

**COMPATIBILITY OF  
RECOMMENDED INSECTICIDES  
AND FUNGICIDES FOR THE  
MANAGEMENT OF MAJOR INSECT  
PESTS AND DISEASES OF PADDY**

**KUSUME ANIL KUMAR**

**B.Sc. (Ag.)**

**MASTER OF SCIENCE IN AGRICULTURE  
(ENTOMOLOGY)**



**2015**

## ABSTRACT

**Name of the Author** : **K. ANIL KUMAR**

**Title of the thesis** : **“COMPATIBILITY OF  
RECOMMENDED INSECTICIDES  
AND FUNGICIDES FOR THE  
MANAGEMENT OF MAJOR  
INSECT PESTS AND DISEASES OF  
PADDY”**

**Submitted for the award of** : **Master of Science**

**Faculty** : **AGRICULTURE**

**Discipline** : **ENTOMOLOGY**

**Major Advisor** : **Dr. A. SITHA RAMA SARMA**

**University** : **ACHARYA N.G. RANGA  
AGRICULTURAL UNIVERSITY**

**Year of submission** : **2015**

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Studies on **“COMPATIBILITY OF RECOMMENDED INSECTICIDES AND FUNGICIDES FOR THE MANAGEMENT OF MAJOR INSECT PESTS AND DISEASES OF PADDY”** were conducted in the laboratory of the Department of Entomology and Agricultural College Farm, Agricultural College, Bapatla, Guntur District, Andhra Pradesh during 2014-15. In the investigations, seasonal incidence of insect pests and diseases of paddy, physical, chemical compatibility and biological efficacy of insecticides, fungicides alone and in combinations were studied.

A bulk plot of 200 m<sup>2</sup> and a light trap was maintained to study the seasonal incidence of pests of paddy during *kharif*, 2014. The leaf folder, *Cnaphalocrosis medinalis* L. infestation started during 39<sup>th</sup> standard week (September 24<sup>th</sup>- 30<sup>th</sup>) with 12.95 per cent per 50 hills and reached a peak level at 48<sup>th</sup> standard week (November 26<sup>th</sup>- December 2<sup>nd</sup>) with 18.31% and declined gradually to 8.10% in 49<sup>th</sup> standard week. The symptoms of rice leaf blast disease caused by *Pyricularia oryzae* appeared initially during 43<sup>rd</sup> standard week (October 22<sup>nd</sup> – 28<sup>th</sup>) with 1.55 per cent disease severity and reached a peak level at 48<sup>th</sup> standard week with 14.66% and decreased gradually to 2.55% at 51<sup>st</sup> standard week. In light trap the catches of brown plant hopper, *Nilaparvata lugens* L. started appearing from 25<sup>th</sup> October (15.00) and gradually increased and attained two peaks during 9<sup>th</sup> November (5400) and 3<sup>rd</sup> December (2145) respectively thereafter the population gradually decreased towards the

end of the season. However the green leafhopper, *Nephotettix virescens* L. catches started appearing from 31<sup>st</sup> October (11.33), gradually increased and attained two peaks during 15<sup>th</sup> November (2328.67) and 15<sup>th</sup> December (4731.33) respectively and thereafter the population gradually declined. The leaf folder adults in light trap started appearing from 6<sup>th</sup> November (1.33) and attained peak at 12<sup>th</sup> December (20) and thereafter gradually decreased. No significant correlation between weather factors studied with brown planthopper catches and leaf folder infestation. However, green leafhopper catches showed a non-significant and negative correlation with maximum temperature and rainfall and significant and positive correlation with morning and evening relative humidity. Whereas the leaf folder adult catches in light trap showed a non-significant correlation with maximum temperature, minimum temperature, rainfall and significant and positive correlation with morning relative humidity. Leaf blast incidence showed a significant and negative correlation with maximum and minimum temperature but significantly positive correlation was observed with morning relative humidity.

Laboratory experiment conducted in the Department of Entomology, Agricultural College, Bapatla to test the physical and chemical compatibility of insecticide and fungicide combinations. There was no formation of sediment at the bottom and the creamy layer at the top when insecticides and fungicides mixed in distilled water, tap water and standard hard water. The specific gravity values, pH and EC values also did not vary much. The experiment conducted in green house at Agricultural College, Bapatla to assess the phytotoxicity revealed that no phytotoxicity symptoms were observed when insecticides and fungicides mixed and applied to potted plants at recommended and higher dose (double). The per cent leaf injury was less than one implying the tested insecticides and fungicides are physically, chemically and biologically compatible with each other.

From the field experiment conducted during *kharif*, 2014 in the College Farm, Agricultural College, Bapatla to evaluate the efficacy of foliar sprays of insecticides, fungicides alone and in combination against major pests of paddy. Chlorantraniliprole + isoprothiolane (0.3 ml l<sup>-1</sup>+1.5 ml l<sup>-1</sup>) emerged as the most effective treatment to control leaf folder infestation with 83.04 per cent leaf damage reduction over control followed by chlorantraniliprole (0.3 ml l<sup>-1</sup>) and chlorpyrifos (2.5 ml l<sup>-1</sup>) with 81.86 and 79.67%. With respect to leaf blast, tricyclazole (0.6 g l<sup>-1</sup>) was found superior over other treatments in reducing leaf blast severity with 74.13 per cent reduction of disease over control followed by isoprothiolane (1.5 ml l<sup>-1</sup>) with 69.42 per cent reduction of disease incidence over control. Significantly highest yield (5.39 t ha<sup>-1</sup>) was recorded in chlorantraniliprole + isoprothiolane (0.3 ml l<sup>-1</sup>+1.5 ml l<sup>-1</sup>) followed by all other combination, individual treatments. The untreated control recorded the lowest yield (2.00 t ha<sup>-1</sup>). There was no reduction in the efficacy of insecticides when mixed with fungicides and *vice-versa* against both leaf folder infestation and leaf blast severity.

## **ACKNOWLEDGEMENTS**

*At the outset, I submit that it is by the blessings of the almighty GOD, I had been able to bring to light this humble piece of work for which I am externally indebted.*

*Diction is not enough to formulate my lovable thanks to my gifted parents, **K. Subba Rao, K. Santha Kumari** and my brothers **Rajendra Prasad** and **Ashok Kumar** and my sister-in-law **Deepthi** and **Suneetha** and my lovely “**Minnu**” and “**Deepu**”. They are ineffable and to their beloved feet I am bestowing this thesis with great pleasure.*

*With honourable respects and immense pleasure, I express my profound sense of gratitude to the chairman of my advisory committee **Dr. A. SITHA RAMA SARMA**, Scientist (Entomology) R.A.R.S, Nandyal for his learned counsel, unstinted attention, arduous and meticulous guidance in all the stages which provided me commendable encouragement and shaped my efforts into a successful research work.*

*I feel elated to express my hearty thanks to **Dr. T. Madhumathi**, Professor, Department of Entomology, Agricultural College, Bapatla and member of my advisory committee for her immense interest, transcendent suggestions, and affectionate encouragement at every stage of shaping my thesis.*

*With deep respect and esteem regards I owe my indebtedness to **Dr. V. Prasanna Kumari**, Assistant professor, Department of Plant Pathology and member of my advisory committee for her timely help and meticulous guidance during the period of study.*

*I have immense pleasure to elucidate my heartfull thanks to **Dr. P. V. Krishnayya**, Professor and University Head, Department of Entomology, Agricultural College, Bapatla for his unstinted attention, critical supervision, timely and kind help during the course of investigation.*

*I cordially offer my indebted remarks to **Dr. V. Sai Ram Kumar** and **Dr. C. Sandhya Rani** Associate Professors, from the Department of Entomology, for their co-operation and encouragement extended to me during my study.*

*I fervently express my immense and gargantuan respect and thanks to **Dr. P. V. N. Prasad**, Head of College Farm, for keeping abreast of me and providing their valuable help when ever needed, during the period of my investigation.*

*My keen sense of gratitude to my seniors, **Suneel, Sitaramaraj, Darvin, Ravi, Anil, Muthu, Dinesh, Bapujinaidu, Sadgurumurthy, Naidu, Jyothi, Divya, Revathi, Janaki** and my juniors **Deekshitha, Satyasree, Priyanka, Rekha, Sudha, Madhurya, Appalraju, Adhil, Sameer, Ajith, Shiva, Prasanna** who helped me a lot in my research work.*

*I am very much beholden and profoundedly indebted to my affectionate colleagues **Dhanapal, Krishna Kanth, Sai, Venkatesh, Chaitanya, Divya, Yogeshwari, Sravani, Susrutha** and to my dearest friends **Ramesh babu, Rama rao, Ashok, Pradeep, Jaya, Nagendra, Prabhakar, Manjunath, Chithanya, Rajesh and Sekhar** for their help and cooperation during the course of my research work. There are no words to express my love and affection to all my friends each and every one, who had encouraged and supported me a lot.*

*My hearty thanks to all the **non-teaching staff** of Department of Entomology and farm workers for their timely help for carrying out my research work. I am very thankful to our **College Librarian** and other **Library Staff** for providing necessary facilities.*

*I shall be failing in my duty, if I don't express my thanks to **ANGRAU** for providing me the financial help in the form of stipend and also encouragement to complete the study successfully.*

*While travelling on this part of education, many hands pushed me forth, learned hearts put me on the right track. I ever rest **THANKS** to all of them.*

*Any omission in this brief acknowledgement doesn't mean lack of gratitude.*

*Place : Bapatla*

*Date :*

**(K. Anil Kumar)**

## APPENDIX-I

**Weekly meteorological data at Agricultural College Farm, Bapatla during the  
crop growth period (10-09-2014 to 04-03-2015)**

Standard Meteorological week	Date and Month	Mean Temperature (°C)		Mean R.H. (%)	Rainfall (mm)
		Max.	Min.		
1	37 (10-16 <sup>th</sup> Sep 2014)	35.70	24.98	74.50	4.24
2	38 (17-23 <sup>rd</sup> Sep)	32.05	24.02	81.43	12.08
3	39 (24-30 <sup>th</sup> Sep)	33.78	25.72	77.36	0.00
4	40 (01-07 <sup>th</sup> Oct)	33.27	24.76	77.71	3.00
5	41 (08 -14 <sup>th</sup> Oct)	34.18	25.70	78.00	1.40
6	42 (15-21 <sup>st</sup> Oct)	36.82	24.44	69.50	1.20
7	43 (22-28 <sup>th</sup> Oct)	32.00	22.78	79.21	19.60
8	44 (29 Oct -4 <sup>th</sup> Nov)	30.55	21.61	80.57	141.20
9	45 (05-11 <sup>th</sup> Nov)	30.28	20.81	76.21	0.00
10	46 (12-18 <sup>th</sup> Nov)	30.51	22.01	79.14	34.50
11	47 (19-25 <sup>th</sup> Nov)	30.74	20.30	85.71	76.00
12	48 (26 Nov- 2 <sup>nd</sup> Dec)	30.41	17.65	82.07	0.00
13	49 (03-09 <sup>th</sup> Dec)	30.27	17.91	76.00	0.00
14	50 (10-16 <sup>th</sup> Dec)	30.58	18.20	77.23	0.00
15	51 (16-23 <sup>rd</sup> Dec)	29.34	20.97	76.94	0.00
16	52 (24-30 <sup>th</sup> Dec)	29.31	16.3	76.82	0.20
17	01 (01 - 7 <sup>th</sup> Jan 2015)	30.5	20.9	83.3	-
18	02 (08- 14 <sup>th</sup> Jan)	30.3	15.2	67.9	-
19	03 (15- 21 <sup>st</sup> Jan)	30.0	15.8	71.4	-
20	04 (22- 28 <sup>th</sup> Jan)	29.8	16.0	73.3	-
21	05 (29 <sup>th</sup> Jan – 4 <sup>th</sup> Feb)	30.0	17.6	78.6	-
22	06 (5- 11 Feb)	30.7	17.0	76.6	-
23	07 (12- 18 <sup>th</sup> Feb)	31.3	18.9	80.4	-
24	08 (19- 25 <sup>th</sup> Feb)	31.9	18.1	70.5	-
25	09 (26- 4 <sup>th</sup> Mar)	31.1	20.9	72.4	0.6
<b>Mean</b>		31.41	20.34	76.91	16.49

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## **DECLARATION**

I, **Mr. K. ANIL KUMAR**, hereby declare that the thesis entitled **“COMPATIBILITY OF RECOMMENDED INSECTICIDES AND FUNGICIDES FOR THE MANAGEMENT OF MAJOR INSECT PESTS AND DISEASES OF PADDY”**, submitted to **Acharya N.G. Ranga Agricultural University** for the degree of **Master of Science in Agriculture** in the major field of **Entomology** is the result of original research work done by me. I also declare that no material contained in the thesis has been published earlier in any manner.

