


Fig.4.10: Regression equation between weather parameters and population buildup of mirid bug.

4.1.5 Seasonal incidence of green stink bug, *Nezara viridula*

The green stink bug appeared during 36th SMW *i.e.* 1st week of September with a mean population of 1.08 green stink bugs / plant. The population build up gradually and reached to its peak in the fourth week of September (39th SMW) with a mean population of 3.8 green stink bugs/plant, when the maximum and minimum temperature, rainfall and relative humidity (mor. and eve.) were 32.9°C, 25°C, 11.0 mm, 93 per cent and 59 per cent, respectively. Then, the population declined and reached to its minimum levels of 0.96 green stink bug / plant during 3rd week of October (42nd SMW). The results indicated that the green stink bug population showed significant positive correlation with maximum temperature ($r = 0.727$). The regression equation being $y = 0.561x - 15.81$ indicating that with an increase in 1⁰C temperature there will be increase in population of green stink bug by 0.561/plant. The green stink bug population also showed significant positive correlation with sunshine hours ($r = 0.682$). The regression equation being $y = 0.323x + 0.283$ indicating that with an increase in 1hours of sunshine there will be increase in population of green stink bug by 0.323/plant.(Table 4.1)

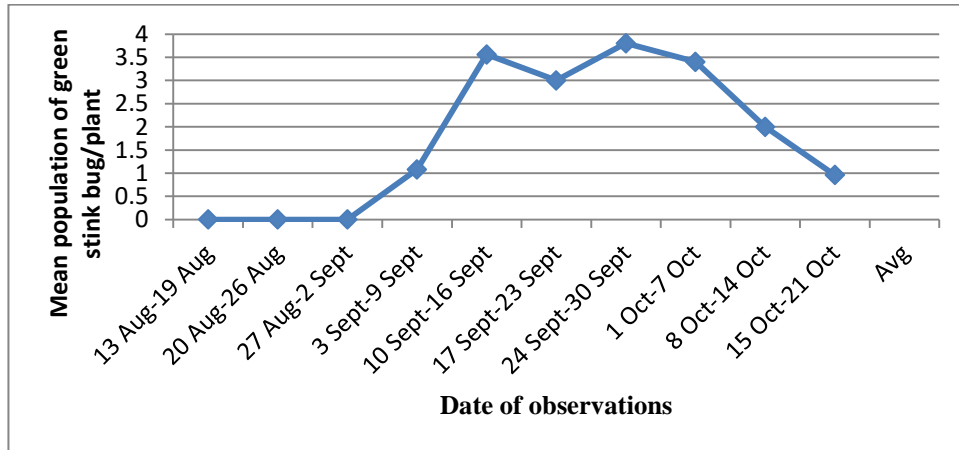


Fig.4.11: Mean population of green stink bug during kharif 2018

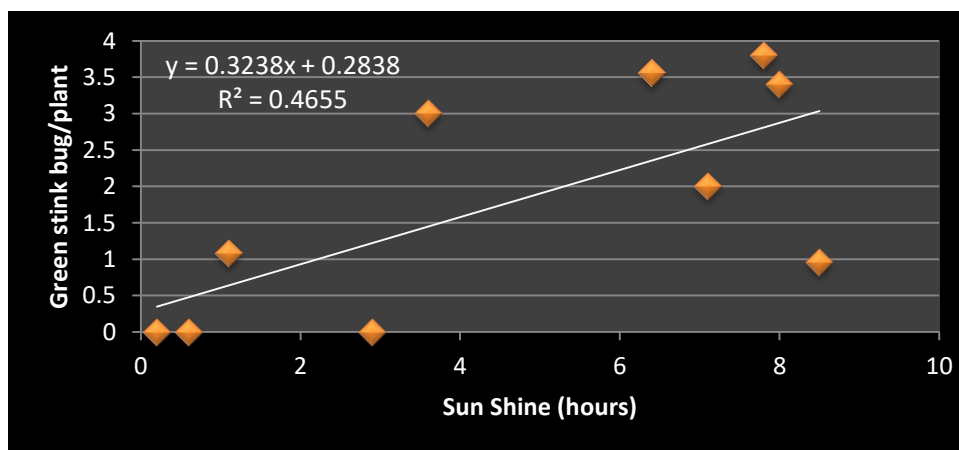
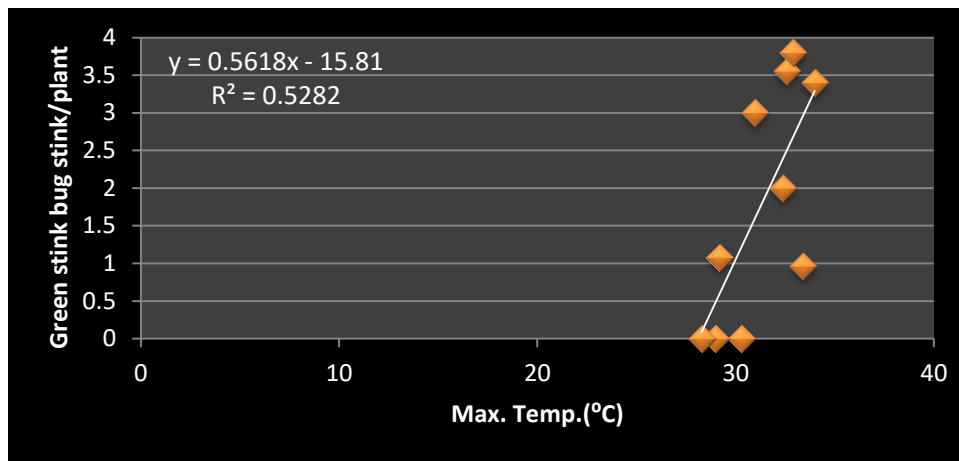


Fig.4.12: Regression equation between weather parameters and population buildup of green stink bug, *Nezara viridula*.



Egg mass of *Antigastra*



Larvae of *Antigastra catalaunalis*



Egg of *Acherontia styx*



Larvae of *Acherontia styx*

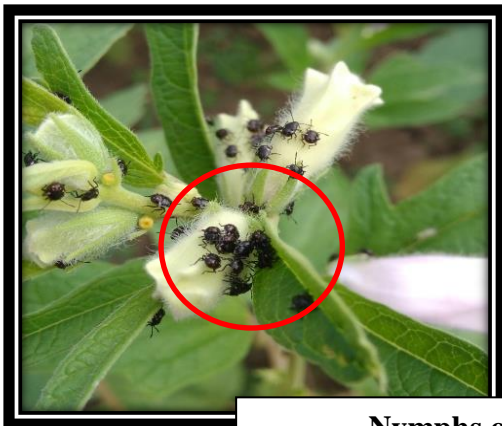
Fig. 4.13: Insect pests observed in sesame crop during *kharif* 2018



Nymphs of *Nesidiocoris tenuis*



Adult of *Nesidiocoris tenuis*



Nymphs of *Nezara viridula*



Adult of *Nezara viridula*



Adult of *Orosius albicinctus*

Fig. 4.14: Insect pests observed on sesame crop during *kharif* 2018

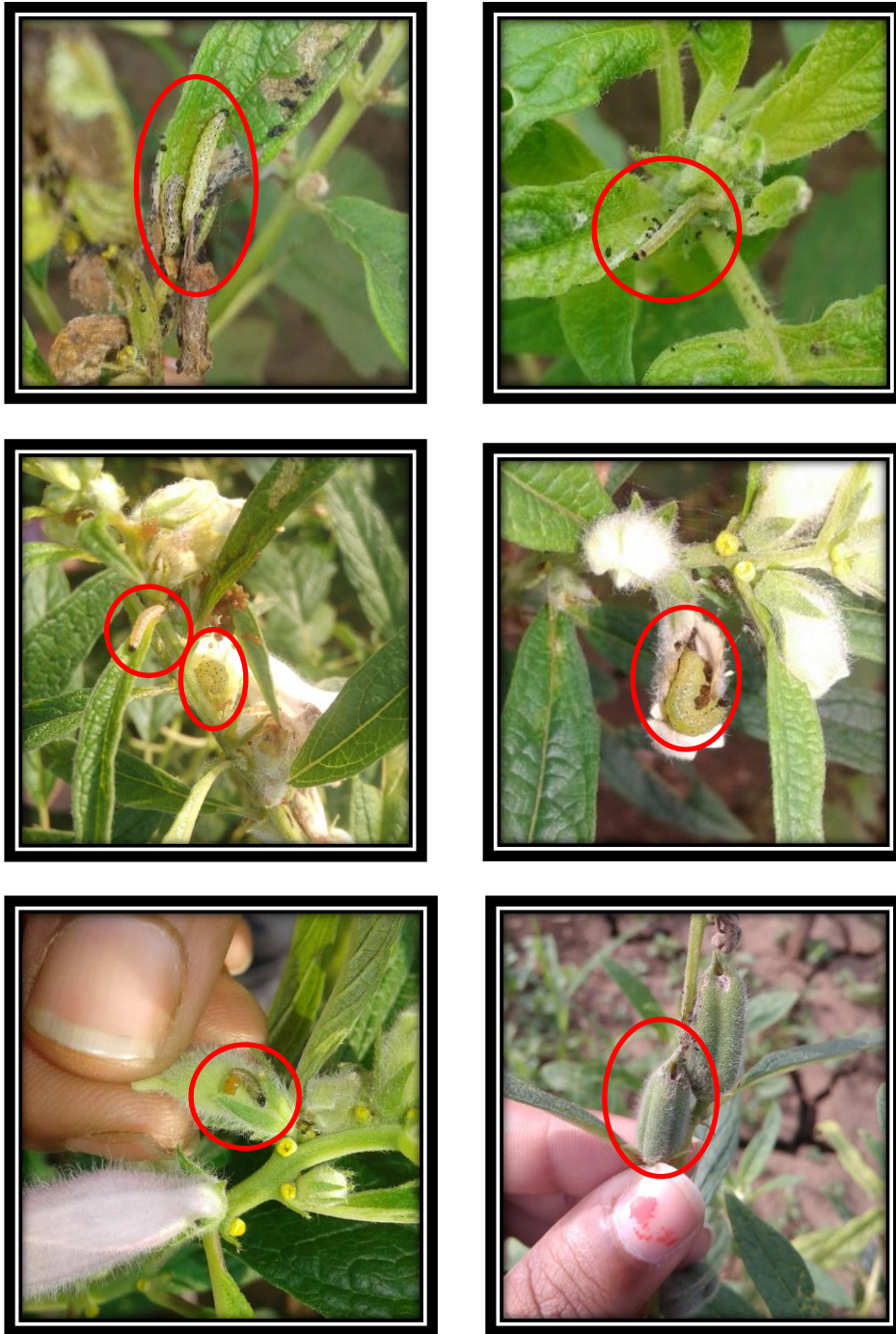


Fig 4.15: Damage caused by *Antigastra catalaunalis* at different stages of sesame crop.



Fig 4.16: Damage caused by *Acherontia styx* at different stages of sesame crop.

Seasonal incidence of natural enemies

Natural enemies found on sesame during study period are presented in Table 4.2. Coccinellid beetles and cantheconid bug were recorded throughout the cropping period. Among non-insect natural enemies spiders were observed throughout the study period.

