

**“SEASONAL INCIDENCE, BIOLOGY AND MANAGEMENT OF  
LEAF EATING CATERPILLAR, *Catopsilia pyranthe* (L) ON INDIAN  
SENNA, *Cassia angustifolia* (Vahl)”**

By

**Mr. Mali Ramu Shivappa**

(Reg.No.018/150)

A thesis submitted to the

**MAHATMA PHULE KRISHI VIDYAPEETH,  
RAHURI - 413 722, DIST. AHMEDNAGAR,  
MAHARASHTRA, INDIA**

in partial fulfilment of the requirements for the degree

of

**MASTER OF SCIENCE (AGRICULTURE)**

in

**AGRICULTURAL ENTOMOLOGY**



**DEPARTMENT OF AGRICULTURAL ENTOMOLOGY**

**POST GRADUATE INSTITUTE  
MAHATMA PHULE KRISHI VIDYAPEETH,  
RAHURI - 413 722, DIST. AHMEDNAGAR,  
MAHARASHTRA, INDIA**

**2021**

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**2021**

## CANDIDATE'S DECLARATION

*I hereby declare that this thesis or part  
thereof has not been submitted  
by me or other person to any  
other University or Institute  
for a Degree or  
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This is to certify that the thesis entitled, “ **SEASONAL INCIDENCE, BIOLOGY AND MANAGEMENT OF LEAF EATING CATERPILLAR, *Catopsilia pyranthe* (L) ON INDIAN SENNA, *Cassia angustifolia* (Vahl)**” submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra) in partial fulfilment of the requirements for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE) in AGRICULTURAL ENTOMOLOGY**, embodies the results of a piece of bonafide research work carried out by **Mr. Mali Ramu Shivappa**, under my guidance and supervision and that no part of the thesis has been submitted to any other University for Degree or Diploma.

The assistance and help received during the course of this investigation have been duly acknowledged.

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## LIST OF ABBREVIATIONS AND SYMBOLS

Abbreviations	:	Title
$^{\circ}\text{C}$	:	Degree celcius
CD	:	Critical Difference
mm	:	Milimeter (s)
cm	:	Centimetre (s)
DBS	:	Days before spraying
DAS	:	Days after spraying
Var	:	Variety
WP	:	Wettable Powder
e.g.	:	Exempli gratia, For example
et al.	:	Etalia and others
etc.	:	Etcetera
G	:	Gram (s)
Ha	:	Hectare (s)
Hr	:	Hour (s)
i.e.	:	Idest, that is
Kg	:	Kilogram (s)
lit.	:	Litre (s)
M	:	Meter
Mg	:	Milligram (s)
ml	:	Milliliter (s)
MPKV	:	Mahatma PhuleKrishiVidyapeeth
MW	:	Meterological Week
Wt	:	Weight
NS	:	Non- significant
Qt	:	Quintal (s)
Rh	:	Ralative humidity
SE	:	Standard Error
q/ha	:	Quintals per hectare

RBD	:	Randomized Block Design
R.H.	:	Relative humidity
SE	:	Standard error
Temp	:	Temperature
Tr. No.	:	Treatment number
S.E.	:	Standard Error
No.	:	Number
viz.,	:	Videlicet (Namely)
N	:	North
%	:	Per cent
/	:	Per
@	:	at the rate of
+, -	:	Plus, minus
t	:	Ton

## ABSTRACT

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### “SEASONAL INCIDENCE, BIOLOGY AND MANAGEMENT OF LEAF EATING CATERPILLAR, *Catopsilia pyranthe* (L) ON INDIAN SENNA, *Cassia angustifolia* (Vahl)”

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2021

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<b>Research Guide</b>	<b>:</b>	<b>Prof. B.Y. Pawar</b>
<b>Department</b>	<b>:</b>	<b>Agricultural Entomology</b>

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The leaf eating caterpillar, *Catopsilia pyranthe* (L) (family – Caesalpinaceae, order - Lepidoptera) is major pest of Indian senna in Maharashtra. The biology and morphometric parameters of leaf eating caterpillar were studied at Post Graduate Laboratory, Department of Agricultural Entomology, MPKV, Rahuri during *khariif* 2019 and the research work on seasonal incidence and management of leaf eating caterpillar were conducted during *khariif* 2019 at the Farm of AICRP on MAP&B, MPKV, Rahuri. The experiment on management studies was laid out in randomized block design with three replications and seven treatments with view to evaluate biorationals and biopesticides against leaf eating caterpillar.

The studies on seasonal incidence of leaf eating caterpillar indicated that the incidence of leaf eating caterpillar was initiated from the last week of July (30<sup>th</sup> MW) and remained continuous up to first week of December (49<sup>th</sup> MW). The data revealed that average number larvae of leaf eating caterpillar per plant ranged from 0.4-26.4 during the entire period. The incidence of leaf eating caterpillar starts in the month of July, 2019. The incidence gradually increased up to the fourth week of October and reached its peak i.e. 26.4 larvae/plant. During peak infestation level of leaf eating caterpillar, the maximum and minimum temperature,

morning and evening relative humidity and rainfall were 31.1°C, 18.4°C, 76%, 46% and 23.4 mm, respectively. Thereafter, population declined gradually from 3<sup>rd</sup> week of November (47<sup>th</sup> MW) and remained up to 0.8% in first week of December (49<sup>th</sup> MW).

Correlation between leaf eating caterpillar population and weather parameters indicated that the significant negative correlation with minimum temperature, wind velocity and rainfall, Sunshine hour had a non significant positive correlation. evaporation while other all parameters like, maximum temperature, RH-morning and evening were non significant negatively correlated with the leaf eating caterpillar population.

The result on biology of leaf eating caterpillar revealed that female moth of *Catopsilia pyraetha* laid eggs singly on upper and lower side of leaves. The incubation period of eggs ranged from 2 to 4 days with mean duration of 3.06 days. The average length and width of egg was measured to be 2.94 and 1.13 mm, respectively. The larval period and pupal period was observed to be, 16.32 and 6.34 days, respectively. The total life span was observed to be 32.65 days. Female has broader black apical margins and traces of a black costal border on the fore wing. Hind wing also have a black border. The male has black apical border on the forewing, and no marking on the hind wing.

As regards, the management of leaf eating caterpillar, all treatments were found to be effective against leaf eating caterpillar. The treatment T<sub>5</sub> (*Bt Bacillus thuringiensis* @ 2ml / lit. water) proved to be significantly superior over all other treatment and found at par with treatment T<sub>3</sub> Azadiractin 10000 ppm @ 2ml /lit.water.

As regards yield and economics, amongst all treatments, the higher dry herbage yield of 16.06 qt. per ha was recorded by T<sub>5</sub> *Bt (Bacillus thuringiensis* @ 2ml/ lit. of water) . Highest ICBR (1:11.13) was recorded in T<sub>5</sub> *Bt (Bacillus thuringiensis* @ 2ml/ lit. of water). All other treatments were also significantly superior in respect to yield and incremental cost benefit ratio (ICBR) over control.

## 1. INTRODUCTION

Indian Senna (*Cassia angustifolia* Vahl), is a perennial shrub of high medicinal importance belongs to the family Caesalpinaceae is a small 1-2 m high under shrub. It was introduced into Tamil Nadu in the eighteenth century where it is grown as an annual crop of 5 to 7 months duration both under rainfed and irrigation conditions. Now it is commercially cultivated in about 20,000 ha land (Paul and Dasgupta, 2014) in Jodhpur (Rajasthan), Mehasana (Gujrat), Tirunelvels, Ramanthapuram and Madurai districts (Tamil Nadu). Parts of Karnataka, Andhra Pradesh and Maharashtra producing 10,000 metric tonnes of leaves (Planning Commission Report GOI, 2007). India earns approximately 7.63 million US dolloars from export of Senna leaves and pods (Uniyal, 2005).

The leaves and pods are the economic parts containing sennosides which are responsible for its laxative properties. Senna is used in medicine as a cathartic. It is especially useful in habitual constipation. It increases the peristaltic movement of the colon. It lowers bowels, increases peristaltic movements of the colon by its local action upon the intestinal wall. It is used as expectorant, wound dresser, antidysentric, carminative and laxative. It is also useful in loss of appetite, hepatomegaly, splenomegaly, indigestion, malaria, skin diseases, jaundice and anaemia. Seeds are used for propagation and it is normally cultivated as post kharif crop (Annual Report, 2013-14, DMAPR, Anand). The pods have the tendency to gripe caused by senna may be obtained by combining it with an aromatic or a saline laxative. The laxative principles of senna are two glycosides, viz., sennoside A and sennoside B. The plant also contains sennosides C and D. A number of other glycosides have also been reported. It also contains beta-sterol (0.33 %) and flavanols-kaemferol, kaempferin and isorhamnetin. They are used in the form of decoctions, powders; confections and many other household preparations. Senna extracts, on storage, lose biological activity more rapidly than is revealed by chemical estimation. The leaves/pods as such or in powder form do not lose potency easily. The quantity administered in the form of infusion ranges from 0.6 to 2 g of leaves or pods soaked in 125 ml of warm water for about 12 hours, whereas, it is usually 30 mg of sennosides per tablet.

*Catopsilia pyranthe* (L) the mottled emigrant butterfly has been reported as a major defoliator of senna when cultivated in North India (Singh et al., 1984). Chaudhary and Saravanan (2009), reported that this pest is regular throughout the year on Senna and is a major pest in the charotar area (Anand) of Gujarat. Eggs are laid singly on young, soft and light green leaves at the terminal parts of growing stem (Atluri et al., 2012). The fourth and fifth instar larvae consume more food, egested more faeces and gained more weight than other instars (Atluri et al., 2004). The crop was reported to be attacked by green leaf caterpillars (*C. pyranthe* (L) and (*Eurema hecabe* (L), Aphids (*Toxoptera odinae* Treit and, *Aphis gossypii* Glover) Spiny pod borer (*Etiella zinckniella* Treit) and Red gram pod fly (*Melanagromyza Obtusa* Malloch) in field and cigarette beetle (*Lasioderma sericorne* Fb.) in storage (Murali et al., 2008 and Rani and Kalyanasundaram, 2006). Till today, there are no comprehensive management strategies for this pest. Most of control measures carried out against this green caterpillar was the manipulation of planting time to avoid its occurrence and the use of chemical insecticides which leaves residue in the raw material causing health hazards and also having adverse effect on the export potential of this crop (Singh et al., 1984). Hence it is urgent need to develop and integrated pest management (IPM) module for managing this important pest of Senna so as to reduce the yield loss without reduction in quality of leaves.

Unwanted use of plant protection chemicals can lead to the residue problems which are having zero tolerance in the international market. Therefore, it is necessary to study the biology of leaf eating caterpillar so that, it could managed effectively.