Place:

Date:

**(K. ANIL KUMAR)**

**I. D. No. BAM-13-27**

**COMPATIBILITY OF RECOMMENDED  
INSECTICIDES AND FUNGICIDES FOR THE  
MANAGEMENT OF MAJOR INSECT PESTS  
AND DISEASES OF PADDY**

**BY  
KUSUME ANIL KUMAR**

**B.Sc. (Ag.)**

**THESIS SUBMITTED TO THE  
ACHARYA N.G. RANGA AGRICULTURAL UNIVERSITY  
IN PARTIAL FULFILMENT OF THE REQUIREMENTS  
FOR THE AWARD OF THE DEGREE OF**

**MASTER OF SCIENCE IN AGRICULTURE  
(ENTOMOLOGY)**

**CHAIRMAN: Dr. A. SITHA RAMA SARMA**



**DEPARTMENT OF ENTOMOLOGY  
AGRICULTURAL COLLEGE, BAPATLA - 522 101  
ACHARYA N.G. RANGA AGRICULTURAL UNIVERSITY**

**2015**

## **CERTIFICATE**

**Mr. K. ANIL KUMAR** has satisfactorily prosecuted the course of research and that thesis entitled **“COMPATIBILITY OF RECOMMENDED INSECTICIDES AND FUNGICIDES FOR THE MANAGEMENT OF MAJOR INSECT PESTS AND DISEASES OF PADDY”** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that neither the thesis nor its part thereof has been previously submitted by him for a degree of any University.

Date:

**(A. SITHA RAMA SARMA)**  
Chairperson of the Advisory Committee  
Scientist (Entomology)  
R.A.R.S, NANDYAL

## **CERTIFICATE**

This is to certify that the thesis entitled “**COMPATIBILITY OF RECOMMENDED INSECTICIDES AND FUNGICIDES FOR THE MANAGEMENT OF MAJOR INSECT PESTS AND DISEASES OF PADDY**”, submitted in partial fulfillment of the requirements for the degree of ‘**Master of Science in Agriculture**’ in the major field of **Entomology** of the Acharya N. G. Ranga Agricultural University, Hyderabad is a record of the bonafide original research work carried out by **Mr. K. ANIL KUMAR** under my guidance and supervision.

No part of the thesis has been submitted by the student for any other degree or diploma. The published part and all the assistance received during the course of the investigations have been duly acknowledged by the author of the thesis.

### **Thesis approved by the Student’s Advisory Committee**

Chairperson      **Dr. A. SITHA RAMA SARMA**      \_\_\_\_\_  
Scientist (Entomology)  
R.A.R.S  
NANDYAL

Member            **Dr. T. MADHUMATHI**            \_\_\_\_\_  
Professor  
Department of Entomology  
Agricultural College, Bapatla

Member            **Dr. V. PRASANNA KUMARI**      \_\_\_\_\_  
Assistant Professor  
Department of Plant Pathology  
Agricultural College, Bapatla

**Date of final *viva-voce*:**

## LIST OF SYMBOLS AND ABBREVIATIONS USED

%	:	Per cent
&	:	And
/	:	Or
@	:	At the rate of
<	:	Less than
>	:	Greater than
<sup>0</sup> C	:	Degree Celsius
a.i.	:	Active ingredient
ADL	:	Average damaged leaves
ANOVA	:	Analysis of variance
Avg.	:	Average
BPH	:	Brown planthopper
C.D. (P=0.05%)	:	Critical difference at 5 per cent
C.I.B and R.C	:	Central Insecticide Board and Registration Committee
cm	:	Centimeter
CRD	:	Completely randomized design
CV	:	Coefficient of variation
DAS	:	Days after spraying
DAT	:	Days after transplantation
DBS	:	Days before spray
DH	:	Dead hearts
DMRT	:	Duncan's new multiple range test
dSm <sup>-1</sup>	:	DeciSemens per meter
EC	:	Emulsifiable Concentrate
E.C	:	Electrical conductivity
<i>et al.</i>	:	Co-workers
<i>etc.,</i>	:	Et cetra
ETL	:	Economic threshold level
Fig.	:	Figure
G	:	Granular formulation
g l <sup>-1</sup>	:	Grams per liter
GLH	:	Green leafhopper

h	:	Hours
ha	:	Hectares
<i>i.e.</i> ,	:	That is
kg ha <sup>-1</sup>	:	Kilograms per hectare
l ha <sup>-1</sup>	:	Liters Per hectare
Ltd.	:	Limited
m	:	Meter
M ha	:	Million hectares
M t	:	Million tonnes
m <sup>2</sup>	:	Square meter
Max.	:	Maximum
mg	:	Milligram
Min.	:	Minimum
ml l <sup>-1</sup>	:	Milliliters per liter
MLR	:	Multiple linear regression
mm	:	Millimeter
NS	:	Non Significant
pH	:	Hydrogen ion concentration
q ha <sup>-1</sup>	:	Quintal per hectare
r	:	Regression coefficient
RBD	:	Randomized block design
RH	:	Relative humidity
SC	:	Suspension Concentrate
SES	:	Standard Evaluation Scale
Sig.	:	Significant
SL	:	Soluble liquid
SMW	:	Standard Meteorological Week
SP	:	Soluble Powder
sq. m	:	Square meter
t ha <sup>-1</sup>	:	Tonnes per hectare
var.	:	Variety
<i>viz.</i> ,	:	Namely
WBPH	:	White backed planthopper
WE	:	White ears
WG	:	Wettable Granules
WP	:	Wettable Powder

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## Chapter I

# INTRODUCTION

Rice (*Oryza sativa* L.) is life and princess of cereals, the staple food of 65% of the total population in India. It constitutes about 52% of the total food grain production and 55% of total cereal production. Rice is grown under diverse growing conditions such as irrigated, rainfed lowland, rainfed upland and flood prone ecosystems. India is the largest rice growing country though China is the largest producer of rice. Out of 722.22 M t production of rice in the world, Asian countries shared 90% (653.83 M t) of world's rice production. While India contributes 157.90 M t annual production with 22% share of world's production and 24% of Asian countries rice production (FAO, 2011). In India, paddy is grown in 44.06 M ha constituting 34.4% of the total cultivable area. About 70% of our farmers are cultivating paddy and the production is about 105.31 M t and the productivity being 2178 t ha<sup>-1</sup>. In Andhra Pradesh, it occupied an area of 4.51 M ha with a production of 13.03 M t and productivity of 2891 kg ha<sup>-1</sup> during 2008-09 (Directorate of Economics and Statistics, 2013-14). It provides nearly 48% of rural employment, about two-third of total calorie supply and about one-half of the total protein intakes of an average person in the country (Islam *et al.*, 2013).

Among various constraints of rice production, the insect pests and diseases are of prime importance and are the limiting factors in getting higher grain yield. They occur simultaneously and damage rice crop under farmer's field conditions and estimated to cause yield losses to the tune of 30 to 40 per cent. A significant correlation between insect pests, diseases and yield loss of rice was observed (Biswas, 2012). Multiple pest damage usually had additive effects on yield loss. The rice crop is attacked by more than 100 species of insects and 20 of them can cause serious economic loss (Reddy and Krishnaiah, 2003). Major factors that have contributed towards changes in the pest scenario are extensive cultivation of high yielding varieties, growing of varieties lacking resistance to major pests, intensified rice cultivation throughout the year providing constant niches for pest multiplication, imbalanced use of fertilizers, non-judicious use of insecticides resulting in pest resistance to insecticides, resurgence of pests and outbreak of minor pests (Prakash *et al.*, 2014).

Among the insect pests of rice, yellow stem borer, *Scirpophaga incertulas* (Walker), white stem borer, *Scirpophaga innotata* (Walker), leaf folder, *Cnaphalocrocis medinalis* (Guenee), gall midge, *Orseolia oryzae* (Wood-Mason), leafhoppers, planthoppers and ear head bug, (*Leptocorisa acuta* Tunb.) occur every year in most of the rice growing areas of the world contributing major economic damage (Boopathi and Bharathi, 2008). Brown planthopper (BPH), *Nilaparvata lugens* (Stal.), White backed plant hopper (WBPH), *Sogatella furcifera* (Horvath) and Green leafhopper (GLH), *Nephotettix virescens* (Distant) constitute the major sucking insect pest in several rice growing tracts of India (Krishnaiah *et al.*, 2004).

The rice leaf folder, *Cnaphalocrocis medinalis* (Guenee) earlier, was considered as a minor pest, but now has assumed major pest status in the entire country particularly in areas of high fertilizer usage. In conducive environment this pest may cause severe damage at maximum tillering and flowering stages of the crop which may lead to 60 to 70% leaf damage with 50% reduction in yield (Kushwana and Singh, 1984).

Among diseases, rice blast (*Pyricularia oryzae* Cav.), brown spot (*Helminthosporium oryzae* Breda de Haan), sheath blight (*Rhizoctonia solani* Kuhn.), false smut (*Ustilaginoidea virens* Cooke.), sheath rot (*Sarocladium oryzae* Sawada), bacterial blight (*Xanthomonas campestris* pv. *oryzae* Ishiyama) and tungro (*Rice Tungro Bacilliform Virus* and *Rice Tungro Spherical Virus*) occur resulting in significant damage to the grain and straw yield in India. However, rice blast, bacterial blight, sheath blight and sheath rot are considered as major diseases because of their wide occurrence. Blast is a most serious disease of rice because of its devastating nature, faster spread, wider distribution and existence of several physiological races. Blast symptoms appear on leaves, nodes and grains. In general 40-50% reduction in yield was recorded but on severe incidence it varies from 70-80% (Prajapathi *et al.*, 2004).

The hot and humid environment wherein rice is grown is highly conducive for proliferation of insect pests resulting in serious outbreak. Weather factors regulate insect pest populations under field circumstances (Hyslops, 1941). Under Indian conditions, though paddy is attracted by a wide range of insect pests as compared to any other crop scanty information is available on the incidence and population build-up of rice pests under varying agro-climatic conditions (Sharma *et al.*, 2004).