Table 4.2: Seasonal incidence of natural enemies on sesame during *kharif* 2018

SMW	Average number of natural enemies		
	Coccinellid beetle (no./plant)	Cantheconid bug (no./plant)	Spider (no./plant)
33	0.32	0.08	0
34	0.28	0.6	0.12
35	0.2	0.04	0.2
36	0.72	0.08	0.32
37	0.88	0	1.04
38	0.96	1.16	1.08
39	0.4	0.56	1
40	0.52	0.32	0.56
41	0.64	0.08	0.6
42	0.56	0.04	0.32
Seasonal Mean	0.54	0.29	0.52

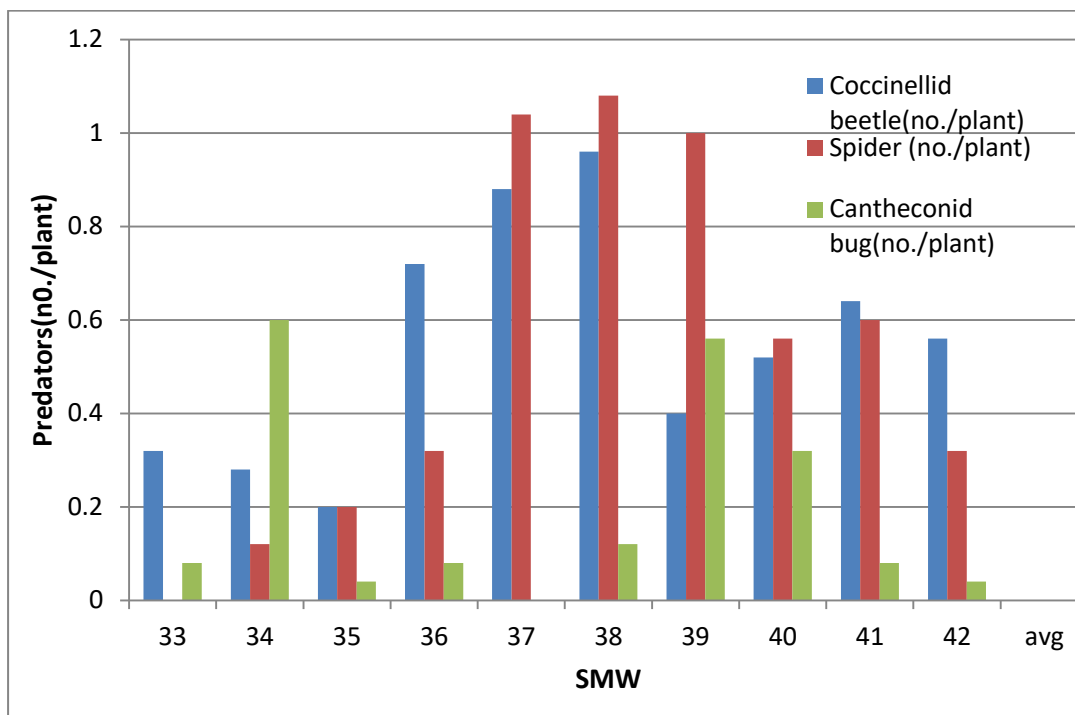


Fig. 4.17: Seasonal fluctuation of predators (no./plant) on sesame crop during *kharif* 2018

4.1.6 Seasonal incidence of coccinellid beetle

Coccinellid beetle appeared during 33rd SMW *i.e.* 2nd week of August with a mean population of 0.32 /plant. The population slowly increased and reached to its peak in 3rd week of September with a mean population of 0.96/plant. Thereafter, the population declined gradually and reached to a minimum level of 0.56/plant during 3rd week of October (42nd SMW). (Table 4.3)

4.1.7 Seasonal incidence of cantheconid bug

Cantheconid bug appeared during 33 SMW *i.e.* 2nd week of August with a mean population of 0.08/plant. The population slowly increased and reached to its peak in the 3rd week of September with a mean population of 1.16/plant. Thereafter, the population declined gradually and reached to a minimum level of 0.04/plant during 3rd week of October (42nd SMW). (Table 4.3)

More or less these findings are agreement with Chakravarty *et al.* (2017) they studied on seasonal incidence of cantheconid bug on pigeonpea. The results showed that bugs appear from the 36th SMW and persisted up to 47th SMW.

4.1.8 Seasonal incidence of Spiders

Spider appeared during 34th SMW *i.e.* 3rd week of August with a mean population of 0.12 /plant. The population slowly increased and reached to its peak in the 3rd week of September with a mean population of 1.08/plant. Thereafter, the population declined gradually and reached to a minimum level of 0.32/plant during 42nd SMW *i.e.* 3rd week of October. (Table 4.3)

4.1.9. Relative abundance of coccinellid beetle in sesame.

Relative density of coccinellid species were recorded during *kharif* season during 2018. Among coccinellid species *Cheilomenes sexmaculata* has contributed 52.77 per cent of total beetle population which were the dominating species. After that *Coccinella transversalis* contributed 34.25 per cent population followed by *Micraspis sp.* (12.96 per cent). Manjula and Prasannalaxmi (2014) also saw that *Chelomenes sexmaculata* accounted for 70 per cent of the total population and population are remain steady upto 60-70 DAS and later declined due to decreasing in pest population. Thangjam and Vastrad (2018) studied that the activity of the natural enemy was highest during *kharif* 2011 than summer 2012 and their relative abundance was 58.33 and 41.67 per cent, respectively.

Table 4.3: Relative abundance of coccinellid beetle in the sesame field (2018-19) (Based on 25 plants observation)

Species of coccinellid	15DAS	22DAS	29DAS	38DAS	45DAS	52DAS	59DAS	66DAS	73 DAS	79DAS	83DAS	Total	Relative abundance (%)
<i>Cheilomenes sexmaculata</i>	1	2	7	1	9	8	10	7	4	5	4	57	52.77
<i>Coccinella transversalis</i>	0	1	2	0	5	7	6	4	3	4	4	37	34.25
<i>Micraspis sp.</i>	0	0	0	1	0	2	3	3	1	3	1	14	12.96
Total	1	3	9	2	14	17	19	14	8	12	9	108	

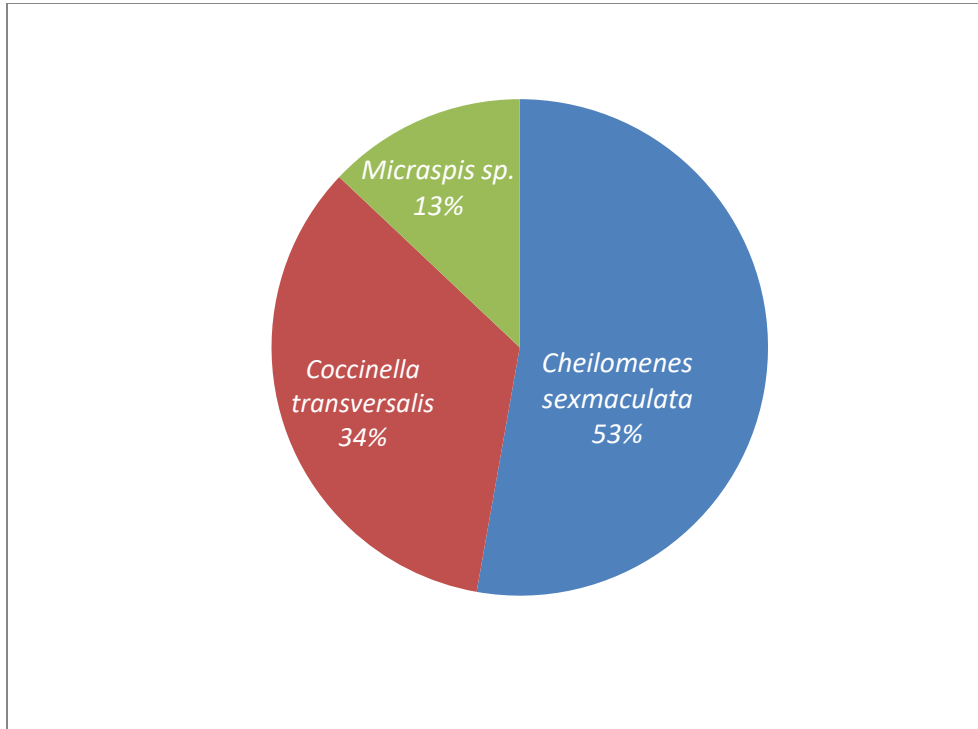


Fig. 4.18: Relative abundance of coccinellid beetle in sesame crop during *kharif* 2018

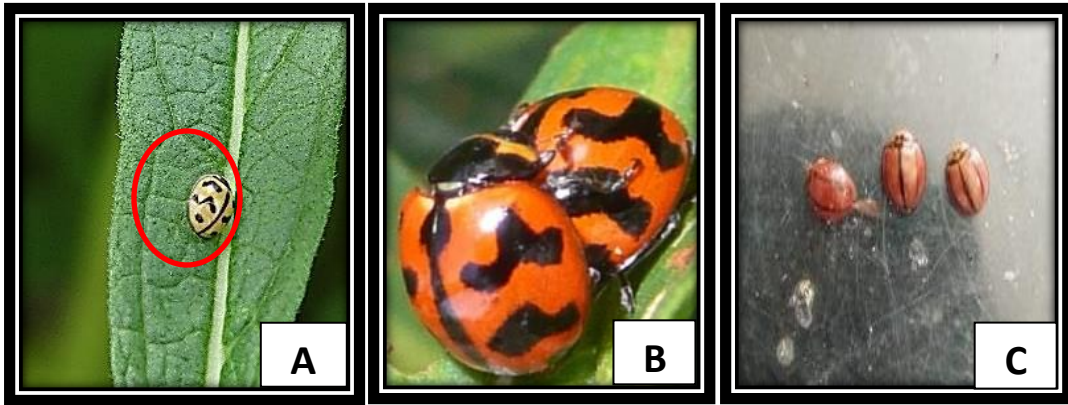


Fig. 4.19: Coccinellid beetle observed on sesame crop (A) *Cheilomenes sexmaculata* (B) *Coccinella transversalis* (C) *Micraspis* sp.

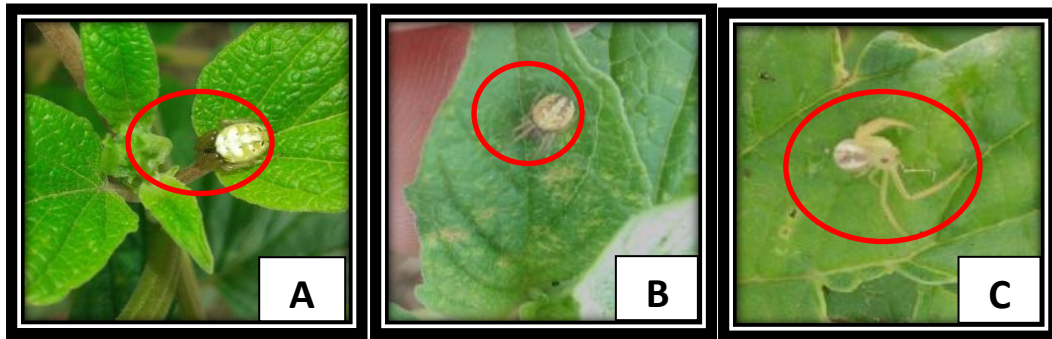


Fig. 4.20: *Neoscona* sp. of spiders observed on sesame crop.