Pesticides are being used extensively in the control of crop pests. Synthetic insecticides are used widely for the control of various insect pests because they can be applied whenever and wherever needed, economical and most important thing is the reliability of control method. Hence, the production and consumption of pesticides has greatly increased in recent years. The contribution of pesticides to increase agricultural production cannot be denied, but synthetic pesticides have also caused unprecedented ecological damage, also induced serious health hazard among workers during manufacture, formulation and field applications. To overcome the problems of

synthetic chemical hazards, one of the best control measures is the use of plant origin products and biopesticides

Keeping this in view, research was undertaken entitled with “Seasonal incidence, biology and management of leaf eating caterpillar, *Catopsilia pyranthe* (L) On Indian senna, *Cassia angustifolia* (Vahl)” during kharif -2019-20 by using bio-pesticides and plant products with following objectives –

- i. To study seasonal incidence of leaf eating caterpillar, *catopsilia pyranthe* (L) on Indian senna.
- ii. To study biology of leaf eating caterpillar, *Catopsilia pyranthe* (L).
- iii. To evaluate biopesticides and biorationals against leaf eating caterpillar on Indian senna.

## 2. REVIEW OF LITERATURE

Leaf eating caterpillar, *Catopsilia pyranthe* (L) is important pest of Indian senna which causes quantitative as well as qualitative damage to the crop throughout the growing period. The studies on various aspects of this pest have been attempted by some researchers previously. Nevertheless, review on management of leaf eating caterpillar was found negligible.

Hence, literature has been reviewed under each aspect of present study irrespective of Indian senna crops. Review thus made is as under.

### 2.1 Seasonal Incidence of Leaf Eating Caterpillar

Chaudhary and Sarvanan (2013) was observed the incidence of *Catopsilia pyranthe* (L) throughout the year in Gujarat, except winter months of December to February. The activity of the pest was more during second fortnight of June to October and maximum population of adults as well as eggs and larvae were observed during September to October coinciding with south west monsoon (June-September).

DMAPR Annual Report (2013-14) reported that The occurrence of *Catopsilia pyranthe* in senna was recorded during September 2012 to August 2013. The egg count and larval counts were taken per plant and the pest incidence was correlated with weather factors like maximum temperature, minimum temperature, maximum relative humidity and minimum relative humidity. Positive correlation was obtained between pest incidence and weather factors. *Catopsilia pyranthe* was prevalent all through the year except during the months of December, January and February. During the month of March, the population of *Catopsilia* started building up, and it reached maximum during the months of June, July, September and October

Infestation of leaf eating caterpillar *Catopsilia pyranthe* (L) was observed on Indian senna, *Cassia angustifolia* (Vahl), during 38<sup>th</sup> to 50<sup>st</sup> met. week in 2015. Maximum number of larvae i.e. 14.8 larvae/plant was observed during 44<sup>st</sup> met. week 2015, when average maximum temperature was 32.2<sup>0</sup>C and average minimum temperature was 17.4<sup>0</sup>C and average morning relative humidity was 57 per cent and average evening relative humidity was 37 per cent at MPKV, Rahuri centre (Annual

report, 2015-16, AICRP on MAP&B, ICAR-Directorate of Medicinal and Aromatic Plants Research, Boriavi Anand).

Thania (2015) reported the larvae of the mottled emigrant butterfly, *Catopsilia pyranthe* (L) has been reported as a major defoliator in Indian Senna. The economic threshold levels (ETL) of the pest were determined in the Senna crop at 45 days after sowing (DAS) and at 75 DAS. At 45 DAS the ETL level was found to be 3.3 larvae/plant and 75 DAS 7.9 larvae/plants

Infestation of leaf eating caterpillar *Catopsilia pyranthe* (L) was observed on Indian senna, *Cassia angustifolia* (Vahl), during 30<sup>th</sup> to 51<sup>st</sup> met. week in 2016.i.e from july second week upto December last week and Maximum number of larvae i.e. 9.8 larvae/plant was observed during 41<sup>st</sup> met. week 2016 (October second week) when average maximum temperature was 31.6<sup>0</sup>C and average minimum temperature was 20.6<sup>0</sup>C and average morning relative humidity was 80 per cent and average evening relative humidity was 53 per cent at MPKV, Rahuri centre (Annual report, 2016-17, AICRP on MAP & B, ICAR-Directorate of Medicinal and Aromatic Plants Research, Boriavi Anand).

## **2.2 Biology of Leaf Eating Caterpillar, *Catopsilia pyranthe* (L) on Indian Senna**

Chaudhary and Sarvanan (2013) Studies on life history of the pest revealed that the developmental period from egg to adult emergence spanned over 20-29 days with several overlapping generations in the study area with incubation period 3-4 days, first instar lasted for 2-3 days, second instar lasted for 2-3 days, third instar lasted for 2-4 days, fourth instar lasts for 3-4 days, fifth instar lasts for 4-5 days, pupal stage lasts for 6-7 days.

Arju *et al.* (2010) reported that the average duration from egg to adult, larval stage and pupal stage were 23.87, 10.93 and 6.8 days, respectively. 56 out of 68 larvae successfully completed their whole 5 instars. There were positive correlation among the larval instars, amount of food consumption and excretion of faeces. About 52 per cent pupa were emerged as adult at laboratory conditions.

Atluri *et al.* (2004) also reported that the eggs are laid singly on both the surface of leaf developed into adult after passing five larval and pupal stages in 22-29 days.

Singh and Rao (1989) in Lucknow condition found that adult lay eggs singly on both the surface of leaf but larval and pupal period lasted for 10-12 and 3-7 days, respectively i.e. developmental period from egg to adult was less in Lucknow conditions.

## **2.3 Management**

### **2.3.1 To Evaluate Biopesticides and Biorationals Against Leaf Eating Caterpillar on Indian Senna**

It is reported that, the foliar application of *Bacillus thuringiensis* @1kg/ha recorded superiority with the mean leaf eating caterpillar population of 2.27 per plant followed by EPN @ 5000 IJS/lit. (2.60) and Neem oil @ 1 % (3.00) as against 8.67 leaf eating caterpillar larvae per plant in untreated control. Maximum marketable leaf (dry) yield was obtained in *Bacillus thuringiensis* @1kg/ha treated plots and followed by EPN @ 5000 IJS/lit. (11.54 q/ha) and Neem oil 1% (10.36 q/ha) as against 6.66 q/ha marketable leaf yield in the untreated control at MPKV, Rahuri Centre (Annual report 2016-17, AICRP on MAP&B, ICAR-Directorate of Medicinal and Aromatic plants Research, Boriavi, Anand).

It is reported that, the application of *Bacillus thuringiensis* @ 2g/lit. is significantly effective against *Catopsilia pyranthe* followed by EPN @ 5000 IJS/lit. and Neem oil @ 1 % and maximum fresh herbage yield 4560 kg/ha (1375 kg/ha dry weight) was recorded in the same treatment *Bacillus thuringiensis* and 3999 kg/ha fresh herbage yield (1224 kg/ha dry weight) in the treatment EPN @ 5000 IJS/lit. as against 2425 kg/ha fresh herbage yield (731 kg/ha dry weight) was recorded in the untreated control at MPKV, Rahuri Centre (Annual report 2017-18, AICRP on MAP&B, ICAR-Directorate of Medicinal and Aromatic plants Research, Boriavi, Anand)

### **2.3.2 Efficacy of Biopesticides and Biorationals Against Other Pests**

Kumar and Singh (2002) reported that many biopesticides have been developed from trees including neem (*Azadirachta indica*), Karanj (*Pongamia pinnata* or *P. glabra*), Mahua (*M. indica* or *M. longifolia*) and Chinaberry (*Meliazedarach*).

Among these, methanolic seed extract, acetone leaf extract, aqueous seed extract, chloroform seed extract and petroleum ether seed extract of karanj were evaluated and found to act as oviposition deterrants, antifeedents and larvicides against a wide range of insect pests.

Ahirwar *et al.* (2013) studied on the six microbial treatments against foliage feeders of soybean crop. Among various treatments, *B. thuringiensis* var. *kurstaki* was found to be most effective as it recorded the lowest larval population (3.63 larvae/mrl) followed by *B. bassiana* (3.93 larvae/mrl), *M. anisopliae* (4.53 larvae/mrl), Spinosad 45 SC (4.66 larvae/mrl), Dipel (5.80 larvae/mrl). All the treatments exhibited significantly higher yield as compared to control.

Razak *et al.* (2014) studied the efficacy of certain neem products *viz.*, neem oil, neem seed kernel extract, neem cake extract, neem leaf extract and one commercial product *Vijaya neem* against third instar larva of tobacco caterpillar *Spodoptera litura*. Among the neem products tested, NSKE 5 % showed the highest larval mortality of 40 per cent.

Chandrayudu *et al.* (2015) evaluated the efficacy of botanical and microbial insecticides against tobacco caterpillar, *Spodoptera litura* infesting groundnut. Among the treatments tested NPV (*S. litura*) @ 250 LE ha<sup>-1</sup> and *Bacillus thuringiensis* (*Bt*) sprays were significantly effective. This was followed by *Nomuraea rileyi* 1.5 x 10<sup>13</sup> spores mL<sup>-1</sup> and NSKE @ 5.0 per cent compared to other treatments neem oil @ 2.0 mL<sup>-1</sup> and *Beauveria bassiana* 1.5 x 10<sup>13</sup> spores mL<sup>-1</sup>, respectively.

Nizamani *et al.* (2016) studied on the ber Hairy caterpillar, *Euproctis fraterna* Moore (Lepidoptera, Lymantriidae) and revealed that the light trap catches plus application of Neem seed extract (NSE) and lorsban significantly reduced the pest population. It is concluded that installation of light trap, application of Neem seed extract and Lorsban efficiently managed the population of Hairy caterpillar in Jujube orchards.

Bochare *et al.* (2018) studied on defoliator of soyabean and revealed that *Beauveria bassiana* and *Nomuraea rileyi* each @ 7.5 g / L and neem seed extract 5 % were most effective in reducing the population of green semilooper and tobacco leaf eating caterpillar as well as registered highest yield of soybean. The neem seed extract 5

% was economically most effective treatment against soybean defoliators followed by *N. rileyi* @7.5 g/l.

Soni *et al.* (2018) studied on the tobacco caterpillar, *S. litura* is the most damaging insect pest of soybean. In the evaluation of plant products against *S. litura* NSKE @ 5 % was found second most effective botanicals after recommended insecticide on soybean after both the sprays 1<sup>st</sup> as well as 2<sup>nd</sup> with benefit cost ratio of 1.14.

Dhepe *et al.* (2018) studied on different microbial treatments against the foliage feeder of soybean crop (*Spodoptera litura*). Among these treatment *Beauveria bassiana* 5 g/l recorded 63.62 per cent larval reduction was found to be the most effective treatment.