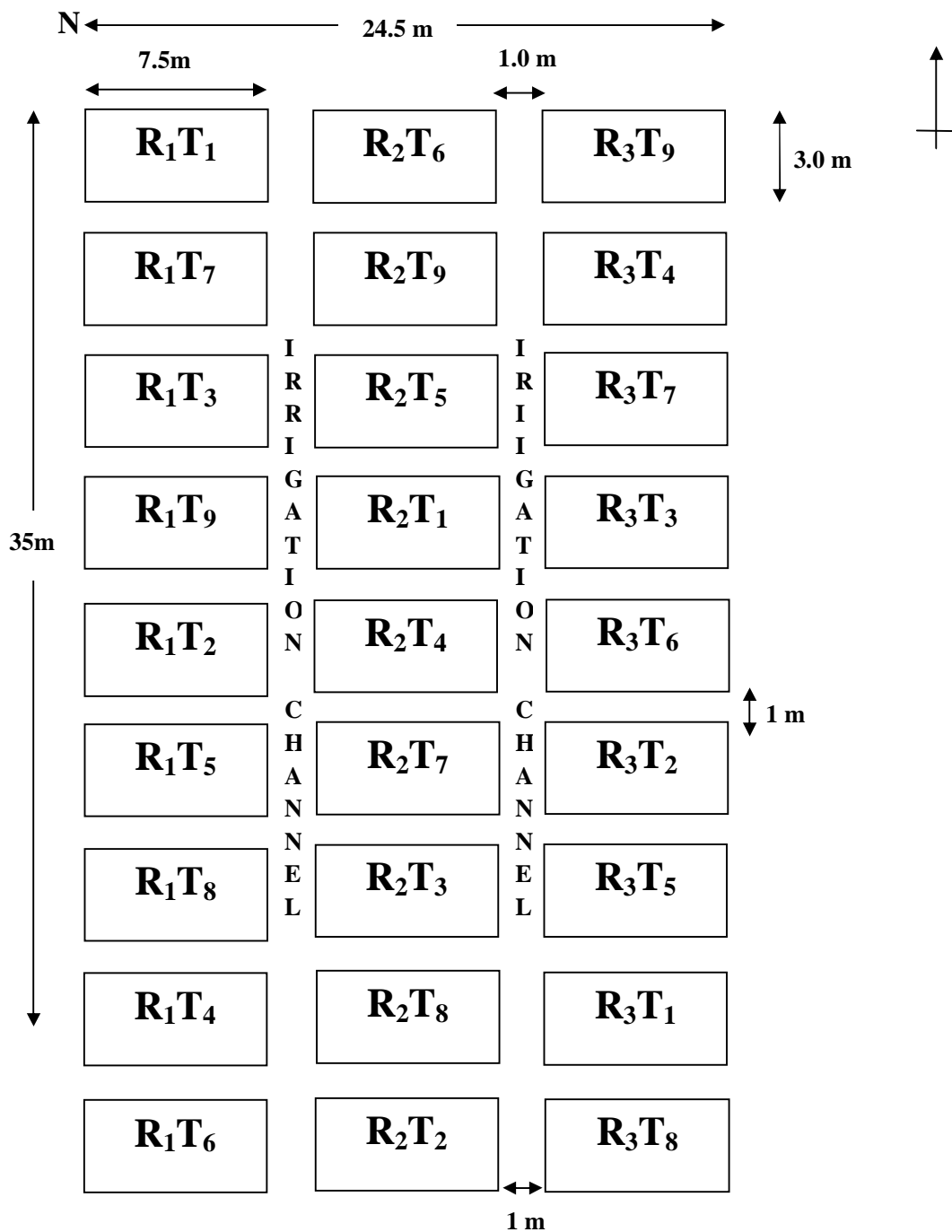
Therefore, there is a dire need to discover newer and safer pest control methods for effective management of pests and diseases. Insect-pests of rice like stem borer, leaf folder, diseases like blast and sheath blight coexist in rice ecosystem which, farmers have to manage simultaneously. Chemical control is one of the best and effective methods of pest control. It is the most commonly practiced method by farmers in rice that has made pest management highly complicated due to which farmers were forced to increase number of sprays, incurring additional cost.

Considering these factors, a novel method called development of pesticide mixture has emerged (Siddegowda, 2009). In this method, compatible and effective insecticide and fungicide combinations were formulated and applied as a single tank mix which saves time, labour, energy, equipment cost to the farmers and prevents ecological problems like enhanced phytotoxicity, resurgence *etc.*

The chemicals involved in plant protection are too many and the information on compatibility of individual chemicals, efficacy of insecticides and fungicides as a tank mix application in rice is scanty in the literature (Lakshmanan, 1992). Common growers find difficulty in ascertaining the compatibility of agrochemicals.

Keeping these problems in view, it was proposed to conduct research on the compatibility of insecticides and fungicides and their combined application in Paddy to find out their efficacy with the following objectives:

1. To study the occurrence of insect pests and diseases in Paddy during *khariif* 2014-15
2. To study the physical and chemical compatibility of insecticide and fungicide combinations.
3. To study the efficacy of foliar sprays of insecticides, fungicides alone and in combination on major insect pests and diseases of Paddy.



- Design** : Randomized Block Design  
**Replications** : 3  
**Treatments** : 9  
**Plot size** : 7.5 m X 3.0 m (22.50 m<sup>2</sup>)  
**Season** : *Kharif*, 2014  
**Spacing** : 25 cm X 15 cm

**Fig 3.1** Field layout plan of bioefficacy experiment

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**\* Original not seen**

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Note: The literature is cited as per the “Thesis Guidelines prescribed by Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad”.

## Chapter III

# MATERIAL AND METHODS

The experiments pertaining to the research topic entitled “**COMPATIBILITY OF RECOMMENDED INSECTICIDES AND FUNGICIDES FOR THE MANAGEMENT OF MAJOR INSECT PESTS AND DISEASES OF PADDY**” were conducted in the laboratory of the Department of Entomology and Agricultural College Farm, Agricultural College, Bapatla, Guntur District, Andhra Pradesh during 2014-15.

The material used and the methods followed in the present investigation are presented in this chapter

### **3.1 FIELD EXPERIMENT 1: STUDIES ON THE OCCURRENCE OF INSECT PESTS AND DISEASES IN PADDY DURING *KHARIF*, 2014**

A field experiment was conducted during *kharif*, 2014 at the College Farm of Agricultural College, Bapatla to study the occurrence of insect pests and diseases on paddy and their incidence was correlated with weather parameters like maximum temperature, minimum temperature, morning and evening relative humidity and rain fall to know their impact on the incidence of insect pests and diseases of paddy.

#### **3.1.1 Crop and Variety**

Most popular and widespread variety of rice, BPT 5204 (*Samba mashuri*) was selected for carrying out the investigations as it is highly susceptible to many insect pests and diseases of paddy.

### **3.1.2 Raising of the Nursery**

Paddy nursery was raised in the southern block of college farm by taking up sowing on 10.8.2014 and adopted all the recommended package of practices prescribed for the crop like irrigation, manures and fertilizers.

### **3.1.3 Preparation of the Main Field**

After onset of monsoon, the field was ploughed twice with tractor drawn cultivator to remove the weeds and stubbles. After letting water into the field, puddling was done twice with the tractor drawn disc harrow followed by levelling with the levelling plank.

### **3.1.4 Layout**

A bulk plot of 200 m<sup>2</sup> was raised and maintained without any insecticidal application.

### **3.1.5 Transplantation**

Transplanting was taken up on 10.09.2014 with 30 day old seedlings on 36<sup>th</sup> Standard Meteorological Week (SMW). Line planting was done at a spacing of 25 × 15 cm (25 between the rows and 15 cm within the row) with the help of a marked rope and 2 to 3 seedlings were maintained per hill.

### **3.1.6 Weeding**

Manual weeding was done at 15 and 30 days after transplantation and thereafter whenever necessary.

### **3.1.7 Irrigation**

Water level was maintained at two cm depth in the experimental field up to tillering stage and thereafter the water level was increased to five cm from post tillering stage to grain filling/maturity stage. Finally the field was completely drained ten days before harvesting.

### **3.1.8 Fertilizer Application**

Recommended dose of fertilizer (120: 60: 60 kg of NPK ha<sup>-1</sup>) was applied to the experimental field in the form of urea, single super phosphate and muriate of potash. Nitrogen was applied in three split doses, *i.e.*, at the time of planting as basal dose and remaining two doses each at tillering and panicle initiation stages as top dressing whereas total amount of the phosphorus was applied at once as basal dose at the time of planting. However, potash was applied in two splits *i.e.*, first half at planting time and the remaining half at panicle initiation stage.

### **3.1.9 Field Observations**

During the crop period, insect pests like leaf folder, stem borer, rice horned caterpillar and skipper, diseases like rice blast and sheath blight and natural enemies like spiders, dragonflies and damselflies were observed.

### **3.1.10 Data Recording**

The field data on various insect pests and natural enemies in the plot were recorded randomly on 50 hills per plot at three day intervals. Data was recorded when the pest and natural enemies activity was high (early hours at 6.00 AM). A light trap with 200 Watt bulb was installed on the field bund. The data on various pests was collected daily and simultaneously, the weather data prevailed was recorded. However, the data pertaining to blast and sheath blight incidence was collected randomly from 20 sampling units each of one sq. m area for seasonal incidence whereas the data was collected from five sampling units in each plot randomly in other experiments. The data on natural enemies was collected through net sweeps and counted individually.

**3.1.10.1 Assessment of leaf folder infestation:** The data so collected with reference to rice leaf folder damage was converted into per cent leaf damage by adopting the following formula

$$\text{Leaf folder per cent infestation} = \frac{\text{Number of damaged leaves per hill}}{\text{Total number of leaves per hill}} \times 100$$

**3.1.10.2 Assessment of leaf blast:** The data so obtained pertaining to blast incidence (score) following the SES (Standard Evaluation Scale) (IRRI, 1996) following 0-9 scale was converted into per cent disease index by using the formula

$$\text{Per cent disease index} = \frac{\text{Sum of all disease ratings}}{\text{Total number of rating} \times \text{maximum disease grade}} \times 100$$

**Table 3.1 Paddy blast scoring scale used in the experiment**

SCALE	PARTICULARS/ SYMPTOMS
0	No lesions
1	Small brown specks of pinhead size
2	Larger brown specks
3	Small, roundish to slightly elongated, necrotic grey spots, about 1-2 mm in diameter, with brown margin
4	Typical blast lesions elliptical, 1-2 cm long, usually confined to the area of the two main veins infecting less than 2% of the leaf area
5	Typical blast lesions infecting less than 10% of the leaf area
6	Typical blast lesions infecting 11-25% of the leaf area
7	Typical blast lesions infecting 26-50% of the leaf area
8	Typical blast lesions infecting 51-75% of the leaf area and many leaves dead
9	All leaves dead

(IRRI, 1996)

**3.1.10.3 Assessment of sheath blight:** The data so obtained on sheath blight was converted into per cent disease index by using the following formula

$$\text{Per cent disease index} = \frac{\text{Sum of all disease ratings}}{\text{Total number of rating} \times \text{maximum disease grade}} \times 100$$

**Table 3.2 Paddy sheath blight scoring scale used in the experiment**

<b>SCALE</b>	<b>PARTICULARS/ SYMPTOMS</b>
0	No incidence
1	Lesions limited to lower quarter of leaf sheath area
3	Lesions present on lower half of sheath area
5	Lesions present on more than half of leaf sheath
7	Lesions present on more than three fourth of leaf sheath. Severe infection on upper leaves including flag leaf.
9	Lesions reaching top of tillers severe infection on leaves and some plants are killed

(IRRI, 1996)

### **3.1.11 Statistical Analysis**

The data so obtained on various parameters were subjected to statistical analysis (Correlation, Multiple Regression Analysis, etc.) for deriving conclusions.

## **3.2 LAB EXPERIMENT: STUDIES ON THE PHYSICAL AND CHEMICAL COMPATIBILITY OF INSECTICIDE AND FUNGICIDE COMBINATIONS**

A laboratory experiment was conducted in the Department of Entomology, Agricultural College, Bapatla to test the physical and chemical compatibility of insecticide and fungicide combinations.

### **3.2.1 Cleaning of Glassware**

The glassware used in the experiment *viz.*, specific gravity bottles, measuring cylinders, pipettes, beakers, volumetric flasks *etc.*, were cleaned in acid cleaning solution which was prepared by dissolving 500 g of potassium dichromate in 5000 ml of distilled water and to this solution 500 ml of sulphuric acid was slowly added through the walls of the container. The glassware was first washed with a detergent followed by thorough cleaning with tap water before placing them in cleaning solution. The glassware was kept in cleaning solution for about four to five hours and later washed thoroughly with running tap water before use.