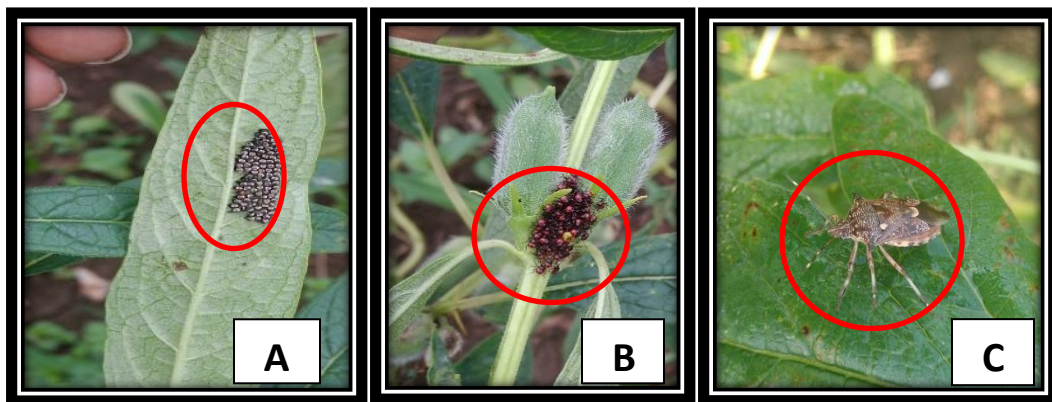


Fig. 4.21: Canthaconid bug observed on sesame crop (A) Egg mass
(B) Nymphs (C) Adult

4.2 Screening of sesame genotypes against major insect pests.

4.2.1 Screening against sesame leaf webber and capsule borer, *Antigastra catalaunalis*

Field screening of 23 sesame genotypes against sesame leaf webber and capsule borer, *Antigastra catalaunalis* were conducted at Research Cum Instructional Farm at IGKV, Raipur (C.G.) during *kharif* 2018.

4.2.1.1 Per cent leaf damage caused by sesame leaf webber and capsule borer, *Antigastra catalaunalis*.

Mean comparison of *A. catalaunalis* leaf damage among twenty three sesame genotype is shown in Table 4.3. Among the twenty three genotype VS-15-014 genotypes found minimum *A. catalaunalis* leaf damage (12.47%), while LT-15-16 genotype was recorded with maximum *A. catalaunalis* leaf damage (18.93%) on the crop. The descending order of mean leaf damage caused by *A. catalaunalis* population was LT-15-16(18.93%)>DS-18-10 (18.59%) > DS-18-46 (18.33) > JLS-907 (18.17%) > JLS-907 (17.56%) > TKG-22 (17.14%) > DS-18-21 (17.04%) > JLS-706 (16.14%)> JCS-2696 (16.03%) > RT-385 (16%)> JTS-8 (15.77%) and TBS-11 (15.77%) > TBS-6 (15.65%) > AT-382 (15.63%) > LT-15-26 (15.4%) > JCS-2420 (15.37%) > GT-10 (15.32%) >VS-15-007 (15.13%) > SVT-333 (14.92%) > RT-383 (13.57%) >ACMS-14-007(12.82%)>LT-15-28(12.73%)>VS-15-014(12.47%).

4.2.1.2 Per cent flower damage caused by sesame leaf webber and capsule borer, *Antigastra catalaunalis*.

Mean comparison of *A. catalaunalis* flower damage among twenty three sesame genotype is shown in Table 4.3. Among the twenty three genotype TBS-11 genotypes found minimum *A. catalaunalis* flower damage (14.68%), while VS-15-014 genotype was recorded with maximum *A. catalaunalis* flower damage (42.58%) on the crop. The descending order of mean flower damage caused by *A. catalaunalis* population was VS-15-014 (42.58%)> DS-18-10 (40.92%) > JCS-2420

(40.73%) > JLS-907 (38.06%) > JCS-2696 (36.51%) > TKG-22 (36.02%) > TBS-6 (35.96%) > RT-383 (35.77%) > JTS-8 (35.74%)> RT-385 (33.33%) > AT-382 (32.91%) > DS-18-46 (32.58%) > RT-384 (32.45%) > SVT-333 (31.92%) > DS-18-21 (31.26%) > LT-15-26 (30.79%) > GT-10(28.15%)>JLS-706(27.87%)> LT-15-16(27.71%) > LT-15-28 (27.41%)> ACMS-14-007 (26.89%)> VS-15-007 (25.64%)> TBS-11 (14.68%).

4.2.1.3 Per cent pod damage caused by sesame leaf webber and capsule borer, *Antigastra catalaunalis*.

Mean comparison of *A. catalaunalis* pod damage among twenty three sesame genotype is shown in Table 4.3. Among the twenty three genotype TBS-11 genotypes found minimum *A. catalaunalis* pod damage (7.35%), while VS-15-014 genotype was recorded with maximum *A. catalaunalis* pod damage (19.03%) on the crop. The descending order of mean pod damage caused by *A. catalaunalis* population was ACMS-14-007 (19.03%)> DS-18-21(15.76%)> LT-15-26 (14.66%)> AT-382 (13.97%)> JLS-907 (12.56%) > DS-18-46 (12.37%) > RT-383 (11.98%) > RT-385 (11.62%) > TBS-6 (11.26%) > JLS-706 (11.22%)> JTS-8 (11.00%)> JCS-2420 (10.96%) > SVT-333 (10.59%) > LT-15-28 (10.01%) > JCS-2696 (9.85%) > LT-15-16 (9.71%) > RT-384 (9.50%) > VS-15-014 (9.35%) > DS-18-10 (8.84%) > TBS-11 (7.92%)> VS-15-007 (7.86%) and TKG-22 (7.86%)> GT-10 (7.35%).

Table 4.4: Per cent leaf, flower and pod damage caused by leaf webber and capsule borer, *A. catalaunalis* and cumulative score of sesame.

Sl. No.	Genotypes	Leaf damage (%)	Score	Flower bud Damage (%)	Score	Pod damage (%)	Score	Cumulative score	Grade
1	ACMS-14-007	12.82	3	26.89	9	19.03	9	7.00	9
2	DS-18-21	17.04	3	31.26	9	15.76	9	7.00	9
3	RT-383	13.57	3	35.77	9	11.98	9	7.00	9
4	JLS-706	16.14	3	27.87	9	11.22	9	7.00	9
5	AT-382	15.63	3	32.91	9	13.97	9	7.00	9
6	LT-15-16	18.93	3	27.71	9	9.71	9	7.00	9
7	GT-10	15.32	3	28.15	9	7.35	7	7.00	9
8	DS-18-10	18.59	3	40.92	9	8.84	9	7.00	9
9	RT-384	17.56	3	32.45	9	9.50	9	7.00	9
10	JLS-907	18.17	3	38.06	9	12.56	9	7.00	9
11	LT-15-26	15.4	3	30.79	9	14.66	9	7.00	9
12	DS-18-46	18.33	3	32.58	9	12.37	9	7.00	9
13	TKG-22	17.14	3	36.02	9	7.86	7	5.33	9
14	RT-385	16.00	3	33.33	9	11.62	9	7.00	9
15	LT-15-28	12.73	3	27.41	9	10.01	9	7.00	9
16	SVT-333	14.92	3	31.92	9	10.59	9	7.00	9
17	VS-15-014	12.47	3	42.58	9	9.35	9	7.00	9
18	JCS-2420	15.37	3	40.73	9	10.96	9	7.00	9
19	VS-15-007	15.13	3	25.64	9	7.86	7	5.33	9
20	JCS-2696	16.03	3	36.51	9	9.85	9	7.00	9
21	JTS-8	15.77	3	35.74	9	11.00	9	7.00	9
22	TBS-6	15.65	3	35.96	9	11.26	9	7.00	9
23	TBS-11	15.77	3	14.68	5	7.92	7	5.00	7

4.2.1.4 Field reaction of sesame genotypes against leaf webber and capsule borer, *A. catalaunalis*.

Twenty three sesame genotypes was screened against leaf webber and capsule borer, *Antigastra catalaunalis* based on mean leaf, flower and pod infestation per cent by leaf webber and capsule borer, none of the genotype was highly resistant , resistant and moderately resistant whereas, TBS-11 genotypes are susceptible and ACMS-14-007, DS-18-21, RT-383, JLS-706, AT-382, LT-15-16, GT-10, DS-18-10, RT-384, JLS-907, LT-15-26, DS-18-46, TKG-22, RT-385, LT-15-28, SVT-333, VS-15-014, JCS-2420, VS-15-007, JCS-2696, JTS-8, TBS-6 were highly susceptible.

Table 4.5: Field reaction of sesame genotypes against leaf webber and capsule borer, *A. catalaunalis* during *kharif* 2018

Cumulative score	Grade	Degree of resistance	Genotypes
0-1	1	Highly resistant (HR)	-
>1-2	3	Resistant (R)	-
>2-3	5	Moderately Resistant (MR)	-
>3-5	7	Susceptible (S)	TBS-11
>5-9	9	Highly Susceptible (HS)	ACMS-14-007, DS-18-21, RT-383, JLS-706, AT-382, LT-15-16, GT-10, DS-18-10, RT-384, JLS-907, LT-15-26, DS-18-46, TKG-22, RT-385, LT-15-28, SVT-333, VS-15-014, JCS-2420, VS-15-007, JCS-2696, JTS-8, TBS-6

More or less these findings are agreement with the Kumar *et al.* (2018) who studied mechanism of action among sixty sesame genotypes against sesame leaf webber and capsule borer, *A. catalaunalis* (Dup.). He found that seven genotypes *viz.*,

IVT-5, IVT- 7, IVT -11, IVT-13, IVT-21, AVT-10, AVT 4-2, Shivalli local were reacted as susceptible (S) with leaf, flower and pod damage varied between 30 to 40%, 15 to 20%, and 6 to 8%, respectively. Out of 60 genotypes evaluated under high pest pressure, 43 genotypes were designated as highly susceptible (HS) with the mean leaf, flower and pod damage of more than 40.00, 20.00 and 8.00%, respectively. More or less these findings are also agreement with the Choudhary *et al.* (2018) who studied 15 varieties of sesame screened against *A. catalaunalis* none was found immune. The varieties, RT-358 (4.63), RT-370 (4.38) and RT-371 (4.18) were ranked as least susceptible, while LT-8(7.93), TC-25 (6.78) and RT-46 (7.88) as highly susceptible.

4.2.1.2 Correlation between plant characteristics and per cent leaf damage caused by sesame leaf webber and capsule borer, *A. catalaunalis*

The per cent leaf damage of sesame caused by sesame leaf webber and capsule borer were recorded on twenty three genotypes and correlated with plant characters such as trichome density (cm²), plant height (cm).

4.2.1.2.1. Trichome density (cm²) 30 days after sowing

The trichome density of sesame showed significant difference in different genotypes. Significantly highest trichome density (43.3 cm²) was observed in the genotype SVT-333. Whereas, the lowest trichome density was observed in the genotype LT-15-16 (14.3 cm²) which were at par with ACMS-14-007(20.9 cm²), DS-18-21(18.9 cm²), JLS-706(20.9 cm²), DS-18-10(16 cm²), RT-384(18.7 cm²), JLS-907(18.6 cm²), DS-18-46(18.3 cm²), LT-15-28(21.1 cm²), JCS-2696(20.9 cm²) and TBS-11(21.2 cm²).