Berani *et al.* (2018) studied the efficacy of botanicals against lepidopteran insect pest infesting black gram. Among the different botanicals, Azadirachtin 0.15 EC 0.0006 per cent, Neem Seed Kernel Extract (NSKE) 5 per cent, neem oil 0.3 per cent and neem leaf extract (NLE) 10 per cent were found highly effective in managing *Spilosoma obliqua* Walker and *Maruca testulalis* (Geyer) in black gram. A treatment of Azadirachtin 0.15 EC 0.0006 %, NSKE 5 % neem oil 0.3 % and neem leaf extract 10 % registered the higher grain yield of black gram.

### 3. MATERIALS AND METHODS

The investigation entitled “Seasonal incidence, biology and management of leaf eating caterpillar, *Catopsilia pyranthe* (L) On Indian senna, *Cassia angustifolia* (Vahl)” was carried out during the *kharif* 2019. The details of material used and methods adopted during the present investigation are described in this chapter.

#### 3.1 Place of Research Work

The experiments were conducted under field as well as laboratory conditions during the year 2019-2020. Field experiments were conducted at AICRP On MAP&B., MPKV, Rahuri during *kharif* 2019. Whereas, laboratory experiment was conducted at Post Graduate Laboratory, Department of Agricultural Entomology, MPKV, Rahuri.

#### 3.2 Geographical Area

Geographically, central campus of Mahatma Phule Krishi Vidyapeeth, Rahuri is situated at 19<sup>0</sup>47 and 19<sup>0</sup>55, North latitude and 74<sup>0</sup>19 to 74<sup>0</sup>42 East longitude with elevation of 525 meter above the mean sea level. This track is lying on the eastern side of western ghat and comes under rain shadow area.

#### 3.3 Climate

On the basis of climate, this area falls in the water scarcity zone with an annual rainfall ranging from 317 to 619 mm. The average annual rainfall is 520 mm. The rainfall is distributed in 15 to 45 rainy days. In case of total annual rainfall, about 80 per cent is received from South –West monsoon while rest is from North-East monsoon.

The average annual temperature is 32<sup>0</sup>C and average minimum temperature is 17.60<sup>0</sup>C. The mean relative humidity at 8.00 and 14.00 hr. is 72.82 and 37.52 per cent, respectively. Agroclimatically, the region is in the drought prone area of Maharashtra.

#### 3.4 Soil

The field was uniform and leveled. The soil of investigation area was medium black, moderately fertile with adequate drainage.

### 3.5 Material

#### 3.5.1 Seeds

Seeds of Indian senna variety, Indian senna (Anand senna-1) were used for sowing. The seeds were made available through AICRP On MAP & B.

#### 3.5.2 Rearing Material

The laboratory material like rearing cages, glasswares, plastic vials, chemicals, apparatus and instruments etc. were provided by Department of Agricultural Entomology, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri.

#### 3.5.3 Pesticides

All the biopesticides and biorationals used for experiment were made available by Department of Agril. Entomology, MPKV, Rahuri and AICRP On MAP&B.

#### 3.5.4 Appliances

Manually operated knapsack sprayer fitted with hollow cone nozzle was used for spraying pesticide on Indian senna.

### 3.6 Methods

#### 3.6.1 Seasonal Incidence of Leaf Eating Caterpillar, *Catopsilia pyranthe* (L)

In order to study the experiment on seasonal incidence of leaf eating caterpillar, *Catopsilia pyranthe* (L) of Indian senna variety Anand senna-1 were sown (dibbling) on well prepared plots having area 100 sq.m each with inter and intra spacing 45 cm x 30 cm, respectively.

##### 3.6.1.1 Details of experiment

1. Season and year	<i>kharif</i> 2019
2. Crop	Indian senna
3. Variety	Indian Senna (Anand senna-1)
4. Design	Randomized Block Design
5. Number treatments	7
6. Number of replication	3
7. Spacing	45 cm x 30 cm
8. Plot size	4 m x3 m
9. Date of Sowing	03-07-2019
10. Fertilizer dose	120 kg:60kg:40 kg (N:P:K/ha)
11. Date of harvesting	
First picking	25-11-2019
Second picking	30-12-2019

### **3.6.1.2 Methods of recording observations**

The seasonal incidence of leaf eating caterpillar was studied in relation to weather parameters. The observations of leaf eating caterpillar, *Catopsilia pyranthe* (L.) was recorded at weekly intervals on 10 randomly selected plants from 10 m x10 m plot size. leaf eating caterpillar count was taken by observing larvae per plant on selected and tagged plant from experimental plot. The weekly leaf eating caterpillar population data recorded was correlated with weather parameters. The whole plot was kept free from insecticidal application.

### **3.6.1.3 Meteorological data**

The data on weather parameters *viz.*, maximum temperature, minimum temperature, relative humidity, rainfall, sunshine hour, wind speed and pan evaporator was obtained from Meteorological observatory at, Mahatma Phule Krishi Vidyapeeth, Rahuri for correlating leaf eating caterpillar population.

### **3.6.1.4 Statistical analysis**

In order to find out the specific impact of different weather parameters on leaf eating caterpillar, the data of leaf eating caterpillar population was correlated with different weather parameters.

### **3.6.2 Biology of Leaf Eating Caterpillar, *Catopsilia pyranthe* (L)**

The biology and morphometric parameters of leaf eating caterpillar were studied at Post Graduate Laboratory, Department of Agricultural Entomology, M.P.K.V., Rahuri during 2019-2020.

#### **3.6.2.1 Rearing of test insect**

For biology study, the larvae of leaf eating caterpillar were collected from Indian senna plot of AICRP On MAP&B, MPKV, Rahuri by picking larvae were kept in plastic bowls and covered with muslin cloth. The food was changed daily in the morning hrs to prevent fungal contamination till the larvae got ready for pupation. The full grown 4<sup>th</sup> instar larvae were shifted to another, plastic bowl containing twigs of Indian senna and covered with muslin cloth for pupation.

The muslin cloth on plastic bowl was kept moist by sprinkling water over it to provide sufficient moisture for the survival of pupae.

The adults that emerged from pupae were sexed on the same day by observing the body size. These adult moths were used for the further studies. One pair of freshly emerged male and female moth was released in glass jar (15 cm x 10 cm) having filter paper placed at the bottom. twenty such glass jars were prepared maintaining 3 replications and each replication was containing 7 jars. Each glass jar was then covered with black chart from outside and the cotton swab dipped in 10 per cent honey solution was hung from the upper side with the help of pins to provide food to the adults. The mouth of the glass jar was covered with muslin cloth. A 50 ml plastic vial containing a twig of Indian senna plant dipped in water was also placed in the glass jar to provide natural environment for adults to facilitate oviposition.

The eggs thus obtained were examined daily to record the incubation period of eggs and also for emergence of neonate larvae. All the parameters were recorded at room temperature and relative humidity.

### **3.6.2.2 Method of recording observations**

#### **3.6.2.2.1 Incubation period**

A set of ten freshly laid eggs in 3 replications was observed daily for the emergence of neonates and incubation period was recorded.

#### **3.6.2.2.2 Larval period**

The larva that hatched from the eggs on the same day were used for biological studies. Ten neonate larvae in 3 replications were transferred by camel hair brush in small vials containing leaves of Indian senna. The time when full grown larvae stopped feeding and became inactive was considered as the termination of the larval stage and initiation of pupal stage.

#### **3.6.2.2.3 Pupal period**

The full grown 5<sup>th</sup> instar larvae were transferred to glass jars and observed daily in the morning hrs to record the pupal period.

#### **3.6.2.2.4 Oviposition period and fecundity**

The adults that emerged were sexed by examining the males are smaller than the females in size. One pair was released in each glass jar (15 cm x 10 cm) covered with black chart from outside and the cotton swabs dipped in 10 per cent honey solution were hung from the upper side with the help of pins to provide food to the adults. These

pairs were observed daily to record the oviposition period and fecundity of the female. To determine the oviposition period, the eggs laid by female in the jars were observed daily till the death of the female moths. The fecundity was calculated by counting the total number of eggs laid by the female on the filter paper, glass jar, Indian senna leaves on the twig placed in the jar and the muslin cloth.

#### **3.6.2.2.5 Sex Ratio**

Sex ratio was observed by counting the number of male and female moths emerged.

#### **3.6.2.2.6 Adult longevity**

To determine the longevity of adults, both male and female moths were observed daily from their emergence till death. Female has broader black apical margins and traces of a black costal border on the fore wing. Hind wing also have a black border. The male has black apical border on the forewing, and no marking on the hind wing. It was observed that the females were larger than the male with respect to length and breadth of the body.

The observation recorded under microscope regarding colour, shape, size, of egg, larvae, pupa and adult male and female moth. The length and breadth of eggs and first instar larvae was measured by using ocular micrometer. The length and breadth of second, third, fourth and fifth instar larvae, pupa and adult male and female moths were measured by Scale.

### **3.6.3 To Evaluate Biopesticides and Biorationals Against Leaf Eating Caterpillar on Indian Senna**

The experiment was conducted on the farm of AICRP On MAP&B., Mahatma Phule Krishi Vidyapeeth, Rahuri to evaluate biopesticides and biorationals and laid out in Randomized Block Design (RBD) with 7 treatments replicated three times using variety Anand senna - 1. The five plants were randomly selected and tagged from each plot. The plan of layout of experiment with necessary details is given in Fig. 1.

#### **3.6.3.1 Details of experiment**

1. Season and year	<i>kharif</i> 2019
2. Crop	Indian senna
3. Variety	Indian Senna (Anand senna - 1)

4. Design	Randomized Block Design
5. Number treatments	7
6. Number of replication	3
7. Spacing	45 cm x 30 cm
8. Plot size	4 m x3 m
9. Date of Sowing	03-07-2019
10. Date of biopesticide application	
1st spray	22-10-2019
2 <sup>nd</sup> spray	07-11-2019

**Table 3.1 Treatment detail for field trial on Indian senna, *Cassia angustifolia* (Vahl)**

Tr. No.	Treatments	Dose g /ml /lit. of water	Source
T <sub>1</sub>	NSE 5%	50 g	Giridhar Agro Pvt. Ltd., Lasalgaon, Nashik (M.S.)
T <sub>2</sub>	Karanj oil 1%	10 ml	Vijaya Agro Industries, Sangamner, Ahmednagar (M.S.)
T <sub>3</sub>	Azadirachtin 10000 ppm	2 ml	T. Stanes and Co. Ltd., Coimbatore
T <sub>4</sub>	<i>Beauveria bassiana</i> 1.15%WP	5 g	Biocontrol Research Laboratory, Department of Entomology, M.P.K.V., Rahuri, Ahmednagar (M.S.)
T <sub>5</sub>	<i>Bt</i> ( <i>Bacillus thuringiensis</i> )	2 ml	Sumitomo Chemical India Pvt. Ltd., Gujarat
T <sub>6</sub>	<i>Metarhizium anisopliae</i> 1.15% WP	5 g	Biocontrol Research Laboratory, Department of Entomology, M.P.K.V., Rahuri, Ahmednagar (M.S.)
T <sub>7</sub>	Untreated control	-	

### 3.6.3.2 Applications of biopesticides

The first spray of respective biopesticides or biorational pesticides was taken on appearance of leaf eating caterpillar and second sprays were taken 15 days after first spray. Spraying was done using manually operated knapsack sprayer with hollow cone nozzle with 500 lit. water/ha during morning time. For preparation of spray solution, the known quantity biopesticides or biorational pesticides were measured and mixed thoroughly and required concentration of spray solution was prepared with known quantity of water, agitated and then poured into the tank of sprayer. Due care was taken

to wash the spray pump before spraying. The spray pump was washed thoroughly after each spray of biopesticides or biorational pesticides and then the next treatment spraying was carried out.