### 3.2.2 Insecticides

Four recommended insecticides were selected for this experiment and their recommended dosages and relevant information is furnished here under:

**Table 3.3 Particulars of insecticides used to study the physical and chemical compatibility of insecticide and fungicide combinations.**

S. No	Common name	Trade name	Chemical name	Formulation	Dosage tested
1	Chlorpyrifos	Classic	O,O-diethyl O-3,5,6-trichloropyridin-2-yl phosphorothioate	20% EC	2.5 ml l <sup>-1</sup>
2	Cartap hydrochloride	Caldan	S-[3-Carbamoylsulfanyl-2-(dimethylamino)propyl] carbamothioate	50% SP	2.0 g l <sup>-1</sup>
3	Chlorantraniliprole	Coragen	3-bromo-4'-chloro-1-(3-chloro-2-pyridyl)-2'-methyl-6'-(methylcarbamoyl) pyrazole-5-carboxanilide	18.5% SC	0.3 ml l <sup>-1</sup>
4	Phosphamidon	Sumidan	[3-Chloro-4-(diethylamino)-4-oxobut-2-en-2-yl] dimethyl phosphate	25% EC	2.0 ml l <sup>-1</sup>

### 3.2.3 Fungicides

Four recommended fungicides were selected for the experiment and their recommended dosages and relevant information is furnished here under:

**Table 3.4 Particulars of fungicides used to study the physical and chemical compatibility of insecticide and fungicide combinations.**

S. No.	Common name	Trade name	Chemical name	Formulation	Dosage
1	Carbendazim	Bavistin	Methyl-2-benzimidazole carbamate	50% WP	1.0 g l <sup>-1</sup>
2	Hexaconazole	Contaf	(RS)-2-(2, 4-dichlorophenyl) – 1 – (1 HH – 1, 2, 4 – triazol-1-yl) hexane-2-01.	5% SC	2.0 ml l <sup>-1</sup>
3	Tricyclazole	Baan	8-methyl-[1,2,4]triazolo[3,4-b][1,3] benzothiazole	75% WP	0.6 g l <sup>-1</sup>
4	Isoprothiolane	Fuzi-one	Dipropan-2-yl 2-(1,3-dithiolan-2-ylidene) propanedioate	40% EC	1.5 ml l <sup>-1</sup>

### 3.2.4 Physical Compatibility

Physical compatibility of spray solutions of insecticides, fungicides alone and in combination was tested by conducting emulsion stability test and specific gravity test.

**Table 3.5 Particulars of dosage of insecticides, fungicides alone and their combination used in physical and chemical compatibility test**

S. No.	Treatments	Recommended Concentration (ml or g l <sup>-1</sup> )
1.	Chlorpyrifos 20% EC	2.5
2.	Cartap hydrochloride 50% SP	2.0
3.	Chlorantraniliprole 18.5% SC	0.3
4.	Phosphamidon 25% EC	2.0
5.	Carbendazim 50% WP	1.0
6.	Hexaconazole 5% SC	2.0
7.	Tricyclazole 75% WP	0.6
8.	Isoprothiolane 40% EC	1.5
9.	Chlorpyrifos 20% EC + carbendazim 50% WP	2.5 + 1.0
10.	Chlorpyrifos 20% EC + hexaconazole 5% SC	2.5 + 2.0
11.	Chlorpyrifos 20% EC + tricyclazole 75% WP	2.5 + 0.6
12.	Chlorpyrifos 20% EC + isoprothiolane 40% EC	2.5 + 1.5
13.	Cartap hydrochloride 50% SP + carbendazim 50% WP	2.0 + 1.0
14.	Cartap hydrochloride 50% SP + hexaconazole 5% SC	2.0 + 2.0
15.	Cartap hydrochloride 50% SP + tricyclazole 75% WP	2.0 + 0.6
16.	Cartap hydrochloride 50% SP + isoprothiolane 40% EC	2.0 + 1.5
17.	Chlorantraniliprole 18.5% SC + carbendazim 50% WP	0.3 + 1.0
18.	Chlorantraniliprole 18.5% SC + hexaconazole 5% SC	0.3 + 2.0
19.	Chlorantraniliprole 18.5% SC + tricyclazole 75% WP	0.3 + 0.6
20.	Chlorantraniliprole 18.5% SC + isoprothiolane 40% EC	0.3 + 1.5
21.	Phosphamidon 40% EC+ carbendazim 50% WP	2.0 + 1.0
22.	Phosphamidon 40% EC + hexaconazole 5% SC	2.0 + 2.0
23.	Phosphamidon 40% EC + tricyclazole 75% WP	2.0 + 0.6
24.	Phosphamidon 40% EC + isoprothiolane 40% EC	2.0 + 1.5
25.	Untreated control	-

**3.2.4.1 Emulsion stability test:** Emulsion stability test was carried out with distilled water, normal tap water and standard hard water (342 ppm) as prescribed by Indian Standard Institution specifications (ISI, 1973). Standard hard water was prepared by dissolving 0.302 g of anhydrous calcium chloride ( $\text{CaCl}_2$ ) and 0.139 g of hexahydrate magnesium chloride ( $\text{MgCl}_2$ ) in one litre of distilled water which gives standard hard water with hardness of 324 ppm of calcium carbonate. Individual pesticide solutions (30 ml each) were prepared by utilizing hard water in a beaker. For testing the emulsion stability of the combinations, each insecticide (30 ml) and fungicide (30 ml) solutions were poured into a beaker. The contents of the beaker was stirred with a glass rod at the rate of four revolutions per second during the addition of pesticides after that the diluted emulsion was made upto 100 ml with standard hard water and transferred immediately to a clean and graduated cylinder. The cylinder with its contents was kept at a temperature of  $30 \pm 1$  °C for one hour without any disturbance. The experiment was replicated thrice. After a specified time *i.e.*, on 1<sup>st</sup>, 6<sup>th</sup> and 24<sup>th</sup> hr. of the experiment, the volume of the creamy matter at the top and or the sediment if any at the bottom were observed. For stable emulsion, the creamy matter or the sediment if any should not exceed 2.0 ml (ISI). The same test was repeated with normal tap water and distilled water.

**3.2.4.2 Specific gravity test:** Specific gravity bottles of 25 ml capacity were taken and the weight of clean and dry specific gravity bottle was recorded as  $W_1$ . The bottle was filled with distilled water and closed with stopper and the excess water adhering to the outer surface of the bottle was wiped out with blotting paper. The weight of the bottle along with distilled water was recorded as  $W_2$ . A known quantity of recommended concentration of pesticide formulation was prepared as detailed earlier for calculating the specific gravity. The bottle with distilled water was emptied and filled with the liquid formulation of pesticide. Weight of the bottle along with pesticide solution was recorded as  $W_3$ . The specific gravity test of the insecticides, fungicides were worked out by using the following formula

$$\text{Specific gravity of pesticide} = \frac{\text{Weight of the known volume of the insecticide}}{\text{Weight of the equal volume of the water}}$$

$$\text{Specific gravity of pesticide} = \frac{(W_3 - W_1)}{(W_2 - W_1)}$$

The test was conducted by using normal tap water, standard hard water and distilled water in three replications to find out the differences in their specific gravity, if any.

### **3.2.5 Chemical Compatibility**

Chemical compatibility of spray solutions of insecticides, fungicides alone and in combination was tested by conducting pH and EC analysis using pH and EC meter, respectively.

**3.2.5.1 pH and EC analysis:** A known quantity of solution was taken in a beaker from the solutions prepared for emulsion stability test individually for all the treatments mentioned in the table and the pH and EC measuring electrodes were dipped into the individual beaker and the values were noted. All the treatments were replicated thrice and the tests were conducted with normal distilled water, tap water and standard hard water.

### **3.2.6 Phytotoxicity Test**

An experiment was conducted in green house at Agricultural College, Bapatla to assess the phytotoxicity of the test chemicals on rice plants by spraying recommended and higher concentration (double dose) of insecticides *viz.*, chlorpyrifos, cartaphydrachloride, chlorantraniliprole, phosphamidon and fungicides *viz.*, carbendazim, hexaconazole, tricyclazole, isoprothiolane alone and their combinations for their compatibility. The experiment was laid out in completely randomized design with three replications and untreated check was also maintained for comparison. Rice plants were grown in the pots containing the sandy loam soils by sowing the seeds at the rate of two seeds per pot. The spraying of insecticides, fungicides alone and its combination was done at 45-50 days after sowing. Plants were observed for phytotoxicity symptoms at 1, 3, 7, 9, 11 and 14

days after spraying. The phytotoxic symptoms like injury to leaf tip and leaf surface, wilting, vein clearing, necrosis, epinasty and hyponasty (Maximum grade points/symptoms) were recorded. The extent of phytotoxicity was recorded based on the scale prescribed by Central Insecticide Board and Registration Committee (C.I.B and R.C). The per cent leaf injury was worked out by using the formulae

$$\text{Per cent leaf injury} = \frac{\text{Total grade points/ Symptoms}}{\text{Maximum grade} \times \text{No. of leaves}} \times 100$$

**Table 3.6 Phytotoxicity visual rating scale**

<b>Rating</b>	<b>Phytotoxicity based on per cent leaf injury</b>
0	No phytotoxicity
1	1-10
2	11-20
3	21-30
4	31-40
5	41-50
6	51-60
7	61-70
8	71-80
9	81-90
10	91-100

**Table 3.7 Particulars of dosage of insecticides, fungicides alone and their combination used in phytotoxicity test**

<b>S. No.</b>	<b>Treatments</b>	<b>Recommended Concentration (ml or g l<sup>-1</sup>)</b>	<b>Higher Concentration (ml or g l<sup>-1</sup>)</b>
1.	Chlorpyrifos 20% EC	2.5	5.0
2.	Cartap hydrochloride 50% SP	2.0	4.0
3.	Chlorantraniliprole 18.5% SC	0.3	0.6
4.	Phosphamidon 25% EC	2.0	4.0
5.	Carbendazim 50% WP	1.0	2.0
6.	Hexaconazole 5% SC	2.0	4.0
7.	Tricyclazole 75% WP	0.6	1.2
8.	Isoprothiolane 40% EC	1.5	3.0
9.	Chlorpyrifos 20% EC + carbendazim 50% WP	2.5 + 1.0	5.0 + 2.0
10.	Chlorpyrifos 20% EC + hexaconazole 5% SC	2.5 + 2.0	5.0 + 4.0
11.	Chlorpyrifos 20% EC + tricyclazole 75% WP	2.5 + 0.6	5.0 + 1.2
12.	Chlorpyrifos 20% EC + isoprothiolane 40% EC	2.5 + 1.5	5.0 + 3.0
13.	Cartap hydrochloride 50% SP + carbendazim 50% WP	2.0 + 1.0	4.0 + 2.0
14.	Cartap hydrochloride 50% SP + hexaconazole 5% SC	2.0 + 2.0	4.0 + 4.0
15.	Cartap hydrochloride 50% SP + Tricyclazole 75% WP	2.0 + 0.6	4.0 + 1.2
16.	Cartap hydrochloride 50% SP + isoprothiolane 40% EC	2.0 + 1.5	4.0 + 3.0
17.	Chlorantraniliprole 18.5% SC + carbendazim 50% WP	0.3 + 1.0	0.6 + 2.0
18.	Chlorantraniliprole 18.5% SC + hexaconazole 5% SC	0.3 + 2.0	0.6 + 4.0
19.	Chlorantraniliprole 18.5% SC + tricyclazole 75% WP	0.3 + 0.6	0.6 + 1.2
20.	Chlorantraniliprole 18.5% SC + isoprothiolane 40% EC	0.3 + 1.5	0.6 + 3.0
21.	Phosphamidon 40% EC + carbendazim 50% WP	2.0 + 1.0	4.0 + 2.0
22.	Phosphamidon 40% EC + hexaconazole 5% SC	2.0 + 2.0	4.0 + 4.0
23.	Phosphamidon 40% EC + tricyclazole 75% WP	2.0 + 0.6	4.0 + 1.2
24.	Phosphamidon 40% EC + isoprothiolane 40% EC	2.0 + 1.5	4.0 + 3.0
25.	Untreated control	-	0.0

### **3.3 FIELD EXPERIMENT 2: STUDIES ON EFFICACY OF FOLIAR SPRAYS OF INSECTICIDES, FUNGICIDES ALONE AND IN COMBINATION FOR THE MANAGEMENT OF MAJOR INSECT PESTS AND DISEASES OF PADDY**

A field experiment was conducted during *khariif*, 2014 in the College Farm, Agricultural College, Bapatla to evaluate the efficacy of foliar sprays of insecticides, fungicides alone and in combination on major insect pests and diseases of paddy. Major insect pests observed during the crop period were leaf folder, green leafhoppers, brown planthoppers and stem borer but only leaf folder crossed the Economic Threshold Limit (ETL) and major disease observed during the crop growth period was paddy blast..