The sesame leaf webber and capsule borer showed significant but negative correlation with trichome density ($r = -0.483$) at 30DAS. The regression equation being $y = -0.150x + 19.234$ indicating that with an increase in 1cm² trichome density there will be decrease in leaf damage by 0.150 per cent.

4.2.1.2.2 Trichome density (cm²) 60 days after sowing

The trichome density of sesame showed significant difference in different genotypes. Significantly highest trichome density (44.6 cm²) was observed in the genotype JTS-8. Whereas, the lowest trichome density was observed in the genotype LT-15-16 (15.8 cm²) which were at par with DS-18-21(21.5 cm²), JLS-706(23.1 cm²), DS-18-10(17.6 cm²), RT-384(20.1 cm²), JLS-907(19.1 cm²), DS-18-46(18.1 cm²) and TKG-22 (21.1 cm²).

The sesame leaf webber and capsule borer showed negatively significant correlation with trichome density ($r = -0.781$) at 60 DAS. The regression equation being $y = -0.213x + 21.398$ indicating that with an increase in 1cm² trichome density there will be decrease in leaf damage by 0.213 per cent.

4.2.1.2.3 Plant height (cm) 60days after sowing

The plant height of 23 sesame genotypes differed significantly .The maximum plant height (194.7cm) was recorded in the genotype JLS-706 which were at par with DS-18-21(182.2cm), RT-384(182.5cm), JLS-907(189.4cm), JCS-2420(189.5cm) and TBS-6 (182.2 cm). Whereas the minimum plant height was recorded in the genotype DS-18-10(155.7cm) and TBS-11(155.7 cm) which were at par with RT-385(159.0cm).

More or less the present works are similar with the Sasane *et al.* (2018) in groundnut genotypes against defoliators who reported that the defoliators were significantly negative correlated with leaf thickness and trichome density. The present findings are contrary with the Karuppaiah and Nadarajan (2013) who studied that the egg laying of *A. catalaunalis* was positively correlated ($r = 0.749$) with the trichome density on the leaf. More or less these findings are also agreement with the Choudhary *et al.* (2018) who studied 15 varieties of sesame screened against *A. catalaunalis* none was found immune. The morphological characters of these varieties viz., no. of leaves, no. of branches, no. of capsules and trichome density had negative correlation with the population of *A. catalaunalis*.

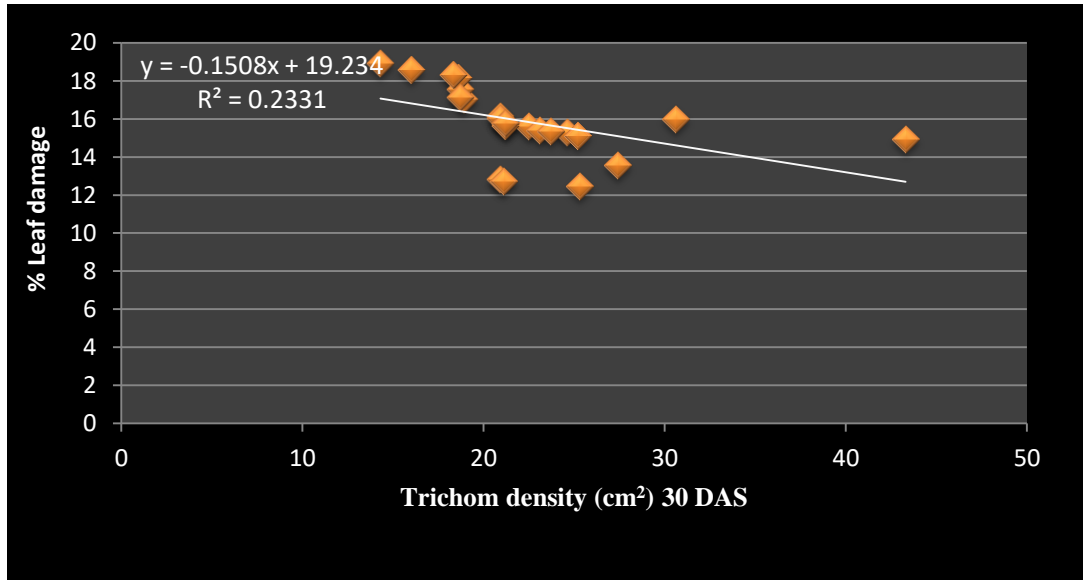


Fig 4.22: Regression equation between trichome density (cm²) 30DAS and per cent leaf damage caused by sesame leaf webber and capsule borer, *A. catalaunalis*.

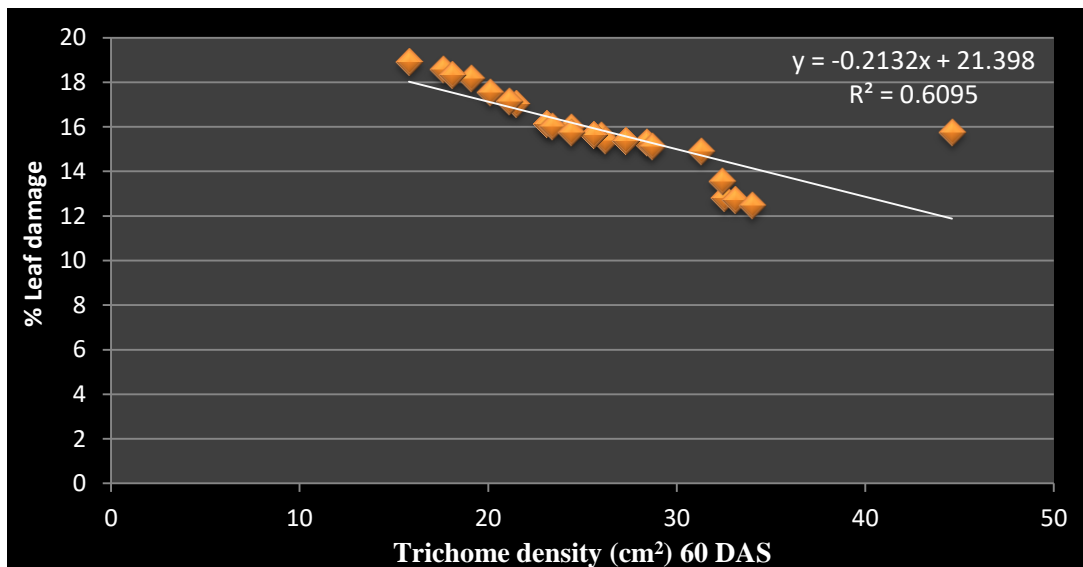


Fig 4.23: Regression equation between trichome density (cm²) 60DAS and per cent leaf damage caused by sesame leaf webber and capsule borer, *A. catalaunalis*

Table 4.6: Correlation between per cent leaf damage caused by sesame leaf webber and capsule borer *A. catalaunalis* and plant characteristics of different sesame genotypes

Genotype	% leaf damage	Trichome density (cm ²) 30DAS	Trichome density (cm ²) 60DAS	Plant height (cm) 60DAS
ACMS-14-007	12.82	20.9	32.5	178.0
DS-18-21	17.04	18.9	21.5	182.2
RT-383	13.57	27.4	32.4	178.3
JLS-706	16.14	20.9	23.1	194.7
AT-382	15.63	22.5	26	180.5
LT-15-16	18.93	14.3	15.8	178.3
GT-10	15.32	24.6	28.4	179.9
DS-18-10	18.59	16	17.6	155.7
RT-384	17.56	18.7	20.1	182.5
JLS-907	18.17	18.6	19.1	189.4
LT-15-26	15.4	23.1	26.2	178.9
DS-18-46	18.33	18.3	18.1	180.4
TKG-22	17.14	18.7	21.1	174.2
RT-385	16.00	30.6	24.4	159.0
LT-15-28	12.73	21.1	33.1	179.9
SVT-333	14.92	43.3	31.3	175.1
VS-15-014	12.47	25.3	34.0	177.4
JCS-2420	15.37	23.7	27.3	189.5
VS-15-007	15.13	25.2	28.7	181.6
JCS-2696	16.03	20.9	23.4	169.9
JTS-8	15.77	21.2	44.6	181.5
TBS-6	15.65	21.2	25.6	182.2
TBS-11	15.77	21.2	24.4	155.7
r		- 0.483*	- 0.781**	-0.1
S.E.m		2.723	4.631	4.495
CD		7.786	8.726	12.854

*Significant at 5% level of significance

**Significant at 1% level of significance

4.2.1.3 Correlation between per cent pod damage caused by sesame leaf webber and capsule borer, *A. catalaunalis* and 100 grain weight and yield (kg/ha).

The per cent pod damage of sesame caused by sesame leaf webber and capsule borer were recorded on twenty three genotypes and correlated with 100-grain weight (gm) and yield (kg/ha).

4.2.1.3.1 100 grain weight

The 100 grain weight of sesame showed significant difference in different genotypes. Significantly highest 100 grain weight (0.47gm) was observed in the genotype DS-18-46. Whereas, the lowest 100 grain weight was observed in the genotype RT-383(0.21gm).

The sesame leaf webber and capsule borer showed significant but negative correlation with 100 grain weight ($r = -0.432$). The regression equation being $y = -0.0112x + 0.4611$ indicating that with an increase in 100 grain weight there will be decrease in pod damage by 0.011per cent.

4.2.1.3.1 Yield (kg/ha)

The yield (kg/ha) of sesame showed significant difference in different genotypes. Significantly highest yield (89.4 kg/ha) was observed in the genotype VS-15-007. Whereas, the lowest yield was observed in the genotype ACMS-14-007 (37.2 kg/ha).

The sesame leaf webber and capsule borer showed significant but negative correlation with yield ($r = -0.689$). The regression equation being $y = -3.567x + 103.78$ indicating that with an increase in 1kg/ha yield there will be decrease in pod damage by 3.567 per cent.

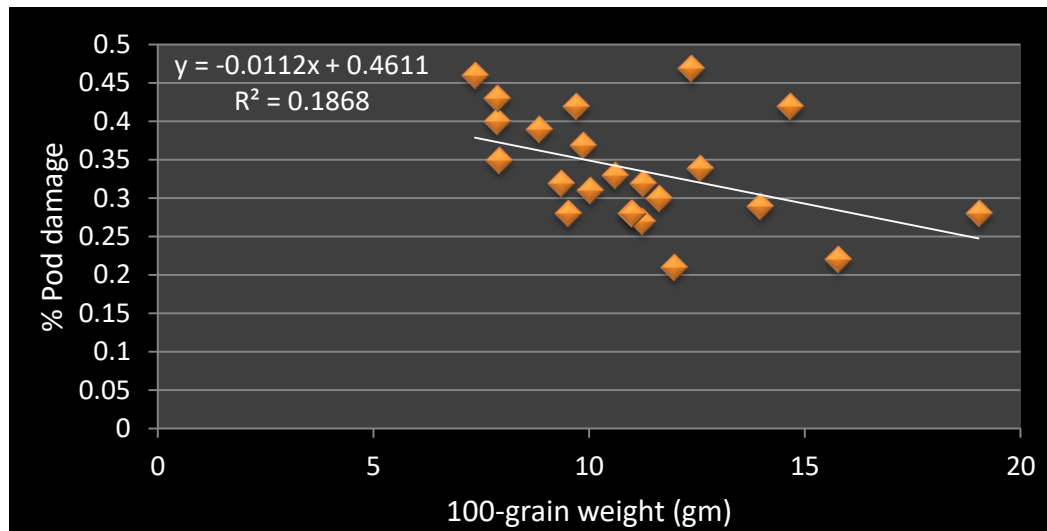


Fig 4.24: Regression equation between 100-grain weight and per cent pod damage caused by sesame sesame leaf webber and capsule borer, *A. catalaunalis*.