### **3.6.3.3 Methods of observations**

Five plants in each plot were randomly selected and tagged for recording observations on surviving larval population. The larval population was recorded one day before spray as pretreatment count. Post treatment count was taken after three, seven and fourteen days of each spraying. Per cent reduction in larval population over pre treatment count after two sprays were also calculated

The data on marketable yield of all pickings were compiled and expressed in kg/plot from which the yield in q/ha was calculated. The increase in yield over control in each treatment were calculated by using the following formula.

$$\text{Increase in yield over control} = \frac{\text{Yield in control plot} - \text{Yield in uncontrolled plot}}{\text{Yield in uncontrolled plot}} \times 100$$

The data of surviving leaf eating caterpillar population recorded from 5 randomly selected plants per plot was transformed into square root transformation values and then data were subjected to statistical analysis as suggested by Panse and Sukhatme (1985). The standard error (S.E.) and critical difference (C.D.) at 5% level of probability were calculated to know the efficacy of each biopesticides or biorationals pesticides.

### **3.6.3.4 Incremental cost benefit ratio**

The incremental cost benefit ratio of each insecticide treatment was calculated by taking into account the prevailing market price of input, produce and labour charges for insecticide application and the net income gained from each treatment over control

## 4. RESULTS AND DISCUSSION

The studies on seasonal incidence, biology and management of leaf eating caterpillar, *Catopsilia pyranthe* (L) On Indian senna, *Cassia angustifolia* (Vahl) were carried out and results are presented in this chapter.

### 4.1 Seasonal Incidence of Leaf Eating Caterpillar

The studies on seasonal incidence of leaf eating caterpillar, *Catopsilia pyranthe* (L) On Indian senna, *Cassia angustifolia* (Vahl) were conducted during *kharif* 2019-20 at the Farm of AICRP on MAP&B, MPKV, Rahuri.

The observations on survival pest population of leaf eating caterpillar were recorded on randomly ten selected plants at weekly interval (7 days) during last week of July (30<sup>th</sup> MW) to first week of December (49<sup>th</sup> MW) in relation to abiotic factors and presented in Table 4.1.

The incidence of leaf eating caterpillar was initiated from the last week of July (30<sup>th</sup> MW) and remained continuous up to first week of December (49<sup>th</sup> MW). The data revealed that average number larvae of leaf eating caterpillar per plant ranged from 0.4-26.4 during the entire period. The incidence of leaf eating caterpillar starts in the month of July, 2019. The incidence gradually increased up to the fourth week of October and reached its peak i.e. 26.4 larvae/plant. During peak infestation level of leaf eating caterpillar, the maximum and minimum temperature, morning and evening relative humidity and rainfall were 31.1<sup>0</sup>C, 18.4<sup>0</sup>C, 76 %, 46 % and 23.4 mm, respectively. Thereafter, population declined gradually from 3<sup>rd</sup> week of November (47<sup>th</sup> MW ) and remained up to 0.8 larvae/plant in first week of December (49<sup>th</sup> MW).

The large number of butterflies of *Catopsilia pyranthe* (L) were swarming in the experimental field as well as at university campus. The butterflies laid egg singly on plants. They lay eggs during morning hours up to 11.00 hours. The maximum egg laying was observed during 8.00 to 9.30 AM, during July to October 2019. On leaves of the sonamukhi plant early instar larvae were observed feeding on chlorophyll and observed on under surface of leaves. From second instar observed feeding leaves and heavy infestation results into complete defoliation of plant.

**Table 4.1. Seasonal incidence of leaf eating caterpillar, *Catopsilia pyranthe* (L) during July – December 2019 on Indian senna**

Sr. No.	MW	Average No. of larvae / plant	Max. Temp. (°C)	Min.Temp. (°C)	R.H. Morn. (%)	R.H. Even. (%)	Sunshine (Hours)	Wind Speed (Km/hr)	Rainfall (mm)	E. Pan (mm)
1	30	0.4	30.6	23.5	79	63	2.3	4.1	018.4	3.3
2	31	0.8	27.0	22.8	88	77	0.2	4.8	047.8	1.9
3	32	1.0	28.0	23.3	80	68	2.0	8.2	003.6	3.6
4	33	1.2	31.0	22.5	75	59	8.4	6.9	001.4	5.4
5	34	1.2	32.5	21.3	72	47	7.9	4.1	000.0	6.2
6	35	1.6	32.0	23.0	75	56	5.9	4.1	087.2	4.8
7	36	1.2	30.0	23.3	77	71	1.8	3.6	003.0	4.3
8	37	1.6	28.8	22.5	78	68	1.3	4.6	021.6	3.7
9	38	2.0	29.8	21.7	83	71	4.2	1.6	084.2	3.7
10	39	3.8	30.2	21.9	83	67	4.9	0.8	036.6	3.3
11	40	5.4	31.1	21.1	80	59	6.1	1.1	007.8	5.0
12	41	7.6	31.7	21.1	77	50	7.1	0.7	002.8	4.9
13	42	10.4	23.2	18.6	81	68	5.0	1.4	052.4	3.6
14	43	16.0	25.7	20.8	87	79	2.4	1.3	141.8	1.6
15	44	18.2	30.4	21.0	84	58	6.1	1.1	004.0	5.0
16	45	26.4	31.1	18.4	76	46	9.0	0.6	023.4	5.4
17	46	23.2	29.7	16.7	73	48	7.5	0.8	000.0	5.6
18	47	16.6	30.0	15.2	74	45	7.8	0.3	000.0	5.4
19	48	8.4	30.5	15.9	74	44	7.3	0.2	000.0	4.9
20	49	0.8	28.8	16.4	71	47	5.4	0.3	000.0	4.9

The present findings on seasonal incidence were coincide with the results of Chaudhary and Sarvanan (2013) who reported the activity of *Catopsilia pyranthe* (L.) was more during second fortnight of June to October and maximum population of adult as well as eggs and larvae were observed during September and October coinciding with southwest monsoon (June-September).

It is reported that, infestation of leaf eating caterpillar *Catopsilia pyranthe* (L.) was observed on Indian senna, *Cassia angustifolia* (Vahl), during 30<sup>th</sup> to 51<sup>st</sup> met. week in 2016 i.e from july second week upto December last week and Maximum number of larvae i.e. 9.8 larvae/plant was observed during 41<sup>st</sup> met. week 2016 (October second week) when average maximum temperature was 31.6<sup>0</sup>C and average minimum temperature was 20.6<sup>0</sup>C and average morning relative humidity was 80 per cent and average evening relative humidity was 53 per cent at MPKV, Rahuri centre (Annual report, 2016-17b, AICRP on MAP&B, ICAR-Directorate of Medicinal and Aromatic Plants Research, Boriavi Anand).

#### **4.1.2 Correlation of weather parameters with seasonal incidence of leaf eating caterpillar**

Correlation coefficient of leaf eating caterpillar with various weather parameters *viz.*, temperature, humidity, rainfall, etc were calculated and results were analyzed. The data pertaining correlation coefficient is presented in the Table 4.2.

##### **4.1.2.1 Correlation coefficient of temperature (<sup>0</sup>C) on *Catopsilia pyranthe* (L)**

The study of correlation between maximum temperature (<sup>0</sup>C) and population of *Catopsilia pyranthe* (L) showed that maximum temperature (<sup>0</sup>C) has non significant negative relationship. The study of correlation between minimum temperature (<sup>0</sup>C) and population of *Catopsilia pyranthe* (L) showed that minimum temperature (<sup>0</sup>C) has significant negative relationship which means when temperature is high the population of leaf eating caterpillar reduces.

**4.1.2.2 Correlation coefficient of sunshine (hrs) on *Catopsilia pyranthe* (L)**

The study of correlation between sunshine (hrs.) and population of *Catopsilia pyranthe* (L) showed that sunshine (hrs.) has non significant negative relationship.

**4.1.2.3 Correlation coefficient of rainfall (mm) on *Catopsilia pyranthe* (L)**

The study of correlation between rainfall (mm) and eggs population of *Catopsilia pyranthe* (L) showed that the rainfall had non significant positive relationship.

**4.1.2.4 Correlation coefficient of relative humidity (%) on *Catopsilia pyranthe* (L)**

The study of correlation between relative humidity (%) and population of *Catopsilia pyranthe* (L) showed that morning relative humidity (%) and evening relative humidity (%) has non significant negative relationship.

**4.1.2.5 Correlation coefficient of wind velocity (km/hr) on *Catopsilia pyranthe* (L)**

The study of correlation between wind velocity and population of *Catopsilia pyranthe* (L) showed that the wind velocity had significant positive relationship, which means when the wind velocity is more the larval population is increases and it has got significant at 5 % level.

**4.1.2.6 Correlation coefficient of evaporation (mm) on *Catopsilia pyranthe* (L)**

The study of correlation between evaporation and population of *Catopsilia pyranthe* (L) showed that the evaporation (mm) has significant positive relationship which mean when the evaporation is more the population of leaf eating caterpillar increases and it has got significant at 5% level.

**Table 4.2. Correlation coefficient (r) of leaf eating caterpillar with weather parameter**

Sr. No.	Weather Parameters	Leaf eating caterpillar
1.	Maximum temperature ( <sup>0</sup> c)	-0.079
2.	Minimum temperature ( <sup>0</sup> c)	-0.593*
3.	Morning relative humidity (%)	-0.020
4.	Evening relative humidity (%)	-0.355
5.	Wind velocity (Km/hrs)	0.480*
6.	Sunshine (hrs)	-0.579

\* Significant at 5% level

## 4.2 Biology of Leaf Eating Caterpillar

The biology and morphometric parameters of leaf eating caterpillar were studied at Post Graduate Laboratory, Department of Agricultural Entomology, M.P.K.V. Rahuri during 2019-2020.

Leaf eating caterpillar is a lepidopterous pest which undergoes complete metamorphosis having egg, larva, pupa and adult as different life stages. The results pertaining to developmental period of different life stages of *Catopsilia pyrathe* (L) are presented in Table 4.3 and 4.4.