The field preparation, raising of nursery, fertilizers applied, irrigations and weed management followed for the crop were already detailed under 3.1.

#### **3.3.1 Lay out**

The experiment was laid out in a simple Randomised Block Design (RBD) with twelve treatments replicated thrice including the untreated check. Replications were separated with a gap of one metre for irrigation channels (Fig. 3.1). Thirty days old seedlings were then transplanted on 10. 11. 2014.

#### **3.3.2 Treatments**

From the emulsion stability test and phytotoxicity tests, only nine treatments were chosen for testing under field conditions because of the incidence of leaf folder and blast in the field. Among the treatments selected for study, two are insecticides, two are fungicides, four are insecticide and fungicide combinations and an untreated check. The details of the treatments are given here under 3.1

**Table 3.8 Particulars of insecticides, fungicides alone and their combination used in the experiment**

S. No.	TREATMENTS
T <sub>1</sub>	Chlorpyrifos 20% EC
T <sub>2</sub>	Chlorantraniliprole 18.5% SC
T <sub>3</sub>	Tricyclazole 75% WP
T <sub>4</sub>	Isoprothiolane 40% EC
T <sub>5</sub>	Chlorpyrifos 20% EC + Tricyclazole 75% WP
T <sub>6</sub>	Chlorpyrifos 20% EC + Isoprothiolane 40% EC
T <sub>7</sub>	Chlorantraniliprole 18.5% SC + Tricyclazole 75% WP
T <sub>8</sub>	Chlorantraniliprole 18.5% SC + Isoprothiolane 40% EC
T <sub>9</sub>	Untreated check

### **3.3.3 Preparation and Application of Insecticides**

The concentrations of the different treatments were selected as per the Zonal Research and Extension Advisory Committee proceedings and recommendations (ZREAC, 2015). Calculated quantities of selected insecticides and combinations were measured with the help of micro pipettes and mixed with required quantities of water to get desired dilution and sprayed with a hand compression knapsack sprayer. After every application of each of the treatments, the sprayer was thoroughly washed and rinsed twice with water and used for further treatments.

### **3.3.4 Field Observations**

During the crop period, almost all the insect pests were observed, but only leaf folder crossed the ETL levels while others remained below ETL. The efficacy of different treatments was studied against the leaf folder and rice leaf blast.

### **3.3.5 Data Recording**

#### **3.3.5.1 Leaf folder**

The treatments were imposed when the population crossed the ETL, *i.e.*, one larva per hill or one damaged leaf per hill. Observations on number of damaged leaves or average damaged leaves (ADL) on the randomly selected 20 per hill in each treatment under each replication were recorded at a day before spraying and on 5<sup>th</sup>, 10<sup>th</sup> and 15<sup>th</sup> day after treatment imposition. Finally mean per cent leaf damage per hill was calculated from the data obtained by adopting the following formula.

$$\text{Per cent leaf folder infestation} = \frac{\text{Number of damaged leaves per hill}}{\text{Total number of leaves per hill}} \times 100$$

The data obtained was suitably transformed and subjected to statistical analysis.

**3.3.5.2 Leaf blast:** The data on blast was taken from five sampling units each of one square metre area in each plot at random and disease severity was recorded at 10 days interval from the day of its appearance and terminal severity at heading stage following 0-9 scale as per the SES (Standard Evaluation Scale). Per cent disease index was calculated and analyzed after suitable transformation.

### 3.3.6 Yield

The yield data was recorded by harvesting net plots replication wise excluding two border rows and yield per plot was recorded in kg, based on which yield per hectare was calculated.

### 3.3.7 Statistical Analysis

Data on the leaf damage of leaf folder and per cent disease index of blast were transformed into angular/arc sine values and subjected to ANOVA in simple RBD analysis. The yield data in each treatment was recorded separately and subjected to statistical analysis to test the significance of mean yield in different treatments. The per cent increase in yield over control in various treatments was calculated by using the following formula.

$$\begin{array}{l} \text{Per cent increase of} \\ \text{yield in treatment} \\ \text{over control} \end{array} = \frac{\text{Yield in treatment} - \text{Yield in control}}{\text{Yield in control}} \times 100$$

## Chapter IV

# RESULTS AND DISCUSSION

The results pertaining to the present study “**COMPATIBILITY OF RECOMMENDED INSECTICIDES AND FUNGICIDES FOR THE MANAGEMENT OF MAJOR INSECT PESTS AND DISEASES OF PADDY**” are presented in this chapter.

### 4.1 STUDIES ON SEASONAL INCIDENCE OF INSECT PESTS, DISEASES AND NATURAL ENEMIES OF RICE

The present investigations to assess the seasonal incidence of insect pests, diseases and natural enemies of rice was conducted at college farm, Agricultural College, Bapatla during *kharif*, 2014. The results pertaining to the influence of weather factors on insect pests and diseases are presented under the following sections.

#### 4.1.1 Correlation of Weather Factors with Leaf folder Incidence

The initial incidence of leaf folder infestation started during 39<sup>th</sup> standard week with 12.95 per cent leaf folder infestation. Then the infestation decreased up to 42<sup>nd</sup> standard week and then increased gradually up to 48<sup>th</sup> standard week with 18.31 per cent leaf folder infestation per 50 hills. Later, the infestation declined and reached to minimum during 49<sup>rd</sup> standard week with 8.10 per cent infestation per 50 hills (Table 4.1) (Fig. 4.1).

The correlation analysis between weather factors and leaf folder incidence revealed that, there was no significant correlation between leaf folder infestation and maximum temperature ( $r = -0.088$ ), minimum temperature ( $r = -0.009$ ), rainfall ( $r = 0.296$ ), morning relative humidity ( $r = 0.232$ ) and evening relative humidity ( $r = 0.400$ ) (Table 4.2). The data on leaf folder infestation and weather factors were subjected to multiple linear regression analysis and the following equation was obtained (Table 4.3).

$$Y = -0.3295 + 0.1814 X_1 - 0.3609 X_2 + 0.0874 X_3 + 0.7662 X_4 + 0.3045 X_5$$

Thus, it was observed that the coefficient of determination ( $R^2$ ) for leaf folder infestation was 0.2008 which indicated that the abiotic factors were able to cause the variation in leaf folder infestation to the extent of 20.08 per cent only. These observations are similar to the results of Ahmed *et al.* (2010) who reported that mean maximum and minimum temperature had no impact on leaf infestation by leaf folder. However, the present results differed from the findings of Khan and Ramamurthy *et al.* (2004) who reported that all weather factors *viz.*, maximum and minimum temperature, rainfall and relative humidity showed a significant and negative relation with per cent leaf damage of leaf folder. These variations may be due to variation in weather parameters in different locations and their influence on activity of the pest. But, according to Kumar *et al.* (1996), weather factors *viz.*, maximum and minimum temperature, rainfall and relative humidity had no definite role on population dynamics of leaf folder infestation. Leaf folder infestation started at maximum tillering stage but there were no favourable weather factors for multiplication of the pest. Later, though favourable factors occurred, the crop has escaped the most susceptible stage. There was an irregular infestation level throughout the crop period and hence, it was difficult to estimate the correlation of leaf folder infestation with that of weather factors.

**Table 4.1 Damage by leaf folder and incidence of blast during *kharif*, 2014**

S. No.	Standard Week	Leaf folder damage (%)	Blast disease severity (%)	Temp. Max. (°C)	Temp. Min. (°C)	Rainfall (mm)	RH Mor. (%)	RH Eve. (%)
1	37 (10-16 <sup>th</sup> Sep)	0.00	0.00	35.70	24.98	4.24	76.00	73.00
2	38 (17-23 <sup>rd</sup> Sep)	0.00	0.00	32.05	24.02	12.08	84.57	78.28
3	39 (24-30 <sup>th</sup> Sep)	12.95	0.00	33.78	25.72	0.00	80.57	74.14
4	40 (01-07 <sup>th</sup> Oct)	10.89	0.00	33.27	24.76	3.00	82.42	73.00
5	41 (08 -14 <sup>th</sup> Oct)	5.89	0.00	34.18	25.70	1.40	82.57	73.43
6	42 (15-21 <sup>st</sup> Oct)	8.39	0.00	36.82	24.44	1.20	72.42	66.57
7	43 (22-28 <sup>th</sup> Oct)	10.56	1.55	32.00	22.78	19.60	83.14	75.29
8	44 (29 Oct -4 <sup>th</sup> Nov)	10.34	5.77	30.55	21.61	141.20	85.85	75.29
9	45 (05-11 <sup>th</sup> Nov)	14.74	8.88	30.28	20.81	0.00	83.85	68.57
10	46 (12-18 <sup>th</sup> Nov)	15.47	8.22	30.51	22.01	34.50	84.71	73.57
11	47 (19-25 <sup>th</sup> Nov)	17.34	13.55	30.74	20.30	76.00	91.14	80.29
<b>12</b>	<b>48 (26 Nov- 2<sup>nd</sup> Dec)</b>	<b>18.31</b>	<b>14.66</b>	30.41	17.65	0.00	88.57	75.57
13	49 (03-09 <sup>th</sup> Dec)	8.10	12.66	30.27	17.91	0.00	87.14	64.86
14	50 (10-16 <sup>th</sup> Dec)	0.00	6.22	30.58	18.20	0.00	87.05	67.40
15	51 (16-23 <sup>rd</sup> Dec)	0.00	2.55	29.34	20.97	0.00	85.28	68.59
16	52 (24-30 <sup>th</sup> Dec)	0.00	0.00	29.31	16.3	0.20	86.12	65.37

**Table 4.2 Correlation between rice leaf folder infestation with abiotic factors during *kharif*, 2014**

Variable	Correlation Co-efficient (r)
X <sub>1</sub> - Maximum temperature ( °C )	-0.088
X <sub>2</sub> -Minimum temperature ( °C )	-0.009
X <sub>3</sub> -Morning relative humidity (%)	0.232
X <sub>4</sub> - Evening relative humidity (%)	0.400
X <sub>5</sub> - Rain fall (mm)	0.296

**r<sub>tab</sub> (14,0.05)=0.497**

**r<sub>tab</sub> (14,0.01)=0.62**

**Table 4.3 Multiple linear regressions – interaction of rice leaf folder infestation with abiotic factors during *kharif*, 2014**

Variable	Regression Coefficient (r)	Standard error (B)	t-value
X <sub>1</sub> - Maximum temperature ( °C )	0.398	2.196	0.1814
X <sub>2</sub> -Minimum temperature ( °C )	-0.477	1.322	-0.3609
X <sub>3</sub> -Morning relative humidity (%)	0.106	1.220	0.0874
X <sub>4</sub> - Evening relative humidity (%)	0.583	0.761	0.7662
X <sub>5</sub> - Rain fall (mm)	0.017	0.058	0.3045

Intercept (a) = -0.453

F (cal) = 5.025

Percentage of variation attribute to the regression (R<sup>2</sup>) = 20.08 %

\* Significance at 5 %

#### 4.1.2 Correlation of weather factors with blast severity

The leaf blast incidence was started during 43<sup>rd</sup> standard week with 1.55 per cent leaf blast severity and then the infestation gradually increased and reached a peak during 48<sup>th</sup> standard week with 14.66 per cent leaf blast severity per 50 hills. Later, the incidence has declined gradually and reached minimum during 51<sup>st</sup> standard week with 2.55 per cent leaf blast severity per 50 hills (Table 4.1) (Fig. 4.1)

The correlation analysis between weather factors and leaf blast severity revealed that, there was a significant and negative correlation with maximum temperature ( $r = -0.560$ ) and minimum temperature ( $r = -0.631$ ) whereas a significant and positive correlation was observed with morning relative humidity ( $r = 0.672$ ) (Table 4.4). The data on leaf blast severity and weather factors were subjected to multiple linear regression (MLR) analysis and the following equation was obtained (Table 4.5)

$$Y = -0.8355 + 0.807 X_1 - 1.511 X_2 + 0.858 X_3 + 0.389 X_4 + 0.404 X_5$$

Thus it was observed that the coefficient of determination ( $R^2$ ) for leaf blast was 0.5747 which indicated that the abiotic factors were able to cause the variation in leaf blast incidence to the extent of 57.47 per cent. There was no significant influence of individual weather parameter in development of disease. These results are in conformity with the findings of Kapoor *et al.* (2004) and Paatro and Madhuri (2014) who reported that mean relative humidity and rainfall will have positive impact on development of blast disease but according to Padmanabhan *et al.* (1969) low night temperatures of 20-26 and high relative humidity of 90 per cent will favour the blast disease.