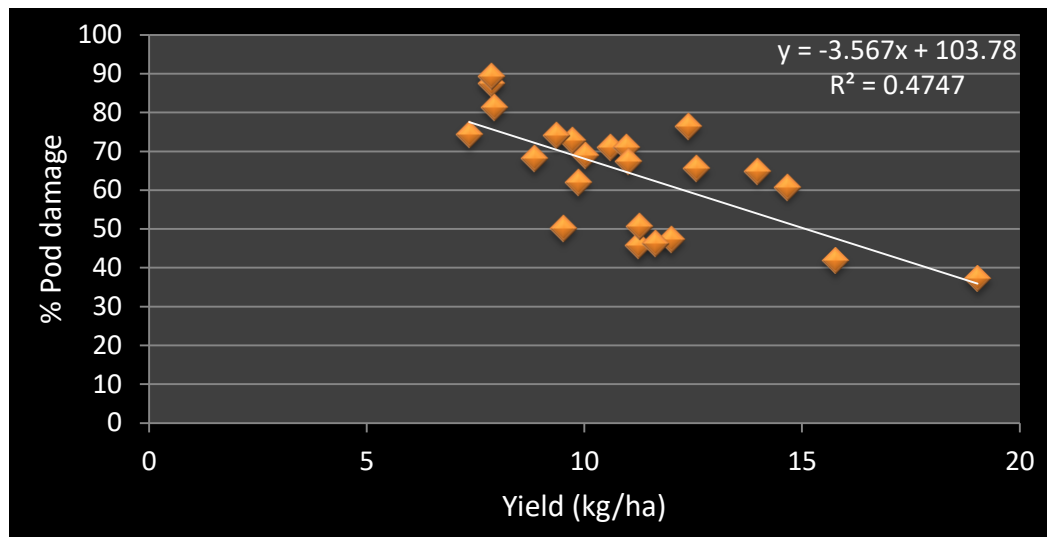


Fig 4.25: Regression equation between yield and per cent pod damage caused by sesame sesame leaf webber and capsule borer, *A. catalaunalis*.

Table 4.7: Relation between per cent pod damage caused by *A. catalaunalis* and 100-grain weight and yield of different sesame genotypes.

Genotype	Pod damage (%)	100-grain weight (gm)	Yield(kg/ha)
ACMS-14-007	19.03	0.28	37.2
DS-18-21	15.76	0.22	42.1
RT-383	11.98	0.21	47.4
JLS-706	11.22	0.27	45.8
AT-382	13.97	0.29	64.57
LT-15-16	9.71	0.42	72.7
GT-10	7.35	0.46	74.4
DS-18-10	8.84	0.39	68.8
RT-384	9.50	0.28	50.2
JLS-907	12.56	0.34	65.6
LT-15-26	14.66	0.42	60.8
DS-18-46	12.37	0.47	76.5
TKG-22	7.86	0.40	87.6
RT-385	11.62	0.30	46
LT-15-28	10.01	0.31	69.6
SVT-333	10.59	0.33	70.54
VS-15-014	9.35	0.32	74.5
JCS-2420	10.96	0.28	71.1
VS-15-007	7.86	0.43	89.4
JCS-2696	9.85	0.37	62.8
JTS-8	11.00	0.28	67.5
TBS-6	11.26	0.32	50.8
TBS-11	7.92	0.35	81.3
r		-0.432*	-0.689**
S.E.m			0.128
CD		0.28	0.366

*Significant at 5% level of significance

**Significant at 1% level of significance

4.3 Biology of leaf webber and capsule borer, *Antigastra catalaunalis* (Duponchel) and til hawk moth, *Acherontia styx* (Westwood).

4.3.1 Biology of leaf webber and capsule borer, *A. catalaunalis* on sesame crop under laboratory conditions.

The following biological parameters were observed:-

Eggs: The freshly laid eggs by the female are conical in shape, white colour, laid in batches. The egg measures about 0.40-0.49 mm in length and 0.20-0.25 mm in width. The fecundity is 39-79 in numbers. The incubation period of the eggs under laboratory conditions ranged between 2 to 3 days with an average of 2.34 days.

Larva:-The larvae after hatching fed on epidermal layer of the leaf tissue. The newly hatched caterpillar (first instar) was a tiny, cylindrical, semi translucent, cream coloured caterpillar with reddish brown head capsule. Caterpillar had four pairs of prolegs and one pair of anal proleg besides three pairs of thoracic legs. The first, second, third, fourth, and fifth instar larva measures about 4.5 to 5.5 mm, 7.15 to 9.5 mm, 11.15 to 13.0 mm, 13.50 to 13.90 mm and 14.5 mm to 16.5 mm, respectively in length . Fifth instar caterpillar which fed on leaves and other vegetative parts was dark green or pink in colour. The total larval period completed in 9-12 days with an average of 10.51 days. To characterize the webbing (spinning) behaviour of the larvae, spinning was observed directly, since larvae in the feeding stage start to web (spin) almost immediately when placed on a fresh leaf (Fraenkel and Fallil, 1981).

Pupa: The pupation occurred inside the webbed leaves and the total pupal duration ranged between 5-7 days with an average of 6.33 days in the laboratory. The duration of male pupa varied from 3 to 4 days, with an average of 3.42 days, whereas the duration of female pupa varied from 3 to 5 days with an average of 4.32 days. The average length and breadth of pupa was 8.29 ± 0.40 and 1.36 ± 0.30 mm.

Adult: Adults were stout and medium in size. The colour varied from light reddish brown to dark reddish brown. The females lived slightly longer than the males. The total life cycle (egg to adult emergence) varied from 21 to 29 days with an average of 25.40 days. The adult female period was 5-7 days and male period was 4-6 days, respectively with an average of 6.16 days and 4.83 days.

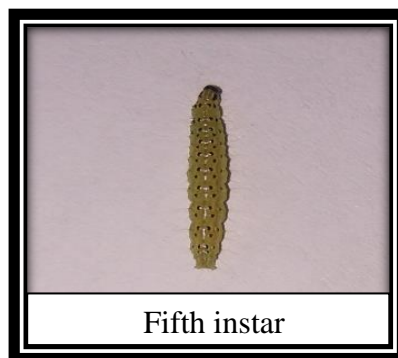
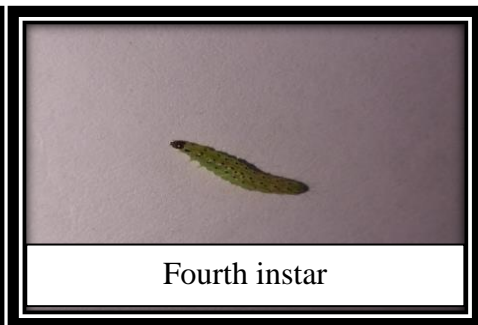
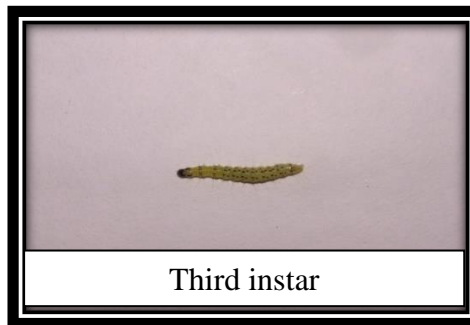
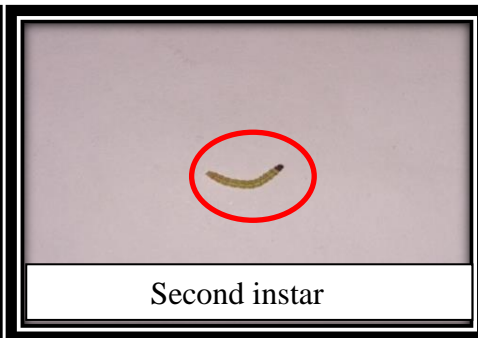
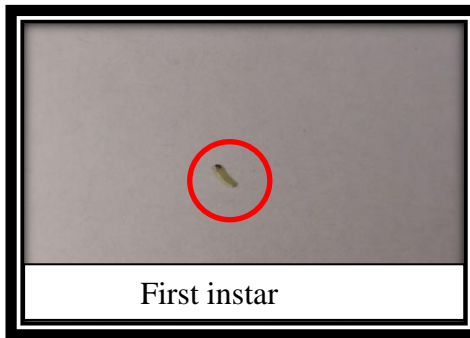


Fig.4.26: Egg mass and different larval instars of *Antigastra catalaunalis*.



Fig 4.27: Pupa and adult of *Antigastra catalaunalis*

Table 4.8: Duration of different life stages of leaf webber and capsule borer, *A. catalaunalis* on sesame crop under laboratory conditions

Biological stages	Range (days)	Mean
Fecundity (number)	39-79	58.66
Incubation period	2-3	2.34
Larval period	9-12	10.51
Pre Pupa	2-3	2.16
Pupal period	5-7	6.33
Male	3-4	3.42
Female	3-5	4.32
Total life cycle(Egg to Adult emergence)	21-29	25.40
Adult longevity		
Female	5-7	6.16
Male	4-6	4.83

The present findings are in agreement with the results of Pandey *et al.* (2018) who studied that the eggs are conical in shape and white in colour with length and width varied from 0.35 - 0.45 mm and 0.18 - 0.25 mm, respectively. Incubation period varied from 2.32 to 2.42 days. There were five larval instars and total larval period varied from 9.88 to 13.08 days. The pupal period lasted from 5.25 to 7.25 days. The average length and breadth of pupa was 7.29 ± 0.32 and 1.26 ± 0.29 mm. Adults were stout and medium in size. The colour varied from light reddish brown to dark reddish brown. The females lived slightly longer than the males. The present findings are in also agreement with the results of Choudhary *et al.* (2017) who studied that the total life cycle of *A. catalaunalis* varied from 21 to 39 days with an average of 28.1 days. The incubation period varied from 47- 73 hours with an average of 60.6 hours. The larva passed through five instars on sesame leaves under laboratory conditions.

4.3.2 Biology of til hawk moth, *Acherontia styx* on sesame crop under laboratory conditions

The following biological parameters were observed:-

Eggs: The freshly laid eggs by the female are spherical and shape and yellowish green in colour. The eggs were laid singly on upper surface of leaves. It turns into orange before hatching. Egg measures about 0.94 to 1.15 mm in length and 0.94 to 1.06 mm in breadth. Egg period lasts for 3- 5 days with an average of 4.66 days.

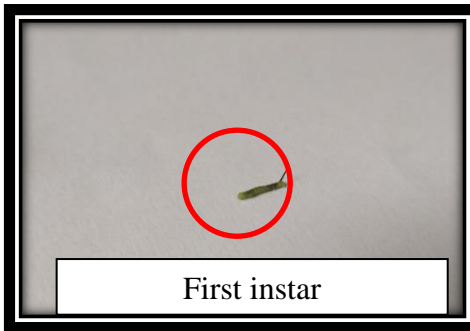
Larva:-The larvae after hatching fed on epidermal layer of the leaf tissue. Neonate larva was pale green with black colour horn at the eighth abdominal segment. Larva measured about 4.0 mm on first day and it grew up to 90 mm with a tail horn length of 10 mm before pupation. Each spiracle consisted of a black central slit, encircled with white. The total larval period completed in 17-22 days with an average of 19.50 days.