### 4.2.1 Incubation Period

The female moth of *Catopsilia pyrathe* (L) laid eggs singly on upper and lower side of leaves. The eggs were erect, fusiform (tapered at both end) laid singly on leaf, whitish in colour initially and turned creamy-white after one day. The incubation period was found to vary from 2 to 4 days with mean incubation period of  $3.06 \pm 0.35$  days (Table 4.3). The results are in accordance with the observations of various investigators i.e. Chaudhary and Sarvanan (2013).

In case of size of the eggs, the average length and width were measured to be 2.94 and 1.13 mm, respectively (Table 4.4). The present findings are in agreement with Chaudhary and Sarvanan, 2013 who reported that length of eggs of *Catopsilia pyrathe* (L) varied from 2 to 3 mm.

### 4.2.2 Larval Stage

The larvae passed through five instars. The larval instars were determined by the number of moults manifested by exuviae formed during moulting. In order to study the various larval instar of *Catopsilia pyrathe* (L) in laboratory condition, newly hatched larvae were reared individually in plastic culture tube.

#### 4.2.2.1 First instar

The newly hatched larva was very tiny. Body shape was cylindrical and pale green in colour. Body distinct into head, thorax and anal region. Yellow abdominal prolegs were also observed. Head was rounded and plain. The duration of first instar larvae ranged from 2 to 3 days with a mean of  $2.27 \pm 0.31$  days (Table 4.3). In past, Chaudhary and Sarvanan (2013) and Atluri *et al.* (2004) reported the duration of first

instar larva of *Catopsilia pyraethe* (L) was ranged from 2-3 days, respectively when reared on Indian senna which supports the present findings.

The mean length of first instar larva was  $5.13 \pm 0.54$  mm and width  $0.81 \pm 0.17$  mm, (Table 4.4). The present findings are more or less in conformation with findings of Chaudhary and Sarvanan (2013) and Atluri *et al.* (2004)

#### 4.2.2.2 Second instar

Second instar larva was pale green and lateral sides yellow in colour. Head was pale yellow, body segments were slightly visible. Larva fed slowly and excreted a very less amount of faeces which was black in colour and alike to dust. The larva was more active than previous instar. The mean duration of second instar larvae varied from  $2.38 \pm 0.36$  days (Table 4.3).

According to Atluri *et al.* (2004), the duration of second instar larva of *Catopsilia pyraethe* was 2-3 days.

The mean length and width of second instar was  $10.94 \pm 1.31$  mm and  $1.76 \pm 0.16$  mm, respectively (Table 4.4). The present findings are more or less in conformation with findings of Chaudhary and Sarvanan (2013) who reported that average length of second instar larvae of *Catopsilia pyraethe* (L) was  $10.3 \pm 0.29$  mm.

#### 4.2.2.3 Third instar

Second instar larvae moulted to third instar and become longer than the second instar. Body green in colour, a distinct black band was observed just above the white lateral line. Legs and prolegs were very distinct. In this stage larva fed very fast and grew rapidly. It excreted a huge amount of faeces which was black in colour and granular. The duration ranged from 2 to 4 days with an average of  $3.06 \pm 0.72$  days (Table 4.3). Previously, it was reported as 3 to 4 days by Chaudhary and Sarvanan (2013) which is more or less in support to present investigation.

The third instar larvae measured  $16.04 \pm 1.04$  mm in length and  $3.18 \pm 0.40$  mm in width (Table 4.4). The present findings are in agreement with Chaudhary and Sarvanan (2013) who reported that the mean length of third instar larva was  $15.5 \pm 0.27$  mm.

#### 4.2.2.4 Fourth instar

The fourth instar larva was green in colour. Head rounded, yellowish green. In this instar larva consumed a huge amount of host plant leaves. Remaining characters were identical to third instar. The duration of this instar ranged from 3 to 5 days with mean duration of  $4.11 \pm 0.65$  days (Table 4.3). Previously, it was reported as 3 to 4 days by Chaudhary and Sarvanan (2013) which is more or less in support to present investigation. At this stage the larva measured  $23.60 \pm 1.46$  mm in length and  $4.28 \pm 0.33$  mm in width, (Table 4.4). The result lend support to Chaudhary and Sarvanan (2013) who recorded the length of *Catopsilia pyrathe* (L) varying from  $21.9 \pm 0.53$  mm when reared on Indian senna.

#### 4.2.2.5 Fifth instar

The fifth instar larva was green in colour, lateral yellow line broad and distinct and segmentation clearly visible. abdominal prolegs were distinct and clearly visible. At this stage larva consumed the leaves as their food voraciously and excreted a huge amount of faeces. the duration of this instar ranged from 4 to 5 days with mean duration of  $4.38 \pm 0.45$  days (Table 4.3). Previously, it was reported as 4 to 5 days by Chaudhary and Sarvanan (2013) which is more or less in support to present investigation. At this stage the larva measured  $33.26 \pm 1.55$  mm in length and  $6.16 \pm 0.40$  mm in width, (Table 4.4). The present findings are more or less in conformation with findings of Chaudhary and Sarvanan (2013) who reported that average length of fifth instar larvae of *Catopsilia pyrathe* (L) was  $32.2 \pm 0.39$  mm when reared on Indian senna.

#### 4.2.2.6 Total larval period

The total larval duration varied from 13 to 19 days with mean duration of  $16.2 \pm 2.49$  days. (Table 4.3). The results of the present study are more or less in agreement with the findings of Arju *et al.* (2010) who reported that, the total larval duration varied from 10 to 12 days with a mean of 10.93 days.

#### 4.2.3 Pupal Stage

Body becomes thick and short by contraction. pupa was pale green in colour with a yellow lateral line. It was totally inactive. It had a hard protective coating. The pupa was 23.17 mm long and 7.63 mm broad (Table 4.4). Pupation occurred on muslin cloth, inside plastic bowl and leaves of Indian senna. The pupal period was found

varied from 6 to 8 days with mean duration of 6.34 days (Table 4.3). According to Atluri *et al.* (2004) and Chaudhary and Sarvanan (2013), the duration of pupa of *Catopsilia pyrathe* (L) was 6-7 days. Arju *et al.* (2010) reported that, the duration of pupa of *Catopsilia pyrathe* (L) was 6-8 days. The results of the present study are more or less in line with the above reports.

#### **4.2.4 Adult Stage**

Female has broader black apical margins and traces of a black costal border on the fore wing. Hind wing also have a black border. The male has black apical border on the forewing, and no marking on the hind wing. It was observed that the females were larger than the male with respect to length and breadth of the body. The mean length of adult male was observed as 15.74 mm and mean width was observed as 26.08 mm across the wings whereas in case of female the mean length was observed as 18.52 mm and mean width was observed as 27.59 mm across the wings (Table 4.4).

#### **4.2.5 Pre-oviposition Period**

The pre-ovipositional period ranged from 2 to 4 days with an average of  $2.83 \pm 0.73$  days (Table 4.3).

#### **4.2.6 Oviposition Period**

The oviposition period of adult of *Catopsilia pyrathe* (L) ranged from 5 to 8 days with an average  $6.37 \pm 1.20$  days (Table 4.3).

#### **4.2.7 Fecundity**

The fecundity of *Catopsilia pyrathe* (L) was observed to vary from 172 to 212 with average fecundity of 191 eggs/ female (Table 4.3).

#### **4.2.8 Longevity of Adults**

In general, females lived longer than males. Mean longevity of male adult was observed to be 6.45 days whereas in case of female, the longevity was 7.6 days (Table 4.3).

#### **4.2.9 Total Life Span**

Total life span of leaf eating caterpillar was observed to be  $32.65 \pm 3.65$  days (Table 4.3).

#### **4.2.10 Sex Ratio**

Sex ratio (Male: Female) was observed to be 1:1.60 (Table 4.3).

**Table 4.3** Developmental period of different life stages of leaf eating caterpillar, *Catopsilia pyraethe* (L)

Sr. No.	Stage	Mean $\pm$ SD (Days)	Range (Days)
1.	Incubation period of eggs	3.06 $\pm$ 0.35	2-4
2.	Larva		
	1 <sup>st</sup> instar	2.27 $\pm$ 0.31	2-3
	2 <sup>nd</sup> instar	2.38 $\pm$ 0.36	2-3
	3 <sup>rd</sup> instar	3.06 $\pm$ 0.72	2-4
	4 <sup>th</sup> instar	4.11 $\pm$ 0.65	3-5
	5 <sup>th</sup> instar	4.38 $\pm$ 0.45	4-5
	Total larval period	16.2 $\pm$ 2.49	13-19
3.	Pupa	6.34 $\pm$ 0.40	6-8
4.	Adult		
	Male	6.45 $\pm$ 0.44	5-7
	Female	7.6 $\pm$ 0.39	6-10
5.	Total period taken from egg to adult Stage	32.65 $\pm$ 3.65	26-38
	Pre-oviposition period in days	2.83 $\pm$ 0.73	2-4
	Oviposition period in days	6.37 $\pm$ 1.20	5-8
	Fecundity eggs in numbers	191 $\pm$ 12.69	172-212
	Sex ratio ( Male: Female)	1 : 1.60	

**Table 4.4** Measurements of different developmental stages of leaf eating caterpillar, *Catopsilia pyraethe* (L)

Stage		Length (mm)	Width (mm)
Eggs*		2.94 $\pm$ 0.23	1.13 $\pm$ 0.19
Larva	1 <sup>st</sup> instar	5.13 $\pm$ 0.54	0.81 $\pm$ 0.17
	2 <sup>nd</sup> instar	10.94 $\pm$ 1.31	1.76 $\pm$ 0.16
	3 <sup>rd</sup> instar	16.04 $\pm$ 1.04	3.18 $\pm$ 0.40
	4 <sup>th</sup> instar	23.60 $\pm$ 1.46	4.28 $\pm$ 0.33
	5 <sup>th</sup> instar	33.26 $\pm$ 1.55	6.16 $\pm$ 0.40
Pupa		23.17 $\pm$ 1.14	7.63 $\pm$ 0.65
Adult	Male	15.74 $\pm$ 0.82	26.08 $\pm$ 1.23
	Female	18.52 $\pm$ .75	27.59 $\pm$ 0.61

\* Observations at 40 X magnification

### 4.3 Efficacy of Biopesticides and Biorationals Against Leaf Eating Caterpillar

The field experiment was conducted on the experimental farm of AICRP on MAP & B, MPKV, Rahuri (M.S.) to evaluate biopesticides and biorationals and the experiment was laid out in Randomized Block Design (RBD) with 7 treatments replicated three times using variety Anand senna-1. The five plants were randomly selected and tagged from each plot and observations were taken by counting surviving leaf eating caterpillar population per plant.

The data on leaf eating caterpillar population per plant of Indian senna one day before application and post count at 3<sup>rd</sup>, 7<sup>th</sup> and 14<sup>th</sup> days after first and second application and mean of two applications are presented in Table 4.5 to 4.7.