#### 4.1.3 Natural Enemies

Among the natural enemies, spiders, dragonflies and damselflies have dominated the ecosystem. The number of spiders ranged from 1.00 to 21.00 per 50 hills whereas damselflies the population ranged from 5.00 to 16.00 per 20 hills. However, the population of dragonfly was less compared to both spiders and damselflies and ranged from 1.00 to 18.00 per 20 hills (table 4.6).

**Table 4.4 Correlation between rice leaf blast with abiotic factors during *kharif*, 2014**

Variable	Correlation Co-efficient (r)
X <sub>1</sub> - Maximum temperature ( °C )	-0.560*
X <sub>2</sub> -Minimum temperature ( °C )	-0.631**
X <sub>3</sub> -Morning relative humidity (%)	0.672**
X <sub>4</sub> - Evening relative humidity (%)	0.100
X <sub>5</sub> - Rain fall (mm)	0.255

$r_{\text{tab}}(14,0.05)=0.497$

$r_{\text{tab}}(14,0.01)=0.62$

**Table 4.5 Multiple linear regressions – interaction of rice leaf blast infestation with abiotic factors during *kharif*, 2014**

Variable	Regression Coefficient (r)	Standard error (B)	t-value
X <sub>1</sub> - Maximum temperature ( °C )	1.058	1.310	0.807
X <sub>2</sub> -Minimum temperature ( °C )	-1.192	0.788	-1.511
X <sub>3</sub> -Morning relative humidity (%)	0.625	0.035	0.858
X <sub>4</sub> - Evening relative humidity (%)	0.176	0.727	0.389
X <sub>5</sub> - Rain fall (mm)	0.014	0.454	0.404

Intercept (a) = -0.685

F (cal) = 2.702

Percentage of variation attribute to the regression ( $R^2$ ) = 57.47 %

\* Significance at 5 % level

#### 4.1.4 Correlation of Weather Factors with Light Trap Catches during *kharif*, 2014

**4.1.4.1 Brown planthopper:** In light trap, the BPH catches started appearing from 25<sup>th</sup> October (15.00) and gradually increased and attained peak during 9<sup>th</sup> November (5400) and then the population decreased gradually up to 24<sup>th</sup> November (156.33) and again the population increased gradually and attained 2<sup>nd</sup> peak during 3<sup>rd</sup> December (2145) and gradually decreased towards the end of the season. (Table 4.6)

The correlation analysis between weather factors and brown planthopper population revealed that, there was no significant correlation existing between brown planthopper population catches and maximum temperature ( $r = -0.240$ ), minimum temperature ( $r = -0.297$ ), rainfall ( $r = 0.028$ ), morning relative humidity ( $r = 0.053$ ) and evening relative humidity ( $r = 0.029$ ) (Table 4.6). The data on brown planthopper population and weather factors were subjected to multiple linear regression (MLR) analysis and the following equation was obtained (Table 4.8)

$$Y = 2.050 - 0.624 X_1 - 2.727 X_2 - 2.074 X_3 + 2.682 X_4 + 0.057 X_5$$

Thus, it was observed that the coefficient of determination ( $R^2$ ) for brown planthopper catches was 0.367 which indicates that the abiotic factors were able to cause variation in brown planthopper population upto to the extent of 36.72 per cent. It was also observed from the MLR equation that among the abiotic factors studied, the partial regression coefficient ( $b$ ) of brown planthopper was significant and negatively correlated (-2.727) with minimum temperature and significant and positively correlated with evening relative humidity (2.682). Therefore, it was evident that for every one per cent decrease in minimum temperature or increase in evening relative humidity will lead to increase of 2.7 per cent of brown plant hoppers. These results are in conformity with Vijaykumar and Patil (2006) who reported that light trap catches of brown planthoppers showed non-significant and negative correlation with maximum and minimum temperature and non-significant and positive correlation with morning and evening relative humidity. Similarly, Krishnaiah *et al.* (2006) also reported that there was no correlation existing between maximum temperature, rainfall, morning and evening relative humidity with the light trap catches of brown planthopper.

**Table 4.6 Incidence of BPH, GLH, Leaf folder adults (light trap) and natural enemies (field) during *kharif*, 2014.**

Day of Observation	Light Trap catches			Natural enemies			Temp. Max. (°C)	Temp. Min. (°C)	Rain fall (mm)	RH (Mor) (%)	RH (Eve) (%)
	Brown plant hopper	Green leaf hopper	Leaf folder adults	Spider	Dragon fly	Damsel fly					
16-Oct	0.00	0.00	0.00	0.00	1.00	5.00	41.97	25.47	6.37	81.67	79.33
19-Oct	0.00	0.00	0.00	4.00	3.00	6.00	32.77	23.57	0.13	85.00	74.67
22-Oct	0.00	0.00	0.00	2.00	3.00	6.00	32.90	23.80	0.03	80.33	71.00
25-Oct	15.00	0.00	0.00	0.00	2.00	7.00	32.93	22.93	7.43	83.33	74.33
28-Oct	91.33	0.00	0.00	3.00	2.00	5.00	29.37	21.87	39.63	90.33	78.00
31-Oct	390.67	11.33	0.00	4.00	5.00	5.00	31.17	21.23	0.00	83.67	66.00
03-Nov	846.67	31.67	0.00	15.00	6.00	16.00	30.80	21.77	56.22	82.67	71.00
06-Nov	2473.33	25.33	1.33	13.00	4.00	10.00	30.93	19.37	0.00	82.67	70.00
09-Nov	<b>5400.00</b>	64.00	0.00	10.00	8.00	9.00	31.30	19.90	0.00	83.67	72.67
12-Nov	3000.00	581.00	3.00	21.00	14.00	12.00	29.70	22.30	11.50	91.67	79.33
15-Nov	880.00	<b>2328.67</b>	1.00	16.00	8.00	8.00	29.37	22.37	6.40	90.67	84.00
18-Nov	526.67	1097.67	6.67	14.00	18.00	8.00	31.40	21.40	18.93	91.00	76.00
21-Nov	409.33	949.00	3.33	12.00	6.00	5.00	31.23	23.73	0.00	88.33	77.67
24-Nov	156.33	886.00	6.00	15.00	4.00	5.00	30.60	20.17	0.00	90.00	76.67
27-Nov	307.67	224.67	0.00	11.00	4.00	12.00	30.10	18.83	0.00	87.33	64.67
30-Nov	1392.33	301.33	2.00	11.00	16.00	10.00	29.97	18.13	0.00	87.33	66.67
3-Dec	<b>2145.00</b>	404.00	1.00	18.00	4.00	15.00	31.00	16.80	38.10	86.67	63.33
6-Dec	855.00	458.00	5.00	8.00	5.00	12.00	30.57	17.63	0.00	88.67	67.00
9-Dec	1197.67	1211.23	6.67	18.00	8.00	12.00	30.47	19.27	0.00	86.67	71.50
12-Dec	1928.00	4400.00	<b>20.00</b>	21.00	15.00	8.00	28.67	21.03	0.67	90.67	83.00
15-Dec	1087.33	<b>4731.33</b>	10.67	20.00	3.00	14.00	29.63	20.87	0.00	87.67	76.33
18-Dec	906.00	615.33	6.67	11.00	3.00	6.00	30.93	19.67	0.00	88.33	74.67
21-Dec	381.33	20.33	5.00	4.00	2.00	0.00	29.17	16.23	0.00	83.67	53.33

**Table 4.7 Correlation between brown planthopper population with abiotic factors during *kharif*, 2014**

Variable	Correlation Co-efficient (r)
X <sub>1</sub> - Maximum temperature ( °C )	-0.240
X <sub>2</sub> -Minimum temperature ( °C )	-0.297
X <sub>3</sub> -Morning relative humidity (%)	0.053
X <sub>4</sub> - Evening relative humidity (%)	0.029
X <sub>5</sub> - Rain fall (mm)	-0.028

$$r_{\text{tab}} (21,0.05)=0.413$$

$$r_{\text{tab}} (21,0.01)=0.523$$

**Table 4.8 Multiple linear regressions – interaction of brown planthopper with abiotic factors during *kharif*, 2014**

Variable	Regression Coefficient (r)	Standard Error (S.E)	t-value
X <sub>1</sub> - Maximum temperature ( °C )	-0.833	0.133	-0.624
X <sub>2</sub> -Minimum temperature ( °C )	-0.591	0.216	-2.727*
X <sub>3</sub> -Morning relative humidity (%)	-0.258	0.124	-2.074
X <sub>4</sub> - Evening relative humidity (%)	0.206	0.076	2.682*
X <sub>5</sub> - Rain fall (mm)	0.909	0.015	0.057

$$\text{Intercept (a)} = 23.313$$

$$F \text{ cal value} = 1.973$$

$$\text{Percentage of variation attribute to the regression (R}^2\text{)} = 36.72 \%$$

\* Significance at 5 % level

**4.1.4.2 Green leafhopper:** In light trap, the green leafhoppers catches started appearing from 31<sup>st</sup> October (11.33) and gradually increased and attained peak during 15<sup>th</sup> November (2328.67) and then the population decreased gradually upto 27<sup>th</sup> November (224.67) and again the catches increased gradually and attained 2<sup>nd</sup> peak during 15<sup>th</sup> December (4731.33) and thereafter the catches gradually decreased towards the end of crop season. (Table 4.6)

The correlation analysis between weather factors and green leafhopper population revealed that, there was a significant and positive correlation with morning ( $r = 0.478$ ) and evening relative humidity ( $r = 0.465$ ) whereas the correlation was non-significant with maximum temperature ( $r = -0.337$ ) and rainfall ( $r = -0.189$ ) at 5% (Table 4.8). The data on green leafhopper population and weather factors were subjected to multiple linear regression analysis and the following equation was obtained.

$$Y = 0.2676 - 1.227 X_1 - 1.201 X_2 - 0.402 X_3 + 2.291^* X_4 - 1.125 X_5$$

Thus it was observed that the coefficient of determination ( $R^2$ ) green leaf hopper was 0.4823 which indicated that the abiotic factors were able to cause the variation in green leafhopper catches upto to the extent of 48.23 per cent (Table 4.10). It was also observed from the MLR equation that among the abiotic factors studied, the partial regression coefficient (b) of green leafhopper was significant and positive with evening relative humidity. Therefore, it was evident that for every one per cent increase in evening relative humidity lead to increase of 2.29 per cent of green leafhoppers catches. These results are in corroboration with Singh *et al.* (2007) who reported that a positive correlation exists between insect population and weather *i.e.*, fall in the minimum temperature and rise in evening relative humidity