Pupa: Initially, the pupa was green in colour but later turned to brown. Pupation occurs in earthen cells. The sex of the larvae can easily be distinguished during this stage. Posterior portion of the pupa was narrow in the male and broad in the female. The genital opening in female pupa was present on the 8th abdominal segment while it was present on the 9th segment in case of male pupa. The total pupal duration ranged between 17-26 days with an average of 21.66 days in the laboratory. Pupa brownish in colour. It measured about 42-50 mm in length.

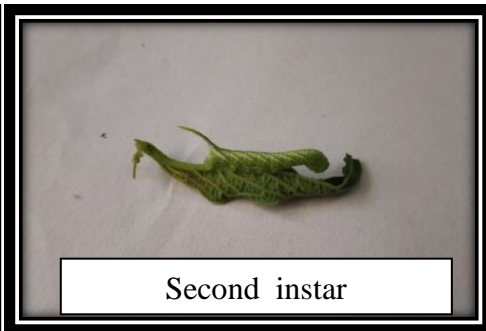
Adult: Skull like marking on thorax is the characteristic feature of the genus *Acherontia*. Forewing large and blackish brown in colour with two medial bands present on the underside and on upper side with yellowish brown streaks. The discal spot (stigma) present on upper side of forewing with orange colour. Hind wing yellow with two black bands on upper side. The adult female period was 2-3 days and male period was 3-5 days, respectively with an average of 2.50 days and 4.50 days.



Egg of *A. styx*



First instar



Second instar



Third instar



Fourth instar



Fifth instar



Larva goes into pupation

Fig 4.28: Different life stages of *Acherontia styx*

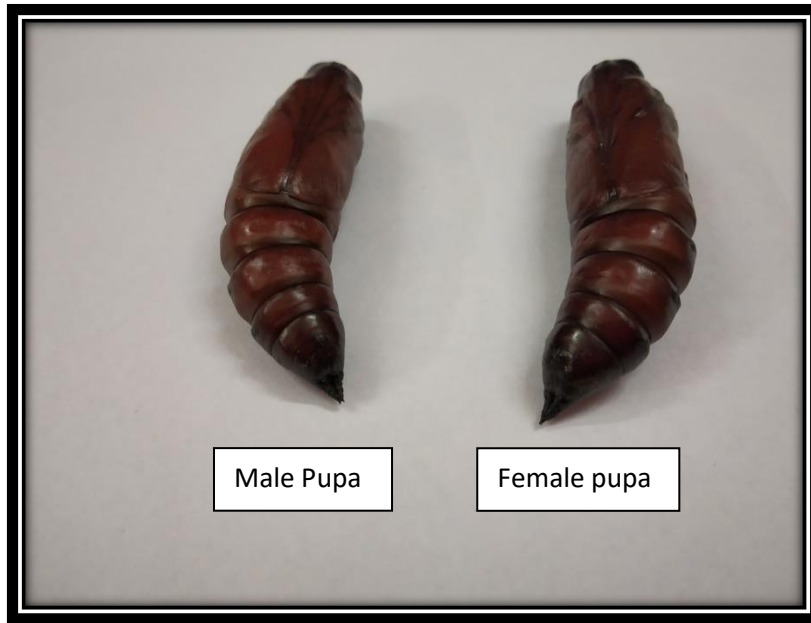


Fig. 4.29: Male and female pupae of til hawk moth *Acherontia styx*.



Fig. 4.30: Male and Female adult of til hawk moth *Acherontia styx*.

Table 4.9: Duration of different life stages of til hawk moth, *Acherontia styx* on sesame crop under laboratory conditions.

Biological stages	Range (days)	Mean
Fecundity (number)	90-200	141.33
Incubation period	3-5	4.66
Larval period	17-22	19.50
Pre Pupa	2-3	2.16
Pupal period	17-26	21.66
Total life cycle(Egg to Adult emergence)	39-56	47.50
Adult longevity		
Female	2-3	2.50
Male	3-5	4.50

The present findings are in agreement with the results of Jamuna and Ramaraju (2016) who studied that Moth stout and dark brown in colour. Thorax with characteristic skull mark. Abdominal segments with alternate black and yellow bands. The eggs were laid singly on upper surface of leaves, spherical and shape and yellowish green in colour. The present findings are also in agreement with the results of Kanaburgi (2011) who reported that the sex was easily discernible at pupal stage, based on the genital opening. Posterior portion of the pupa was narrow in the male and broad in the female. In both the sexes the abdominal segment had an anal opening or slit. In case of male the genital slit was situated on the 9th abdominal segment ventrally, which was smaller and closer to the anal opening. While in female, genital and anal openings were separated as the former was situated on the 8th abdominal segment.

One dipterous saprophagous species of genus *Saprophaga* belongs to Tachinidae family were observed on late instar larvae of *Acherontia tyx* on sesame crop during kharif 2018,.From a single larva of *Acherontia styx* 10-15 maggots of *Saprophaga* could emerge within 3-4 days after infestation.



Infested larvae of *Acherontia styx*



Saprohaga larva



Saprohaga pupae



Saprohaga adult

Fig. 4.31 Different life stages of *Saprohagous* sp.

CHAPTER-V

SUMMARY AND CONCLUSIONS

The present research work on “**Insect pest scenario and succession on sesame, *Sesamum indicum* L. crop with their relative preference on different genotypes**” were carried out during *kharif* 2018. The experiment work was undertaken at field on Research Cum Instructional Farm at IGKV, Raipur (C.G.) whereas, laboratory works were taken under controlled conditions in Department of Entomology IGKV, Raipur (C.G.). The summary of present work is given below:

5.1 Seasonal incidence and scenario of insect pests and their natural enemies.

The infestation of leaf webber and capsule borer, *Antigastra catalaunalis* started during 2nd week of August with mean population of 0.24 larva/plant. The population reached to its peak in the 3rd week of September with a mean population of 1.68 larva/plant. The correlation between leaf webber or capsule borer, *Antigastra catalaunalis* with maximum temperature showed significant positive ($r = 0.727$), significant positive correlation with sunshine hours ($r = 0.708$), while, significant negative correlation with rainfall ($r = - 0.632$).

The til hawk moth larva was appeared during 1st week of September with a mean population of 0.08 larva / plant. The population reached to its peak in the 2nd week of October with a mean population of 0.48 larva/ plant. Til hawk moth larval population showed significant positive correlation with maximum temperature ($r = 0.692$) and sunshine hours ($r = 0.757$), while, significant negative correlation with morning relative humidity ($r = - 0.727$) and evening relative humidity ($r = - 0.674$).

The highest number of leaf hoppers was seen during 2nd week of October with a mean population of 3.25 hoppers / plant. The correlation between the hoppers population and weather parameters demonstrated significant positive correlation with maximum temperature ($r = 0.658$), sunshine hours ($r = 0.641$), while leaf hoppers population showed significant negative correlation with

morning relative humidity ($r = - 0.735$), evening relative humidity ($r = - 0.723$) and wind velocity ($r = 0.679$).

The highest number of mirid bug was seen during 1st week of September (4.86 bug / plant). The correlation between the mirid bug population and weather parameters demonstrated significant negative correlation with wind velocity ($r = 0.662$). The mirid bug population also showed significant negative correlation with rainfall ($r = 0.632$).

The highest number of green stink bug was seen during 4th week of September (3.8 bug / plant). The correlation between the green stink bug population and weather parameters demonstrated significant positive correlation with maximum temperature ($r = 0.727$) and sunshine hours ($r = 0.682$).

Among natural enemies coccinellid beetles, cantheconid bug and spiders were observed during the study period. The maximum coccinellid beetle population were seen during 3rd week of September (0.96/plant). The maximum spider population were seen during 3rd week of September (1.08/plant). The maximum cantheconid bug population were seen during 3rd week of October (1.16/plant).

5.2 Screening of sesame genotypes against major insect pests.

Among twenty three genotypes VS-15-014 genotypes found minimum *A.catalaunalis* leaf damage (12.47%), while LT-15-16 genotype was recorded with maximum *A.catalaunalis* leaf damage (18.93%) on the crop.

The sesame leaf webber and capsule borer showed significant but negative correlation with trichome density ($r = - 0.483$) at 30DAS and negatively significant correlation with trichome density ($r = - 0.781$) at 60DAS.

Twenty three sesame genotypes was screened against leaf webber and capsule borer, *Antigastra catalaunalis* based on mean leaf, flower and pod infestation per cent by leaf webber and capsule borer, none of the genotype was highly resistant , resistant and moderately resistant whereas, TBS-11 genotypes are

susceptible and ACMS-14-007, DS-18-21, RT-383, JLS-706, AT-382, LT-15-16, GT-10, DS-18-10, RT-384, JLS-907, LT-15-26, DS-18-46, TKG-22, RT-385, LT-15-28, SVT-333, VS-15-014, JCS-2420, VS-15-007, JCS-2696, JTS-8, TBS-6 were highly susceptible.

5.3 Biology of leaf webber and capsule borer, *Antigastra catalaunalis* (Duponchel) and til hawk moth, *Acherontia styx* (Westwood).

Freshly laid eggs of leaf webber and capsule borer, *Antigastra catalaunalis* are conical in shape and white in colour. The egg measures about 0.40-0.49 mm in length and 0.20-0.25 mm in width. The fecundity ranged from 39 to 79. The incubation period ranged between 2 to 3 days with an average of 2.34 days. The total larval period completed in 9-12 days with an average of 10.51 days. The pupation occurred inside the webbed leaves and the total pupal duration ranged between 5-7 days with an average of 6.33 days. The duration of male pupa varied from 3 to 4 days, with an average of 3.42 days, whereas the duration of female pupa varied from 3 to 5 days with an average of 4.32 days. The total life cycle (egg to adult emergence) varied from 21 to 29 days with an average of 25.40 days.

The eggs of til hawk moth, *Acherontia styx* are spherical in shape and yellowish green in colour. The eggs were laid singly on upper surface of leaves. It turns into orange before hatching. Egg period lasts for 3 - 5 days with an average of 4.66 days. The total larval period completed in 17-22 days with an average of 19.50 days. Posterior portion of the pupa was narrow in the male and broad in the female. The genital opening in female pupa was present on the 8th abdominal segment while it was present on the 9th segment in case of male pupa. The total pupal duration ranged between 17-26 days with an average of 21.66 days. The adult female period was 2-3 days and male period was 3-5 days, respectively with an average of 2.50 days and 4.50 days.