#### 4.3.1 First Spray

##### 4.3.1.1 At 1 day before spray (pre count)

The data presented in Table 4.5, revealed that the leaf eating caterpillar was ranged from 15.53 to 18.40 per plant showing stastically non-significant.

##### 4.3.1.2 At 3 days after spraying

At 3<sup>rd</sup> day after first application the results are significant. Among the all treatments, T<sub>3</sub> Azadiractin 10000 ppm @ 2 ml /lit.water showed to be the most promising treatment and found statistically superior over all other treatments which recorded 11.80 leaf eating caterpillar per plant and found at par with the treatment T<sub>2</sub> karanj oil @ 10 /lit. water (13.53 leaf eating caterpillar) followed by the treatments NSE 5% @ 50 g /lit.water (14.87 leaf eating caterpillar per plant), T<sub>5</sub> *Bt (Bacillus thuringiensis)* @ 2 ml /lit. water (15.93 leaf eating caterpillar per plant) T<sub>4</sub> *Beauveria bassiana* 1.15%WP @ 5 g /lit. water (17.20), T<sub>6</sub> *Metarhizium anisopliae* 1.15%WP @ 5 g/lit. water (18.00 leaf eating caterpillar per plant) Whereas, untreated control recorded highest 18.47 leaf eating caterpillar population per plant.

**Table 4.5 Management of leaf eating caterpillar after first spray**

Sr. No.	Treatments	Dose g/ml/lit of water	Av. No. of survival population of leaf eating caterpillar /Plant				Per cent reduction in pest population
			Pre count	3 DAS	7 DAS	14 DAS	
T <sub>1</sub>	NSE 5%	50 g	16.47 (4.11)	14.87 (3.92)	11.87 (3.51)	11.20 (3.42)	31.99
T <sub>2</sub>	Karanj oil 1%	10 ml	15.53 (4.00)	13.53 (3.75)	10.07 (3.25)	9.53 (3.17)	38.63
T <sub>3</sub>	Azadiractin 10000 ppm	2 ml	16.40 (4.11)	11.80 (3.50)	7.87 (2.89)	7.40 (2.81)	54.87
T <sub>4</sub>	<i>Beauveria bassiana</i> 1.15%WP	5 g	17.47 (4.24)	17.20 (4.21)	16.07 (4.07)	14.33 (3.85)	17.97
T <sub>5</sub>	Bt ( <i>Bacillus thuringiensis</i> )	2 ml	16.93 (4.16)	15.93 (4.05)	11.87 (3.51)	7.13 (2.76)	57.88
T <sub>6</sub>	<i>Metarhizium anisopliae</i> 1.15 % WP	5 g	18.20 (4.32)	18.00 (4.29)	17.13 (4.19)	15.47 (3.99)	15.00
T <sub>7</sub>	Untreated control		17.07 (4.19)	18.47 (4.35)	20.40 (4.57)	18.53 (4.36)	-
	S.E.		0.13	0.12	0.12	0.10	
	CD@5%		NS	0.39	0.37	0.31	

**Note :** Figures in the parenthesis are transformed values of  $\sqrt{x+0.5}$  where x is original value

#### 4.3.1.3 At 7 days after spraying

Among the all treatments, T<sub>3</sub> Azadiractin 10000 ppm @ 2 ml/lit.water showed to be the most promising treatment and found statistically superior over all other treatments which recorded 7.87 leaf eating caterpillar per plant and found at par with the treatment T<sub>2</sub> karanj oil @ 10 /lit. water (10.07 leaf eating caterpillar per plant) followed by NSE 5% @ 50 g/lit. water (11.87 leaf eating caterpillar per plant), T<sub>5</sub> Bt (*Bacillus thuringiensis*) @ 2 ml/lit. water (11.87 leaf eating caterpillar), T<sub>4</sub> *Beauveria bassiana* 1.15%WP @ 5 g/lit. water (16.07), T<sub>6</sub> *Metarhizium anisopliae* 1.15%WP @ 5 g/lit. water (17.13 leaf eating caterpillar per plant). The maximum population was found in the untreated control i.e. 20.40 leaf eating caterpillar per plant.

#### 4.3.1.4 At 14 days after spraying

Among the all treatments, T<sub>5</sub> (*Bt Bacillus thuringiensis* @ 2 ml/lit. water) showed to be the most promising treatment and found statistically superior over all other treatments which recorded 7.13 leaf eating caterpillar per plant and found at par with the

treatment T<sub>3</sub> Azadiractin 10000 ppm @ 2 ml/lit.water (7.40 leaf eating caterpillar per plant) followed by the treatments T<sub>2</sub> karanj oil @ 10 ml/lit. water (9.53 leaf eating caterpillar per plant), NSE 5% @ 50 g/lit. water (11.20 leaf eating caterpillar), T<sub>4</sub> *Beauveria bassiana* 1.15 % WP @ 5 g/lit. water (14.33 leaf eating caterpillar per plant), T<sub>6</sub> *Metarhizium anisopliae* 1.15 % WP @ 5 g/lit. water 15.47 leaf eating caterpillar per plant). The maximum population was found under the untreated control i.e. 18.53 leaf eating caterpillar per plant.

From the data on percent reduction in larval population over pre count after first spray the descending order of different treatments in reducing larval population as *Bt (Bacillus thuringiensis)* @ 2 ml /lit. water (57.88), Azadiractin 10000 ppm @ 2 ml /lit. water (54.87), karanj oil @ 10 ml/lit. water (38.63), NSE 5% @ 50g /lit. water (31.99), *Beauveria bassiana* 1.15 % WP @ 5 g/lit. water (17.97), *Metarhizium anisopliae* 1.15 % WP @ 5 g/lit. water (15.00).

### 4.3.2 Second Spray

The data presented in Table 4.6 revealed that all the treatments were found significantly superior over untreated control at 3, 7 and 14 days after second application.

#### 4.3.2.1 At 3 days after spraying

Among the all treatments, T<sub>3</sub> Azadiractin 10000 ppm @ 2 ml/lit. water showed to be the most promising treatment and found statistically superior over all other treatments which recorded 5.33 leaf eating caterpillar per plant and found at par with the treatment T<sub>5</sub> *Bt (Bacillus thuringiensis)* @ 2 ml/lit. water (5.93 leaf eating caterpillar) followed by T<sub>2</sub> karanj oil @ 10 / lit. water (8.27 leaf eating caterpillar), NSE 5% @ 50 g/ lit. water (10.07 leaf eating caterpillar), T<sub>4</sub> *Beauveria bassiana* 1.15 % WP @ 5 g /lit. water (13.93 leaf eating caterpillar per plant), T<sub>6</sub> *Metarhizium anisopliae* 1.15 % WP @ 5 g /lit. water (15.13 leaf eating caterpillar per plant) Whereas, untreated control recorded highest 17.47 leaf eating caterpillar per plant.

#### 4.3.2.2 At 7 days after spraying

Among the all treatments, T<sub>3</sub> Azadiractin 10000 ppm @ 2 ml/lit. water showed to be the most promising treatment and found statistically superior over all other treatments which recorded 3.53 leaf eating caterpillar per plant followed by T<sub>5</sub> *Bt*

(*Bacillus thuringiensis*) @ 2 ml/lit. water (5.00 leaf eating caterpillar per plant), T<sub>2</sub> karanj oil @ 10 /lit. water (6.20 leaf eating caterpillar per plant), NSE 5% @ 50g /lit.water (7.80 leaf eating caterpillar per plant), T<sub>4</sub> *Beauveria bassiana* 1.15%WP @ 5 g/lit. water (13.13 leaf eating caterpillar per plant), T<sub>6</sub> *Metarhizium anisopliae* 1.15%WP @ 5 g/lit. water (14.53 leaf eating caterpillar per plant). The maximum population was found under the untreated control i.e. 16.33 leaf eating caterpillar per plant.

**Table 4.6. Management of leaf eating caterpillar after second spray**

Tr. No.	Treatments	Dose g/ ml/lit. of water	Av. No. of survival population of leaf eating caterpillar /Plant			Per cent reduction in pest population
			3 DAS	7 DAS	14 DAS	
T <sub>1</sub>	NSE 5%	50 g	10.07 (3.25)	7.80 (2.88)	7.60 (2.84)	32.14
T <sub>2</sub>	Karanj oil 1%	10 ml	8.27 (2.96)	6.20 (2.59)	5.80 (2.51)	39.13
T <sub>3</sub>	Azadiractin 10000 ppm	2 ml	5.33 (2.41)	3.53 (2.01)	3.33 (1.96)	55.00
T <sub>4</sub>	<i>Beauveria bassiana</i> 1.15 % WP	5 g	13.93 (3.80)	13.13 (3.69)	11.80 (3.51)	16.74
T <sub>5</sub>	Bt ( <i>Bacillus thuringiensis</i> )	2 ml	5.93 (2.53)	5.00 (2.34)	3.00 (1.87)	57.92
T <sub>6</sub>	<i>Metarhizium anisopliae</i> 1.15%WP	5 g	15.13 (3.95)	14.53 (3.87)	13.20 (3.70)	14.67
T <sub>7</sub>	Untreated control		17.47 (4.24)	16.33 (4.10)	15.67 (4.02)	
	S.E.		0.10	0.08	0.08	
	CD @ 5%		0.31	0.27	0.26	

**Note :** Figures in the parenthesis are transformed values of  $\sqrt{x+0.5}$  where x is original value

#### 4.3.2.3 At 14 days after spraying

Among the all treatments, T<sub>5</sub> (*Bt Bacillus thuringiensis* @ 2 ml/lit. water) showed to be the most promising treatment and found statistically superior over all other treatments which recorded 3.00 leaf eating caterpillar per plant and found at par with the treatment T<sub>3</sub> Azadiractin 10000 ppm @ 2 ml/lit.water (3.33 leaf eating caterpillar) followed by T<sub>2</sub> karanj oil @ 10 ml/lit. water (5.80 leaf eating caterpillar), NSE 5% @ 50 g/lit. water (7.60 leaf eating caterpillar per plant), T<sub>4</sub> *Beauveria bassiana* 1.15 % WP @ 5 g/lit. water (11.80 leaf eating caterpillar per plant), T<sub>6</sub> *Metarhizium anisopliae* 1.15 %

WP @ 5 g/lit water (13.20 leaf eating caterpillar per plant). The maximum population was found under the untreated control i.e. 15.67 leaf eating caterpillar per plant.

From the data on per cent reduction in larval population over pre count after second spray the descending order of different treatments in reducing larval population as *Bt (Bacillus thuringiensis)* @ 2 ml /lit. water (57.92), Azadiractin 10000 ppm @ 2 ml/lit. water (55.00), karanj oil @ 10 ml /lit. water (39.13), NSE 5% @ 50 g/lit. water (32.14), *Beauveria bassianan* 1.15%WP @ 5 g/lit. water (17.65), *Metarhizium anisopliae* 1.15% WP @ 5 g/lit. water (14.67).