**Table 4.9 Correlation between rice green leafhopper population with abiotic factors during *kharif*, 2014**

Variable	Correlation Co-efficient (r)
X <sub>1</sub> - Maximum temperature ( °C )	-0.337
X <sub>2</sub> -Minimum temperature ( °C )	0.025
X <sub>3</sub> -Morning relative humidity (%)	0.478*
X <sub>4</sub> - Evening relative humidity (%)	0.465*
X <sub>5</sub> - Rain fall (mm)	-0.189

$r_{tab} (21,0.05)=0.413$

$r_{tab} (21,0.01)=0.523$

**Table 4.10 Multiple linear regressions – interaction of rice green leafhopper population with abiotic factors during *kharif*, 2014**

Variable	Regression Coefficient (r)	Standard error (B)	t-value
X <sub>1</sub> - Maximum temperature ( °C )	-0.154	0.125	-1.227
X <sub>2</sub> -Minimum temperature ( °C )	-0.245	0.204	-1.201
X <sub>3</sub> -Morning relative humidity (%)	-0.047	0.117	-0.402
X <sub>4</sub> - Evening relative humidity (%)	0.165	0.072	2.291*
X <sub>5</sub> - Rain fall (mm)	-0.016	0.014	-1.125

Intercept (a) = 2.8645

F cal value = 3.167

Percentage of variation attribute to the regression (R<sup>2</sup>) = 48.23 %

\* Significance at 5 % level

**4.1.4.3 Leaf folder adult population :** In light trap catches the leaf folder adults started appearing from 6<sup>th</sup> November (1.33) and gradually increased towards the end of crop season and attained peak at 12<sup>th</sup> December (20) and decreased towards the end of crop season. (Table 4.6)

The correlation analysis between weather factors and leaf folder adult population revealed that there was a non-significant and negative correlation with maximum temperature (r = -0.354), minimum temperature (r = -0.186), rainfall (r = -0.254) and non-significant and positive correlation with evening relative humidity (r = 0.268). Significant and positive correlation was observed with morning relative humidity (r = 0.486) (Table 4.10). The correlation between the leaf folder adult population and spiders (r = 0.558) was positive and significant both at 5% and 1%. Dragonflies (r = 0.402) and damsel flies (r = 0.034) showed positive and non-significant correlation to leaf folder adult population. (Table 4.2). The data on leaf folder adult population and weather factors were subjected to Multiple linear regression analysis and the following equation was obtained (Table 4.10)

$$Y = -0.091 - 0.475 X_1 - 1.545 X_2 + 0.139 X_3 + 1.722 X_4 - 1.362 X_5$$

Thus it was observed that the coefficient of determination ( $R^2$ ) green leaf hopper was 0.4280 which indicated that the abiotic factors were able to cause the variation in leaf folder adult population upto to the extent of 42.80 per cent. There was no significant influence of individual weather parameter on leaf folder adult population. These results are in agreement with Khan and Ramamurthy (2004) who reported that maximum temperature, minimum temperature had negative impact on adult numbers, while the relative humidity at morning had positive impact. Chakraborty and Chandradeb (2011) also reported that maximum humidity imparts positive impact on leaf folder numbers.

**Table 4.11 Correlation between rice leaf folder adult population with abiotic factors during *kharif*, 2014**

Variable	Correlation Co-efficient (r)
X <sub>1</sub> - Maximum temperature ( °C )	-0.354
X <sub>2</sub> -Minimum temperature ( °C )	-0.186
X <sub>3</sub> -Morning relative humidity (%)	0.486*
X <sub>4</sub> - Evening relative humidity (%)	0.268
X <sub>5</sub> - Rain fall (mm)	-0.254

$$r_{\text{tab}}(21,0.05)=0.413$$

$$r_{\text{tab}}(21,0.01)=0.523$$

**Table 4.12 Multiple linear regressions – interaction of rice leaf folder adult numbers with abiotic factors during *kharif*, 2014**

Variable	Regression Coefficient (r)	Standard error (B)	t-value
X <sub>1</sub> - Maximum temperature ( °C )	-0.002	0.047	-0.475
X <sub>2</sub> -Minimum temperature ( °C )	-0.119	0.077	-1.545
X <sub>3</sub> -Morning relative humidity (%)	0.061	0.044	0.139
X <sub>4</sub> - Evening relative humidity (%)	0.047	0.027	1.722
X <sub>5</sub> - Rain fall (mm)	-0.007	0.005	-1.362

$$\text{Intercept (a)} = -3.710$$

$$F \text{ cal value} = 2.544$$

$$\text{Percentage of variation attribute to the regression (R}^2\text{)} = 42.80 \%$$

\* Significance at 5 % level

From the aforesaid studies it is clear that almost all the insect pests of rice appeared in the month of October which was due to prevalence of maximum temperatures during the early season of crop and low relative humidity prevalent during August and September months. The activities of pests started with rise in relative humidity and fall in maximum temperature during November and decreased gradually during December month. There was no correlation between leaf folder infestation and weather factors but there was a significant and positive correlation between leaf folder adults and relative humidity. This implies that the interaction of leaf folder adult population with weather factors can be better studied than with that of leaf infestation. Similar results were also obtained by Ahmed (2010) who reported that weather factors had no significant influence on leaf infestation but a significant positive correlation was obtained with mean relative humidity and adult population.

## **4.2 STUDIES ON PHYSICAL AND CHEMICAL COMPATIBILITY OF INSECTICIDE AND FUNGICIDE COMBINATIONS**

### **4.2.1 Physical Compatibility**

Physical compatibility of the insecticide and fungicide combinations was tested by emulsion stability test and specific gravity test as prescribed by Indian standard specifications.

**4.2.1.1 Emulsion stability test:** The results obtained from emulsion stability test revealed that when the insecticides and fungicides were mixed in distilled water, tap water and standard hard water (324 ppm), there was no sedimentation at the bottom and creamy layer at the top of the measuring cylinder in distilled water whereas it was observed up to one ml in standard hard water and tap water. Further there was no formation of clumps, clods, emulsions and separation of mixtures when they were mixed. Since there was no formation of sediment or creamy layer (> 2 ml) in all the three types of water it is proved that all the insecticides and fungicides combinations tested are physically compatible and stable. (Table 4.12 & 4.13).

**Table 4.13 Emulsion stability of insecticides and fungicides alone and in combination using standard hard water**

S. No.	Treatments	Recommended Concentration (g or ml l <sup>-1</sup> )	Creamy top layer in ml (<)			Bottom sediment ml (<)		
			1 h	6 h	24 h	1 h	6 h	24 h
1.	Chlorpyrifos 20% EC	2.5	0	0	0	0	0	0
2.	Cartap hydrochloride 50% SP	2.0	0	0	0	0	0	0
3.	Chlorantraniliprole 18.5% SC	0.3	0	0	0	0	0	0
4.	Phosphamidon 25% EC	2.0	0	0	0	0	0	0
5.	Carbendazim 50% WP	1.0	0	0	0	0	0	0
6.	Hexaconazole 5% SC	2.0	0	0	0	0	0	0
7.	Tricyclazole 75% WP	0.6	0	0	0	0	0	0
8.	Isoprothiolane 40% EC	1.5	0	0	0	0	0	0
9.	Chlorpyrifos 20% EC + Carbendazim 50% WP	2.5 +1.0	0	<b>1</b>	<b>1</b>	<b>0.5</b>	<b>1</b>	<b>1</b>
10.	Chlorpyrifos 20% EC + Hexaconazole 5% SC	2.5 +2.0	<b>0.5</b>	<b>1</b>	0	0	0	0
11.	Chlorpyrifos 20% EC + Tricyclazole 75% WP	2.5 +0.6	<b>0.1*</b>	<b>0.5*</b>	<b>0.5*</b>	0	0	0
12.	Chlorpyrifos 20% EC + Isoprothiolane 40% EC	2.5 +1.5	0	1	1	0	0	<b>0.5</b>
13.	Cartap hydrochloride 50% SP + Carbendazim 50% WP	2.0 +1.0	0	0	0	<b>0.1</b>	<b>0.5</b>	<b>0.5</b>
14.	Cartap hydrochloride 50% SP + Hexaconazole 5% SC	2.0 +2.0	0	<b>1</b>	<b>1</b>	0	0	0
15.	Cartap hydrochloride 50% SP + Tricyclazole 75% WP	2.0 +0.6	0	0	0	0	0	0
16.	Cartap hydrochloride 50% SP + Isoprothiolane 40% EC	2.0 +1.5	0	0	0	0	0	0
17.	Chlorantraniliprole 18.5% SC + Carbendazim 50% WP	0.3 +1.0	0	0	0	0	<b>0.5</b>	<b>0.5</b>
18.	Chlorantraniliprole 18.5% SC + Hexaconazole 5% SC	0.3 +2.0	0	0	0	0	0	0
19.	Chlorantraniliprole 18.5% SC + Tricyclazole 75% WP	0.3 +0.6	0	0	0	0	0	0
20.	Chlorantraniliprole 18.5% SC + Isoprothiolane 40% EC	0.3 +1.5	0	0	0	0	0	0
21.	Phosphamidon 40% EC+ Carbendazim 50% WP	2.0 +1.0	0	0	0	0	0	<b>1</b>
22.	Phosphamidon 40% EC + Hexaconazole 5% SC	2.0 +2.0	<b>0.5</b>	<b>0.5</b>	<b>0.5</b>	0	0	0
23.	Phosphamidon 40% EC + Tricyclazole 75% WP	2.0 +0.6	0	0	0	0	0	0
24.	Phosphamidon 40% EC + Isoprothiolane 40% EC	2.0 +1.5	0	0	0	0	0	0
25.	Untreated control	-	0	0	0	0	0	0

**\*Oily emulsion**

**Table 4.14 Emulsion stability of insecticides and fungicides alone and in combination using tap water**

S. No.	Treatments	Recommended Concentration (g or ml l <sup>-1</sup> )	Creamy top layer in ml (<)			Bottom sediment ml (<)		
			1 h	6 h	24 h	1 h	6 h	24 h
1.	Chlorpyrifos 20% EC	2.5	0	0	0	0	0	0
2.	Cartap hydrochloride 50% SP	2.0	0	0	0	0	0	0
3.	Chlorantraniliprole 18.5% SC	0.3	0	0	0	0	0	0
4.	Phosphamidon 25% EC	2.0	0	0	0	0	0	0
5.	Carbendazim 50% WP	1.0	0	0	0	0	0	0
6.	Hexaconazole 5% SC	2.0	0	0	0	0	0	0
7.	Tricyclazole 75% WP	0.6	0	0	0	0	0	0
8.	Isoprothiolane 40% EC	1.5	0	0	0	0	0	0
9.	Chlorpyrifos 20% EC + Carbendazim 50% WP	2.5 +1.0	0	<b>1</b>	<b>1</b>	<b>0.5</b>	<b>1</b>	<b>1</b>
10.	Chlorpyrifos 20% EC + Hexaconazole 5% SC	2.5 +2.0	<b>0.5</b>	<b>1</b>	0	0	0	0
11.	Chlorpyrifos 20% EC + Tricyclazole 75% WP	2.5 +0.6	<b>0.1*</b>	<b>0.5*</b>	<b>0.5*</b>	0	0	0
12.	Chlorpyrifos 20% EC + Isoprothiolane 40% EC	2.5 +1.5	0	1	1	0	0	<b>0.5</b>
13.	Cartap hydrochloride 50% SP + Carbendazim 50% WP	2.0 +1.0	0	0	0	<b>0.1</b>	<b>0.5</b>	<b>0.5</b>
14.	Cartap hydrochloride 50% SP + Hexaconazole 5% SC	2.0 +2.0	0	<b>1</b>	<b>1</b>	0	0	0
15.	Cartap hydrochloride 50% SP + Tricyclazole 75% WP	2.0 +0.6	0	0	0	0	0	0
16.	Cartap hydrochloride 50% SP + Isoprothiolane 40% EC	2.0 +1.5	0	0	0	0	0	0
17.	Chlorantraniliprole 18.5% SC + Carbendazim 50% WP	0.3 +1.0	0	0	0	0	<b>0.5</b>	<b>0.5</b>
18.	Chlorantraniliprole 18.5% SC + Hexaconazole 5% SC	0.3 +2.0	0	0	0	0	0	0
19.	Chlorantraniliprole 18.5% SC + Tricyclazole 75% WP	0.3 +0.6	0	0	0	0	0	0
20.	Chlorantraniliprole 18.5% SC + Isoprothiolane 40% EC	0.3 +1.5	0	0	0	0	0	0
21.	Phosphamidon 40% EC+ Carbendazim 50% WP	2.0 +1.0	0	0	0	0	0	<b>1</b>
22.	Phosphamidon 40% EC + Hexaconazole 5% SC	2.0 +2.0	<b>0.5</b>	<b>0.5</b>	<b>0.5</b>	0	0	0
23.	Phosphamidon 40% EC + Tricyclazole 75% WP	2.0 +0.6	0	0	0	0	0	0
24.	Phosphamidon 40% EC + Isoprothiolane 40% EC	2.0 +1.5	0	0	0	0	0	0
25.	Untreated control	-	0	0	0	0	0	0