Conclusions-

- The peak population of leaf eating caterpillars viz *Antigastra catalaunalis* (1.68 larva/plant) and *Acherontia styx* (0.48 larva/plant) were seen during 3rd week of September, and 2nd week of October, respectively.
- The peak population of sucking pests viz. leaf hoppers (3.25 hoppers / plant), mirid bug (4.86 bug/plant) and green stink bug (3.8 bug / plant) were seen during 2nd week of October, 1st week of September and 4th week of September, respectively.
- Natural enemies found on sesame during study period are coccinellid beetles and cantheconid bug. Among non-insect natural enemies spiders were observed throughout the study period. *Cheilomenes sexmaculata* contributed 52.77 per cent during the crop period. After that *Coccinella transversalis* contributed 34.25 per cent population followed by *Micraspis sp.* (12.96 per cent).
- Twenty three sesame genotypes are screened against leaf webber and capsule borer, *Antigastra catalaunalis* . On the per cent leaf , flower and pod damage basis, genotypes ACMS-14-007, DS-18-21, RT-383, JLS-706, AT-382, LT-15-16, GT-10, DS-18-10, RT-384, JLS-907, LT-15-26, DS-18-46, TKG-22, RT-385, LT-15-28, SVT-333, VS-15-014, JCS-2420, VS-15-007, JCS-2696, JTS-8 and TBS-6 were comes under highly susceptible. Whereas, TBS-11 comes under susceptible. None of the genotypes was highly resistant, resistant and moderately resistant.
- The biology study of leaf webber and capsule borer, *Antigastra catalaunalis* were recorded on sesame and it was seen that the the incubation period of the eggs ranged from 2 to 3 days with an average of 2.34 days. The total larval period completed in 9-12 days with an average of 10.51days. The pupation occurred inside the webbed leaves and the total pupal duration ranged between 5-7 days with an average of 6.33 days. The total life cycle (egg to adult emergence) varied from 21 to 29 days with an average of 25.40 days.

- The biology study of til hawk moth, *Acherontia styx* were recorded on sesame and it was seen that the egg period from 3 - 5 days with an average of 4.66 days. The total larval period completed in 17-22 days with an average of 19.50 days. The total pupal duration ranged between 17-26 days with an average of 21.66 days. The adult female period was 2-3 days and male period was 3-5 days, respectively with an average of 2.50 days and 4.50 days.

- **SUGGESTIONS FOR FUTURE RESEARCH WORKS**
 1. The study should be repeated for two or more years to verify result and conclusions.
 2. Behaviour and biology should be studied in detailed so that it will help in detailed study of beneficial insects and natural enemies.
 3. Large scale trials should be conducted to compare the efficacy of different biorational insecticides against major insect pests on sesame.
 4. Detailed studies on larval parasitoid should be taken for the effective control of leaf webber and capsule borer and til hawk moth larvae.

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Appendix-A: Per cent leaf damage caused by leaf webber and capsule borer, *Antigastra catalaunalis* during kharif 2018.

Genotype	Date of observation										Overall mean
	15/8/18	20/8/18	27/8/18	03/09/18	10/09/18	17/09/18	24/09/18	1/10/18	8/10/18	15/10/18	
ACMS-14-007	6.25 (14.44)	10.67 (19.04)	11.71 (19.99)	1.9 (7.72)	11.59 (19.88)	13.2 (21.28)	14.71 (22.53)	20.4 (26.83)	18.67 (25.58)	18.55 (25.49)	12.82
DS-18-21	7.5 (15.79)	14.71 (22.53)	7.27 (15.61)	2.89 (9.68)	11.59 (19.88)	14.34 (22.23)	16.94 (24.28)	18.06 (25.13)	19.67 (26.31)	20.28 (26.75)	17.04
RT-383	8.89 (17.32)	11.57 (19.86)	16.23 (23.74)	2.7 (9.34)	12.83 (20.97)	11.6 (19.89)	18.07 (25.14)	18.55 (25.49)	19.35 (26.08)	40.57 (39.54)	13.57
JLS-706	9.13 (17.56)	13.25 (21.32)	13.47 (21.51)	8.57 (16.99)	14.24 (22.15)	11.18 (19.51)	15.83 (23.42)	20.28 (26.75)	16 (23.56)	35.76 (36.71)	16.14
AT-382	8.89 (17.32)	11.57 (19.86)	16.23 (23.74)	8.33 (16.75)	11.59 (19.88)	12.01 (20.26)	16.53 (23.97)	21.12 (27.34)	17.28 (24.54)	32.94 (35.00)	15.63
LT-15-16	9.13 (17.56)	13.25 (21.32)	13.47 (21.51)	7.5 (15.86)	12.01 (20.26)	11.69 (19.97)	16.85 (24.22)	16 (23.56)	17.79 (24.93)	40 (39.21)	18.93
GT-10	11.01 (19.37)	9.13 (17.56)	18.55 (25.49)	6.25 (14.44)	10.67 (19.04)	11.71 (19.99)	18.55 (25.49)	19.13 (25.92)	18.83 (25.70)	36.44 (37.11)	15.32
DS-18-10	13.58 (21.60)	11.77 (20.04)	16.4 (23.87)	7.5 (15.86)	14.71 (22.53)	7.27 (15.63)	13.83 (21.81)	14.18 (22.10)	14.23 (22.14)	37.81 (37.92)	18.59
RT-384	8.89 (17.32)	11.57 (19.86)	16.23 (23.74)	1.9 (7.72)	11.55 (19.84)	12.01 (20.26)	16.85 (24.22)	16 (23.56)	22.18 (28.08)	36.54 (37.17)	17.56
JLS-907	9.13 (17.56)	13.25 (21.32)	13.47 (21.51)	2.43 (8.83)	11.57 (19.86)	10.67 (19.04)	14.76 (22.57)	21.16 (27.37)	18.68 (25.59)	34.11 (35.71)	18.17
LT-15-26	1.96 (7.85)	2.78 (9.48)	2.7 (9.34)	2.54 (9.04)	13.29 (21.36)	12.32 (20.53)	13.84 (21.82)	19.76 (26.37)	18.07 (25.14)	37.45 (37.71)	15.4
DS-18-46	7.27 (15.61)	11.59 (19.88)	17.07 (24.38)	2.65 (9.25)	11.56 (19.85)	12.56 (20.73)	18.55 (25.49)	17.45 (24.67)	22.18 (28.08)	39.14 (38.71)	18.33

TKG-22	12.14 (20.37)	11.59 (19.88)	17.07 (24.38)	0.58 (4.35)	12.01 (20.26)	12.01 (20.26)	16.23 (23.74)	17.45 (24.67)	15.84 (23.43)	56.44 (48.68)	17.14
RT-385	7.27 (15.61)	12.95 (21.07)	17.07 (24.38)	2.23 (8.43)	11.01 (19.35)	9.13 (17.56)	18.55 (25.49)	22.18 (28.08)	17.45 (24.67)	65.44 (53.97)	16
LT-15-28	7.27 (15.61)	13.58 (21.60)	15.83 (23.42)	2.03 (8.01)	13.58 (21.60)	11.77 (20.05)	16.4 (23.87)	19.02 (25.84)	19.07 (25.87)	35.44 (36.51)	12.73
SVT-333	10.88 (19.20)	10.26 (18.66)	19.76 (26.37)	2.38 (8.73)	10.26 (18.66)	12.14 (20.37)	14.71 (22.53)	18.07 (25.14)	17.82 (24.95)	65.44 (53.97)	14.92
VS-15-014	7.27 (15.61)	13.58 (21.60)	15.83 (23.42)	1.96 (7.85)	12.71 (20.86)	11.59 (19.88)	16.57 (24.00)	19.03 (25.85)	20.61 (26.98)	56.44 (48.68)	12.47
JCS-2420	10.88 (19.20)	10.26 (18.66)	19.76 (26.37)	3.23 (10.26)	12.81 (20.95)	12.01 (20.26)	14.71 (22.53)	18.72 (25.62)	18.07 (25.14)	65.44 (53.97)	15.37
VS-15-007	8.89 (17.32)	11.57 (19.86)	16.23 (23.74)	2.78 (9.48)	12.01 (20.26)	11.77 (20.04)	16.4 (23.87)	19.02 (25.84)	19.09 (25.89)	35.44 (36.51)	15.13
JCS-2696	9.13 (17.56)	13.25 (21.32)	13.47 (21.51)	7.5 (15.86)	10.97 (19.32)	11.54 (19.84)	18.07 (25.14)	19.68 (26.32)	20.2 (26.69)	65.44 (53.97)	16.03
JTS-8	7.27 (15.61)	13.58 (21.60)	15.83 (23.42)	3.23 (10.26)	10.67 (19.04)	11.13 (19.46)	14.76 (22.57)	21.16 (27.37)	18.68 (25.59)	40 (39.21)	15.77
TBS-6	10.88 (19.20)	10.26 (18.66)	19.76 (26.37)	2.78 (9.48)	13.84 (21.82)	11.59 (19.88)	18.07 (25.14)	19.76 (26.37)	18.07 (25.14)	36.44 (37.11)	15.65
TBS-11	12.32 (20.5)	13.84 (21.82)	19.76 (26.37)	7.5 (15.86)	12.56 (20.73)	12.01 (20.26)	14.1 (22.03)	20.05 (26.58)	19.45 (26.15)	37.81 (37.92)	15.77
C.D.	2.136	0.31	0.37	0.80	0.50	0.68	0.48	0.26	0.43	0.26	
SE(m)	0.747	0.11	0.13	0.28	0.17	0.24	0.168	0.09	0.15	0.09	

***() figures in parentheses are angular transformed**

**Appendix-B: Per cent flower bud damage caused by leaf webber and capsule borer,
Antigastra catalaunalis during *Kharif* 2018.**

Genotype	Date of observation					Overall mean
	03/09/18	10/09/18	17/09/18	24/09/18	1/10/18	
ACMS-14-007	6.66 (14.92)	31.71 (34.25)	27.04 (31.31)	30.37 (33.42)	38.66 (38.42)	26.89
DS-18-21	16.66 (24.07)	34.75 (36.10)	29.19 (32.68)	32.52 (34.75)	43.19 (41.06)	31.26
RT-383	40 (39.13)	31.57 (34.17)	31.57 (34.17)	32.52 (34.75)	43.19 (41.06)	35.77
JLS-706	0 (0)	35.86 (36.77)	30.3 (33.38)	31.26 (33.97)	41.93 (40.33)	27.87
AT-382	33.33 (35.24)	34.9 (36.19)	27.12 (31.36)	30.46 (33.48)	38.75 (38.48)	32.91
LT-15-16	16.66 (24.07)	30.3 (33.38)	24.75 (29.81)	28.08 (31.98)	38.75 (38.48)	27.71
GT-10	11.33 (19.65)	33.88 (35.58)	26.07 (30.68)	29.41 (32.82)	40.08 (39.26)	28.15
DS-18-10	40 (39.13)	45.41 (42.34)	34.75 (36.10)	38.08 (38.08)	46.37 (42.90)	40.92
RT-384	28.54 (32.27)	38.59 (38.38)	33.04 (35.07)	25.7 (30.44)	36.37 (37.07)	32.45
JLS-907	40 (39.13)	36.75 (37.3)	32.08 (34.48)	35.41 (36.50)	46.08 (42.73)	38.06
LT-15-26	3.33 (10.43)	38.08 (38.08)	32.52 (34.75)	35.86 (36.77)	44.15 (41.62)	30.79
DS-18-46	16.55 (23.99)	40.82 (39.69)	30.15 (33.28)	33.48 (35.33)	41.54 (40.11)	32.58