### **4.3.3 Cumulative Effect of Biopesticides and Biorationals Against Leaf Eating Caterpillar**

The mean data of two applications on per cent infestation of plant caused by leaf eating caterpillar are presented in Table 4.7 reveals that all the biopesticides or biorationals pesticides treatments were significantly superior over untreated control in recording lowest per cent infestation of plant caused by leaf eating caterpillar.

#### **4.3.3.1 At 3 days after spraying**

Among the all treatments, T<sub>3</sub> Azadiractin 10000 ppm @ 2 ml/lit.water showed to be the most promising treatment which recorded 8.56 leaf eating caterpillar per plant followed by T<sub>5</sub> *Bt (Bacillus thuringiensis)* @ 2 ml /lit. water (10.93 leaf eating caterpillar), T<sub>2</sub> karanj oil @ 10 /lit. water (10.9 leaf eating caterpillar per plant), NSE 5% @ 50 g/lit. water (12.47 leaf eating caterpillar per plant), T<sub>4</sub> *Beauveria bassiana* 1.15 % WP @ 5 g/lit. water (15.56 leaf eating caterpillar per plant), T<sub>6</sub> *Metarhizium anisopliae* 1.15 % WP @ 5g / lit. water (16.56 leaf eating caterpillar per plant). The maximum population was found in the untreated control i.e. 17.97 leaf eating caterpillar per plant.

#### **4.3.3.2 At 7 days after spraying**

Among the all treatments, T<sub>3</sub> Azadiractin 10000 ppm @ 2 ml/lit. water showed to be the most promising treatment which recorded 5.7 leaf eating caterpillar per plant followed by T<sub>2</sub> karanj oil @ 10 /lit. water (8.13 leaf eating caterpillar per plant), T<sub>5</sub> *Bt (Bacillus thuringiensis)* @ 2 ml/lit. water (8.43 leaf eating caterpillar per plant), NSE 5% @ 50g /lit.water (9.83 leaf eating caterpillar per plant), T<sub>4</sub> *Beauveria bassiana* 1.15 % WP @ 5 g /lit. water (14.60 leaf eating caterpillar per plant), T<sub>6</sub> *Metarhizium anisopliae* 1.15 % WP @ 5 g /lit. water (15.83 leaf eating caterpillar per plant). The

maximum population was found under the untreated control i.e. 18.36 leaf eating caterpillar per plant.

#### 4.3.3.3 At 14 days after spraying

Among the all treatments, T<sub>5</sub> (*Bt Bacillus thuringiensis* @ 2 ml/lit. water) showed to be the most promising treatment which recorded 5.06 leaf eating caterpillar per plant followed by T<sub>3</sub> Azadiractin 10000 ppm @ 2 ml/lit.water (5.36 leaf eating caterpillar per plant), T<sub>2</sub> karanj oil @ 10ml /lit. water (7.66 leaf eating caterpillar per plant), NSE 5 % @ 50 g/ lit. water (9.4 leaf eating caterpillar per plant), T<sub>4</sub> *Beauveria bassiana* 1.15 % WP @ 5 g /lit. water (13.06 leaf eating caterpillar per plant), T<sub>6</sub> *Metarhizium anisopliae* 1.15 % WP @ 5 g/lit.water (14.33 leaf eating caterpillar). The maximum population was found under the untreated control i.e.17.1 leaf eating caterpillar per plant.

**Table 4.7 Cumulative effect of biopesticides and biorationals against leaf eating caterpillar, *Catopsilia pyranthe* (L)**

Tr. No.	Treatments	Dose g/ ml/L of water	Av. No. of leaf eating caterpillar /Plant				Reduction in population after two spray
T <sub>1</sub>	NSE 5%	50 g	13.83 (3.42)	12.47 (3.58)	9.83 (3.19)	9.4 (3.13)	32.06
T <sub>2</sub>	Karanj oil 1%	10 ml	12.53 (3.58)	10.9 (3.35)	8.13 (2.92)	7.66 (2.84)	38.88
T <sub>3</sub>	Azadiractin 10000 ppm	2 ml	11.9 (3.46)	8.56 (2.95)	5.7 (2.45)	5.36 (2.38)	55.11
T <sub>4</sub>	<i>Beauveria bassiana</i> 1.15 % WP	5 g	15.9 (4.04)	15.56 (4.00)	14.60 (3.88)	13.06 (3.67)	17.35
T <sub>5</sub>	<i>Bt (Bacillus thuringiensis)</i>	2 ml	12.03 (3.46)	10.93 (3.29)	8.43 (2.92)	5.06 (2.31)	57.90
T <sub>6</sub>	<i>Metarhizium anisopliae</i> 1.15%WP	5 g	16.83 (4.15)	16.56 (4.12)	15.83 (4.03)	14.33 (3.84)	15.29
T <sub>7</sub>	Untreated control		17.8 (4.27)	17.97 (4.29)	18.36 (4.33)	17.1 (4.18)	-

**Note :** Figures in the parenthesis are transformed values of  $\sqrt{x+0.5}$  where x is original value

From the data on percent reduction in larval population over pre count after two spray the descending order of different treatments in reducing larval population as *Bt (Bacillus thuringiensis)* @ 2 ml/lit. water (57.90), Azadiractin 10000 ppm @ 2 ml/lit.water (54.93) , karanj oil @ 10ml /lit. water (38.88), NSE 5% @ 50g /lit. water

(32.06), *Beauveria bassiana* 1.15%WP @ 5 g/lit. water (17.81), *Metarhizium anisopliae* 1.15% WP @ 5g / lit. water (14.83)

It is reported that, the foliar application of *Bacillus thuringiensis* @1kg/ha recorded superiority with the mean leaf eating caterpillar population of 2.27 per plant followed by EPN @ 5000 IJS/lit. (2.60) and Neem oil @ 1% (3.00) as against 8.67 leaf eating caterpillar larvae per plant in untreated control. Maximum marketable leaf (dry) yield was obtained in *Bacillus thuringiensis* @1kg/ha treated plots and followed by EPN @ 5000 IJS/lit. (11.54q/ha) and Neem oil 1%(10.36q/ha) as against 6.66 q/ha marketable leaf yield in the untreated control at MPKV, Rahuri Centre (Annual report 2016-17a, AICRP on MAP&B, ICAR-Directorate of Medicinal and Aromatic plants Research, Boriavi, Anand).

#### **4.4 Effect of Different Biopesticides and Biorationals Against Leaf Eating Caterpillar on Dry Herbage Yield of Indian Senna**

The results pertaining to the marketable dry leaf yield of Indian senna are presented in Table 4.8 All the biopesticides were statistically superior over untreated control. The dry herbage yield of Indian senna due to different treatments varied from 9.32 to 16.06 q/ha. Among treatments, the higher dry herbage yield of 16.06 q/ha was produced by T<sub>5</sub> *Bt* (*Bacillus thuringiensis* @ 2ml/ lit. of water) it was followed by T<sub>3</sub> Azadiractin 10000 ppm @ 2 ml/lit.water (15.43 q/ha.), T<sub>2</sub> karanj oil @ 10ml /lit. water (11.21 q/ha.), T<sub>1</sub> NSE 5% @ 50 g/ lit. water (10.36 q/ha. ), T<sub>4</sub> *Beauveria bassiana* 1.15%WP @ 5 g/lit. water (9.75 q/ha.), T<sub>6</sub> *Metarhizium anisopliae* 1.15% WP @ 5 g/lit. water (9.32 q/ha.) However, the lowest dry herbage yield (8.43 q/ha) was recorded in the untreated control.

It is reported that, the application of *Bacillus thuringiensis* @ 2g/lit. is significantly effective against *Catopsilia pyranthe* (L) followed by EPN @ 5000 IJS /lit. and Neem oil @ 1 % and maximum fresh herbage yield 4560 kg/ha (1375 kg/ha dry weight) was recorded in the same treatment *Bacillus thuringiensis* and 3999 kg/ha fresh herbage yield (1224 kg/ha dry weight) in the treatment EPN @ 5000 IJS/lit. as against 2425 kg/ha fresh herbage yield (731 kg/ha dry weight) was recorded in the untreated control at MPKV, Rahuri Centre (Annual report 2017-18, AICRP on MAP&B, ICAR

Directorate of Medicinal and Aromatic plants Research, Boriavi, Anand). These results endorse the result of the present findings.

**Table 4.8 Effect of different biopesticides and biorationals against leaf eating caterpillar on dry herbage yield of Indian senna**

Tr. No.	Treatments	Fresh herbage yield q ha <sup>-1</sup>	Dry herbage yield q ha <sup>-1</sup>	Per cent increase in yield over control (dry herbage)
T <sub>1</sub>	NSE 5%	33.47	10.36	22.89
T <sub>2</sub>	Karanj oil 1%	36.26	11.21	32.97
T <sub>3</sub>	Azadiractin 10000 ppm	50.37	15.43	83.03
T <sub>4</sub>	<i>Beauveria bassiana</i> 1.15 % WP	31.41	9.75	15.65
T <sub>5</sub>	<i>Bt (Bacillus thuringiensis)</i>	52.44	16.06	90.51
T <sub>6</sub>	<i>Metarhizium anisopliae</i> 1.15%WP	29.99	9.32	10.55
T <sub>7</sub>	Untreated control	26.99	8.43	-
	S.E.	2.25	0.67	-
	CD @ 5%	6.94	2.08	-

#### 4.5 Incremental Cost Benefit Ratio (ICBR) and B : C Ratio of Different Biopesticides and Biorationals Against Leaf Eating Caterpillar

The data generated on incremental cost benefit ratio of different biopesticides applied against leaf eating caterpillar of Indian senna are presented in Table 4.9.

As regards the incremental cost benefit ratio among all treatment, the highest ICBR (1:11.13) was recorded in T<sub>5</sub> *Bt(Bacillus thuringiensis @ 2 ml /lit. of water)* with highest B : C ratio (1:2.06) it was followed by T<sub>3</sub> Azadiractin 10000 ppm @ 2 ml/lit.water (1:10.13) with B : C ratio (1:1.98), NSE 5% @ 50 g/ lit. water (1:3.91) with B : C ratio (1:1.37), T<sub>4</sub> *Beauveria bassiana* 1.15 % WP @ 5 g/lit. water (1:2.08) with B : C ratio (1:1.28), T<sub>2</sub> karanj oil @ 10ml /lit.water (1:1.43) with B : C ratio (1:1.35), T<sub>6</sub> *Metarhizium anisopliae* 1.15 % WP @ 5g / lit.water (1:1.07) with B : C ratio (1:1.22).

**Table 4.9 Incremental cost benefit ratio (ICBR) of different biopesticides and biorationals against leaf eating caterpillar**

Sr. No	Treatments	Markatable dry leaf Yield (q ha <sup>-1</sup> )	Increase in yield over control (q ha <sup>-1</sup> )	Value of increase in yield (Rs)	Treatmet cost for 2 applicatio (Rs ha <sup>-1</sup> )	Toatal cost of cultivation (Rs ha <sup>-1</sup> )	Gross monitory returns (Rs ha <sup>-1</sup> )	Net monitory returns (Rs ha <sup>-1</sup> )	B : C ratio	ICBR
1.	NSE	10.36	1.93	13510	2750	52830	72520	19690	1:1.37	1:3.91
2.	Karanj oil 1%	11.21	2.78	19460	8000	58080	78470	20390	1:1.35	1:1.43
3.	Azadiractin 10000 ppm	15.43	7.0	49000	4400	54480	108010	53530	1:1.98	1:10.13
4.	<i>Beauveria bassiana</i> 1.15%WP	9.75	1.32	9240	3000	53080	68250	15170	1:1.28	1:2.08
5.	<i>Bt (Bacillus thuringiensis)</i>	16.06	7.63	53410	4400	54480	112420	57940	1:2.06	1:11.13
6.	<i>Metarhizium anisopliae</i> 1.15%WP	9.32	0.89	6230	3000	53080	62240	12160	1:1.22	1:1.07
7.	Untreated control	8.43	-	-	-	50080	59010	8930	1:1.17	

Treatment cost = Cost of biopesticides or biorationals pesticides + Charges of biopesticides pesticides application (Labour charges)

NSE 5% : Rs 15/kg      *Beauveria bassiana* 1.15%WP : Rs 200/kg      Labour cost @ Rs 1000/ha/spray  
 Karanj oil 1% : Rs 600/L      *Bt (Bacillus thuringiensis)* : Rs 1200/L  
 Azadiractin 10000 ppm : Rs 1200/L      *Metarhizium anisopliae* 1.15%WP : Rs 200/kg

## 5. SUMMARY AND CONCLUSION

The present investigation entitled “seasonal incidence, biology and management of leaf eating caterpillar, *Catopsilia pyranthe* (L) On Indian senna, *Cassia angustifolia* (Vahl)” was conducted during *kharif* 2019-20. The biology of leaf eating caterpillar was conducted under laboratory conditions and seasonal incidence and management at field conditions. The findings of these studies are summarized and concluded in this chapter.

### 5.1 Summary

#### 5.1.1 Seasonal Incidence of Leaf Eating Caterpillar

The studies on seasonal incidence of leaf eating caterpillar, *Catopsilia pyranthe* (L) On Indian senna, *Cassia angustifolia* (Vahl) were conducted during *kharif* 2019-20 at the Farm of AICRP on MAP & B, MPKV, Rahuri.

The incidence of leaf eating caterpillar was initiated from the last week of July (30<sup>th</sup> MW) and remained continuous up to first week of December (49<sup>th</sup> MW). The data revealed that average number larvae of leaf eating caterpillar per plant ranged from 0.4-26.4 during the entire period. The incidence of leaf eating caterpillar starts in the month of July, 2019. The incidence gradually increased up to the fourth week of October and reached its peak i.e. 26.4 larvae/plant. During peak infestation level of leaf eating caterpillar, the maximum and minimum temperature, morning and evening relative humidity and rainfall were 31.1<sup>0</sup>C, 18.4<sup>0</sup>C, 76 per cent, 46 per cent and 23.4 mm, respectively. Thereafter, population declined gradually from 3<sup>rd</sup> week of November (47<sup>th</sup> MW) and remained up to 0.8 larvae /plant in first week of December (49<sup>th</sup> MW).

#### 5.1.2 Correlation of Weather Parameters with Seasonal Incidence of Leaf Eating Caterpillar

Correlation between leaf eating caterpillar population and weather parameters indicated that the significant negative correlation with minimum temperature, wind velocity and rainfall, Sunshine hour had a non significant positive correlation evaporation while other all parameters like, maximum temperature, RH-morning and evening were non significant negatively correlated with the leaf eating caterpillar population.

### 5.1.2.1 Biology of leaf eating caterpillar

The biological parameters of *Catopsilia pyranthe* (L) were studied at room temperature under laboratory conditions. Observations were recorded daily for incubation period, larval period, pupal period, oviposition period, adult longevity, fecundity and sex ratio. Biometric measurements of different developmental stages of leaf eating caterpillar were also recorded.

The mean incubation period was observed to be 3.06 days. During larval development, larvae passed through five instars. There were significant differences in duration of different instars. The total larval duration was observed to be 16.2 days. The pupa was pale green in colour with a yellow lateral line and was 23.17 mm long and 7.63 mm broad. The pupal period was found to be 6.34 days and oviposition period was observed to be 6.37 days.

In general, the females lived longer than males. Mean longevity of males was observed 6.45 days while in case of females, it was 7.6 days. Females outnumbered the males and the sex ratio (female: male) was observed 1:1.60. The fecundity of *Catopsilia pyranthe* (L) was observed 191 eggs/ female. The total life cycle was completed within 32.65 days.

### 5.1.3 Efficacy of Biopesticides and Biorationals Against Leaf Eating Caterpillar

Results from the experiment revealed that, all the treatments were found to be effective in reducing the leaf eating caterpillar population over untreated control. Among treatments, the significantly less number of leaf eating caterpillar was recorded from the treatment T<sub>5</sub> (*Bt Bacillus thuringiensis* @ 2 ml/lit. water) showed to be the most promising treatment which recorded 5.06 leaf eating caterpillar per plant and found at par with the treatment T<sub>3</sub> Azadiractin 10000 ppm @ 2 ml/lit. water (5.36 leaf eating caterpillar) followed by T<sub>2</sub> karanj oil @ 1ml / lit. water (7.66 leaf eating caterpillar), NSE 5% @ 50 g/lit.water (9.4 leaf eating caterpillar), T<sub>4</sub> *Beauveria bassiana* 1.15 % WP @ 5 g/lit. water (13.06), T<sub>6</sub> *Metarhizium anisopliae* 1.15% WP @ 5g / lit.water (14.33 leaf eating caterpillar). The maximum population was found under the untreated control i.e. 17.1 leaf eating caterpillar per plant.

#### 5.1.4 Effect of Different Biopesticides and Biorationals Against Leaf Eating Caterpillar on Dry Herbage Yield of Indian Senna

Results from the experiment revealed that, all the treatments were found to be effective in achieving higher yield over untreated control. The dry herbage yield of Indian senna due to different treatments varied from 9.32 to 16.06 q/ha. Among treatments, the higher dry herbage yield of 16.06 q/ha was produced by T<sub>5</sub> *Bt* (*Bacillus thuringiensis* @ 2 ml/lit. of water) it was followed by T<sub>3</sub> Azadiractin 10000 ppm @ 2 ml /lit.water (15.43 q/ha), T<sub>2</sub> karanj oil @ 1ml / lit. water (11.21 q/ha), NSE 5% @ 50 g/lit.water (10.36 q/ha), T<sub>4</sub> *Beauveria bassiana* 1.15 % WP @ 5 g/lit. water (9.75 q/ha), T<sub>6</sub> *Metarhizium anisopliae* 1.15% WP @ 5 g/lit. water (9.32 q/ha). However, the lowest dry herbage yield (8.43 q/ha) was recorded in the untreated control.

#### 5.1.5 Incremental Cost Benefit Ratio (ICBR) and B : C Ratio of Different Biopesticides and Biorationals Against Leaf Eating Caterpillar

As regards the incremental cost benefit ratio among all treatment, the highest ICBR (1:11.13) was recorded in T<sub>5</sub> *Bt*(*Bacillus thuringiensis* @ 2 ml/lit. of water) with highest B : C ratio (1:2.06) it was followed by T<sub>3</sub> Azadiractin 10000 ppm @ 2 ml/lit.water (1:10.13) with B : C ratio (1:1.98), NSE 5% @ 50 g/ lit. water (1:3.91) with B : C ratio (1:1.37), T<sub>4</sub> *Beauveria bassiana* 1.15%WP @ 5 g/lit. water (1:2.08) with B : C ratio (1:1.28), T<sub>2</sub> karanj oil @ 10ml /lit.water (1:1.43) with B : C ratio (1:1.35), T<sub>6</sub> *Metarhizium anisopliae* 1.15% WP @ 5g / lit.water (1:1.07) with B : C ratio (1:1.22).

## 5.2 Conclusion

Following conclusions were drawn and made from the present investigation.

1. Seasonal incidence of leaf eating caterpillar, *Catopsilia pyrathe* (L) shown fluctuation due to the abiotic factors viz.,Maximum and minimum temperature, RH-morning and RH-evening, rainfall, wind speed, sunshine hours and pan evaporator.
2. The incidence of leaf eating caterpillar was initiated from the last week of July (30<sup>th</sup> MW) and remained continuous up to first week of December (49<sup>th</sup> MW) and incidence of leaf eating caterpillar was found maximum (26.4 larvae/plant ) in 1<sup>st</sup> week of November (45<sup>th</sup> MW).

3. Correlation between leaf eating caterpillar population and weather parameters indicated that the significant negative correlation with minimum temperature, wind velocity and rainfall, Sunshine hour had a non significant positive correlation evaporation while other all parameters like, maximum temperature, RH-mornig and evening were non significant negatively correlated with the leaf eating caterpillar population.
4. The female moth of *Catopsilia pyrathe* (L) laid eggs singly on upper and lower side of leaves. The incubation period of eggs ranged from 2 to 4 days with mean duration of 3.06 days. The average length and width of egg was measured to be 2.94 and 1.13 mm, respectively. The larval period and pupal period was observed to be 16.32 and 6.34 days, respectively. The total life span was observed to be 32.65 days.
5. For the effective management of leaf eating caterpillar among all treatments, T<sub>5</sub> (*Bt Bacillus thuringiensis* @ 2 ml /lit. water) proved to be significantly superior over all treatments and found at par with the treatment T<sub>3</sub> Azadiractin 10000 ppm @ 2 ml /lit. water (10.07 leaf eating caterpillar).
6. The highest dry herbage yield (16.06 qt/ha) was recorded from the treatment, T<sub>5</sub> *Bt* (*Bacillus thuringiensis* @ 2ml/ lit. of water) it was followed by T<sub>3</sub> Azadiractin 10000 ppm @ 2 ml /lit.water (15.43 q/ha)
7. Among all the treatment, the highest incremental cost benefit ratio (1:11.13) with B : C ratio 1:2.06 was recorded by T<sub>5</sub> *Bt* (*Bacillus thuringiensis*) @ 2ml/ lit. water and the cost benefit ratio (1:10.13) with B : C ratio (1:1.98) was recorded in the treatment T<sub>3</sub> Azadiractin 10000 ppm @ 2 ml/lit. water.

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## 8. VITAE

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