TKG-22	33.33 (35.24)	37.12 (37.52)	31.57 (34.17)	34.9 (36.19)	43.19 (41.06)	36.02
RT-385	40 (39.13)	35.33 (36.45)	24.59 (29.71)	28 (31.93)	38.66 (38.42)	33.33
LT-15-28	3.33 (10.43)	39.12 (38.69)	28.46 (32.22)	29.41 (32.82)	36.75 (37.3)	27.41
SVT-333	16.66 (24.07)	32.59 (34.79)	32.59 (34.79)	33.55 (35.38)	44.22 (41.66)	31.92
VS-15-014	40 (39.13)	52.82 (46.59)	42.15 (40.46)	34.82 (36.14)	43.11 (41.02)	42.58
JCS-2420	40 (39.13)	45.41 (42.34)	34.75 (36.10)	38.08 (38.08)	45.41 (42.34)	40.73
VS-15-007	11.33 (19.65)	32.88 (34.97)	22.22 (28.10)	25.55 (30.34)	36.22 (36.98)	25.64
JCS-2696	40 (39.13)	40.97 (39.78)	30.3 (33.38)	30.5 (33.50)	40.97 (39.78)	36.51
JTS-8	33.33 (35.24)	39.12 (38.69)	36.75 (37.3)	29.41 (32.82)	40.08 (39.26)	35.74
TBS-6	40 (39.13)	34.9 (36.19)	29.34 (32.78)	33.64 (35.43)	41.93 (40.33)	35.96
TBS-11	16.66 (24.07)	46.44 (42.94)	35.77 (36.71)	34.44 (35.91)	45.11 (42.17)	14.68
C.D.	4.11	0.024	0.042	0.082	0.21	
SE(m)	1.437	0.008	0.015	0.029	0.075	

* () figures in parentheses are angular transformed

**Appendix-C: Per cent capsule/pod damage caused by leaf webber and capsule borer,
Antigastra catalaunalis during *kharif* 2018.**

Genotype	Date of observation						Overall mean
	10/09/18	17/09/18	24/09/18	1/10/18	8/10/18	15/10/18	
ACMS-14-007	23.52 (28.99)	16 (23.56)	19.35 (26.08)	14.89 (22.68)	18 (25.08)	22.44 (28.26)	19.03
DS-18-21	13.04 (21.15)	16.66 (24.07)	13.51 (21.54)	13.95 (21.91)	17.02 (24.35)	20.4 (26.83)	15.76
RT-383	9.09 (17.52)	5.88 (13.99)	12.11 (20.34)	11.9 (20.16)	15.55 (23.20)	18.36 (25.35)	11.98
JLS-706	21.05 (27.29)	12.5 (20.68)	5.71 (13.78)	5.88 (13.99)	9.43 (17.86)	12.72 (20.87)	11.22
AT-382	12.5 (20.68)	23.07 (28.69)	18.18 (25.22)	7.24 (15.57)	10 (18.41)	12.85 (20.98)	13.97
LT-15-16	7.69 (16.07)	5.26 (13.21)	13.15 (21.24)	7.4 (15.75)	10.71 (19.08)	14.03 (21.98)	9.71
GT-10	4.76 (12.55)	9.52 (17.94)	13.33 (21.39)	4.54 (12.24)	7.35 (15.70)	10.6 (18.98)	8.35
DS-18-10	5.26 (13.21)	18.75 (25.64)	5.71 (13.78)	4.91 (12.75)	7.46 (15.82)	10.42 (18.80)	8.84
RT-384	8.33 (16.75)	6.66 (14.92)	6.06 (14.21)	7.69 (16.07)	11.62 (19.91)	16.66 (24.07)	9.50
JLS-907	11.53 (19.83)	16.66 (24.07)	14.28 (22.18)	6.81 (15.09)	10.2 (18.60)	15.9 (23.48)	12.56
LT-15-26	19.04 (25.85)	16.66 (24.07)	16.66 (24.07)	8.69 (17.12)	10.9 (19.25)	16 (23.56)	14.66

DS-18-46	5.26 (13.21)	11.76 (20.03)	17.14 (24.44)	9.8 (18.22)	12.28 (20.49)	18 (25.08)	12.37
TKG-22	12.5 (20.68)	6.25 (14.44)	5.88 (13.99)	4.08 (11.59)	8.54 (16.96)	10.9 (19.25)	7.86
RT-385	7.69 (16.07)	7.69 (16.07)	13.15 (21.24)	11.11 (19.45)	13.11 (21.21)	16.94 (24.28)	11.62
LT-15-28	5.88 (13.99)	10.52 (18.90)	13.33 (21.39)	7.57 (15.94)	9.72 (18.14)	13.04 (21.15)	10.01
SVT-333	12.5 (20.68)	9.52 (17.94)	5.26 (13.21)	18.75 (25.64)	11.62 (19.91)	5.88 (13.99)	10.59
VS-15-014	5.26 (13.21)	12.5 (20.68)	8.33 (16.75)	6.66 (14.92)	10.2 (18.60)	13.15 (21.24)	9.35
JCS-2420	6.66 (14.92)	6.66 (14.92)	12.53 (20.71)	16.66 (24.07)	10.9 (19.25)	13.33 (21.39)	10.96
VS-15-007	7.69 (16.07)	16.66 (24.07)	19.34 (26.06)	16.66 (24.07)	12.28 (20.49)	5.26 (13.21)	12.93
JCS-2696	9.52 (17.94)	16.66 (24.07)	5.26 (13.21)	11.76 (20.03)	7.54 (15.90)	8.33 (16.75)	9.85
JTS-8	6.66 (14.92)	5.58 (13.65)	19.04 (25.85)	6.25 (14.44)	16.66 (24.07)	12.53 (20.71)	11.00
TBS-6	5.88 (13.99)	12.5 (20.68)	13.04 (21.15)	7.69 (16.07)	11.76 (20.03)	16.66 (24.07)	11.26
TBS-11	12.5 (20.68)	5.26 (13.21)	9.09 (17.52)	10.52 (18.90)	6.25 (14.44)	15.9 (23.48)	7.92
C.D.	0.33	0.51	0.55	0.33	0.39	0.42	
SE(m)	0.11	0.17	0.19	0.11	0.13	0.14	

*() figures in parentheses are angular transformed

**Appendix-D: Weekly meteorological data during the crop period
2018-19**

WR No.	Date	Max. Temp. (°C)	Min. Temp. (°C)	Rain fall (mm)	Relative Humadity (%)	Wind Velocity (Km/h)	Evaporation (mm)	Sun Shine (hours)
30	23-29	28.64	25.0	51.4	88 76	8.1	2.2	0.1
31	30-05	31.9	25.4	31.0	88 67	6.5	26.9	2.3
32	Aug 06-12	30.0	24.8	103.4	92 88	5.8	20.2	1.2
33	13-19	30.3	25.3	101.2	94 79	4.1	24.7	2.9
34	20-26	29.0	24.6	60.4	93 79	5.5	18.0	0.6
35	27-02	28.3	24.1	275.0	96 86	6.8	14.7	0.2
36	Sep 03-09	29.2	23.9	30.2	93 57	0.5	22.7	1.1
37	10-16	32.6	25.1	0.0	90 55	2.2	25.3	6.4
38	17-23	31.0	24.1	32.8	92 68	3.5	19.2	3.6
39	24-30	32.9	25.0	11.0	93 59	1.2	25.6	7.8
40	Oct 01-07	34.0	23.8	0.0	91 44	0.7	28.1	8.0
41	08-14	32.4	22.8	0.0	87 51	2.8	26.8	7.1
42	15-21	33.4	21.3	0.0	89 40	1.0	23.6	8.5
43	22-28	32.9	18.9	0.0	86 48	1.1	25.1	8.3
44	29-04	31.0	19.6	0.0	86 49	2.6	28.8	9.3
45	Nov 05-11	32.3	17.7	0.0	84 34	1.2	23.3	8.5
46	12-18	31.5	14.4	0.0	86 29	1.1	23.3	9.1
47	19-25	31.4	15.3	0.0	88 28	1.1	23.3	7.8

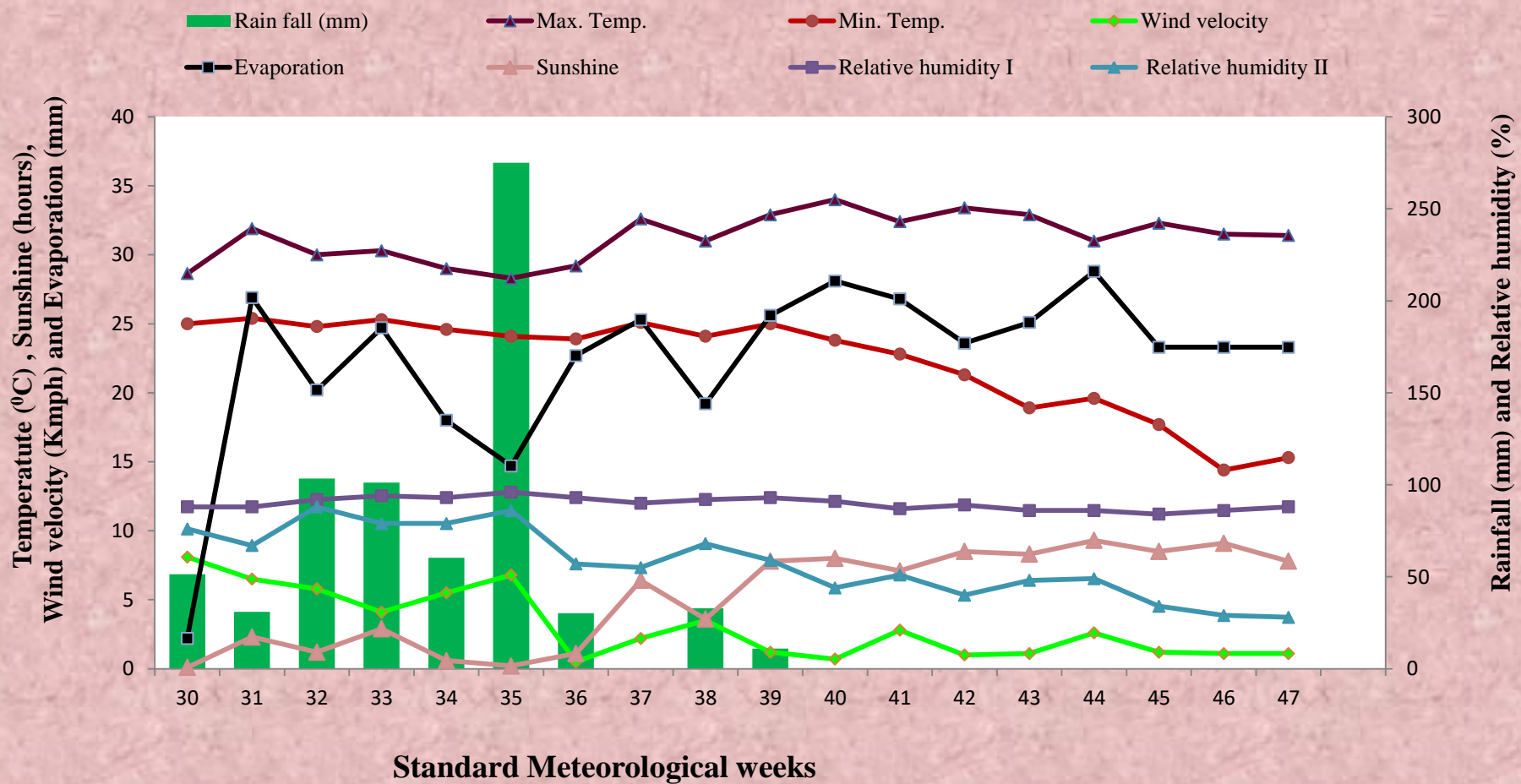


Fig : Weekly meteorological data recorded during the crop growth

RESUME

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