**\*Oily emulsion**

**4.2.1.2 Specific gravity test:** For testing physical compatibility another parameter *i.e.*, specific gravity was also measured by using the specific gravity bottle.

The results obtained for all the insecticides and fungicides alone and in combination with distilled water are presented in the Table 4.14. From the table, it was evident that the specific gravity of the test insecticides, fungicides alone and in combination did not vary much in distilled water. The specific gravity values of the insecticides alone ranged from 0.995 g (chlorpyriphos) to 1.000 g (cartap hydrochloride and phosphamidon) whereas the specific gravity values of fungicides alone in distilled water ranged from 0.901 g (hexaconazole) to 1.000 g (carbendazim). However, the specific gravity values of the insecticide and fungicide combinations in distilled water ranged from 0.999 g (all fungicide combinations with phosphamidon except hexaconazole) to 1.002 g (catap hydrochloride + carbendazim). The small differences in the combinations may be attributed to the higher or lower densities of the respective insecticide and fungicide in their combination.

**Table 4.15 Specific gravity (g) of insecticides and fungicides alone and in combination using distilled water**

	<b>Chlorpyriphos</b>	<b>Cartap hydrochloride</b>	<b>Chlorantraniliprole</b>	<b>Phosphamidon</b>	<b>Alone</b>
<b>Tricyclazole</b>	1.001	1.001	1.000	0.999	<b>0.997</b>
<b>Hexaconazole</b>	1.000	1.001	1.000	1.001	<b>0.901</b>
<b>Carbendazim</b>	1.001	1.002	1.000	0.999	<b>1.000</b>
<b>Isoprothiolane</b>	1.000	1.000	1.000	0.999	<b>0.999</b>
<b>Alone</b>	<b>0.995</b>	<b>1.000</b>	<b>0.999</b>	<b>1.000</b>	

The results obtained for all the insecticides and fungicides alone and in combination with tap water are presented in the Table 4.15. From the table, it is evident that there was no much variation in the specific gravity of the test insecticides, fungicides alone and in combination in tap water. The specific gravity values of the insecticides alone ranged from 1.001 g (phosphamidon) to 1.015 g (cartap

hydrochloride) whereas the specific gravity values of fungicides alone in tap water ranged from 1.004 g (isoprothiolane) to 1.008 g (carbendazim). However the specific gravity values of the insecticide and fungicide combinations in tap water ranged from 1.001 g (chlorantraniliprole + tricyclazole and phosphamidon + isoprothiolane) to 1.011 g (chlorantraniliprole + carbendazim). The small differences in the combinations may be due to the higher or lower densities of the respective insecticide and fungicide in their combination.

**Table 4.16 Specific gravity (g) of insecticides and fungicides alone and in combination using tap water**

	<b>Chlorpyriphos</b>	<b>Cartap hydrochloride</b>	<b>Chlorantraniliprole</b>	<b>Phosphamidon</b>	<b>Alone</b>
<b>Tricyclazole</b>	1.003	1.002	1.001	1.002	<b>1.005</b>
<b>Hexaconazole</b>	1.007	1.006	1.002	1.002	<b>1.007</b>
<b>Carbendazim</b>	1.003	1.003	1.011	1.005	<b>1.008</b>
<b>Isoprothiolane</b>	1.004	1.005	1.004	1.001	<b>1.004</b>
<b>Alone</b>	<b>1.002</b>	<b>1.015</b>	<b>1.006</b>	<b>1.001</b>	

The results obtained for all the insecticides and fungicides alone and in combination with standard hard water are presented in the Table 4.16. From the table, it was evident that the specific gravity of the test insecticides, fungicides alone and in combination did not vary much in standard hard water. The specific gravity values of the insecticides alone ranged from 1.000 g (chlorpyriphos and phosphamidon) to 1.009 g (cartap hydrochloride) whereas the specific gravity values of fungicides alone in tap water ranged from 1.002 g (tricyclazole) to 1.007 g (carbendazim). However, the specific gravity values of the insecticide and fungicide combinations in standard hard water ranged from 1.001 g (phosphamidon + tricyclazole and phosphamidon + isoprothiolane) to 1.008 g (chlorantraniliprole + carbendazim). The small differences in the combinations may be due to the higher or lower densities of the respective insecticide and fungicide in their combination.

**Table 4.17 Specific gravity (g) of insecticides and fungicides alone and in combination using standard hard water**

Chemical	Chlorpyriphos	Cartap hydrochloride	Chlorantraniliprole	Phosphamidon	Alone
Tricyclazole	1.003	1.002	1.002	1.001	<b>1.002</b>
Hexaconazole	1.005	1.004	1.002	1.000	<b>1.005</b>
Carbendazim	1.003	1.004	1.008	1.003	<b>1.007</b>
Isoprothiolane	1.002	1.005	1.004	1.001	<b>1.006</b>
Alone	<b>1.000</b>	<b>1.009</b>	<b>1.007</b>	<b>1.000</b>	

#### 4.2.2 Chemical Compatibility

In chemical compatibility, the parameters like pH (Hydrogen ion concentration) and EC (Electrical conductivity) of the insecticides, fungicides alone and their combinations were measured. From the results obtained, it was clear that there was no much difference in the values of pH, EC when the insecticides and fungicides were combined compared to individual treatments. The insecticides, fungicides alone and in combination were slightly alkaline in nature.

**4.2.2.1 pH :** The results obtained for all the insecticides and fungicides alone and in combination with distilled water are presented in the Table 4.17. The pH values of insecticides alone ranged from 6.0 (cartap hydrochloride) to 6.8 (chlorantraniliprole) whereas the pH values of fungicides alone in distilled water ranged from 6.6 (tricyclazole and carbendazim) to 6.8 (hexaconazole). However, the pH values of the insecticide and fungicide combinations in distilled water ranged from 5.8 (phosphamidon + tricyclazole and phosphamidon + hexaconazole) to 6.7 (chlorantraniliprole + carbendazim and chlorantraniliprole + isoprothiolane).

**Table 4.18 pH of insecticides, fungicides alone and in combination in distilled water**

Chemical	Chlorpyriphos	Cartap hydrochloride	Chlorantraniliprole	Phosphamidon	Alone
<b>Carbendazim</b>	6.2	6.0	6.7	5.9	<b>6.6</b>
<b>Hexaconazole</b>	6.4	6.0	6.6	5.8	<b>6.8</b>
<b>Tricyclazole</b>	6.3	6.2	6.5	5.8	<b>6.6</b>
<b>Isoprothiolane</b>	6.2	5.9	6.7	6.0	<b>6.7</b>
<b>Alone</b>	<b>6.7</b>	<b>6.0</b>	<b>6.8</b>	<b>6.2</b>	

The pH values obtained for all the insecticides and fungicides alone and in combination with tap water are presented in the Table 4.18. The pH values of insecticides alone ranged from 6.8 (cartap hydrochloride) to 7.7 (chlorantraniliprole) whereas the pH values of fungicides alone in distilled water ranged from 7.4 (hexaconazole and isoprothiolane) to 7.7 (carbendazim). However, the pH values of the insecticide and fungicide combinations in distilled water ranged from 6.9 (cartap hydrochloride + tricyclazole, chlorpyriphos + tricyclazole and chlorpyriphos + isoprothiolane) to 7.8 (chlorpyriphos + carbendazim and chlorantraniliprole + tricyclazole).

**Table 4.19 pH of insecticides, fungicides alone and in combination in tap water**

Chemical	Chlorpyriphos	Cartap hydrochloride	Chlorantraniliprole	Phosphamidon	Alone
<b>Carbendazim</b>	7.8	7.0	7.7	7.2	<b>7.7</b>
<b>Hexaconazole</b>	7.0	7.0	7.5	7.5	<b>7.4</b>
<b>Tricyclazole</b>	6.9	6.9	7.8	7.2	<b>7.6</b>
<b>Isoprothiolane</b>	6.9	7.0	7.5	7.4	<b>7.4</b>
<b>Alone</b>	<b>7.4</b>	<b>6.8</b>	<b>7.7</b>	<b>7.3</b>	

The results pertaining to all the insecticides and fungicides alone and in combination with standard hard water are presented in the table 4.19. The pH values of insecticides alone ranged from 6.8 (cartap hydrochloride) to 7.4 (chlorantraniliprole) whereas the pH values of fungicides alone in standard hard water ranged from 7.2 (hexaconazole and isoprothiolane) to 7.5 (carbendazim). However,

the pH values of the insecticide and fungicide combinations in standard water ranged from 6.4 (chlorpyrifos + isoprothiolane) to 7.3 (chlorantraniliprole + tricyclazole and chlorantraniliprole + isoprothiolane).

**Table 4.20 pH of insecticides, fungicides alone and in combination in Standard hard water**

Chemical	Chlorpyrifos	Cartap Hydrochloride	Chlorantraniliprole	Phosphamidon	Alone
<b>Tricyclazole</b>	7.2	6.6	7.3	6.7	<b>7.3</b>
<b>Hexaconazole</b>	6.6	6.7	7.2	7.1	<b>7.2</b>
<b>Carbendazim</b>	6.6	6.5	7.1	6.9	<b>7.5</b>
<b>Isoprothiolane</b>	6.4	6.7	7.3	7.2	<b>7.2</b>
<b>Alone</b>	<b>7.1</b>	<b>6.8</b>	<b>7.4</b>	<b>7.1</b>	

**4.2.2.2 EC :** The results pertaining to Electrical Conductivity (E.C) of all the insecticides and fungicides alone and in combination with distilled water are presented in the Table 4.20. The EC values of insecticides alone ranged from 0.04 dSm<sup>-1</sup> (chlorpyrifos) to 1.77 dSm<sup>-1</sup> (cartap hydrochloride) whereas the EC values of fungicides alone in distilled water ranged from 0.05 dSm<sup>-1</sup> (carbendazim and isoprothiolane) to 0.22 dSm<sup>-1</sup> (tricyclazole). However, the EC values of the insecticide and fungicide combinations in distilled water ranged from 0.02 dSm<sup>-1</sup> (chlorantraniliprole + hexaconazole and chlorantraniliprole + isoprothiolane) to 1.63 dSm<sup>-1</sup> (cartap hydrochloride + tricyclazole and cartap hydrochloride + isoprothiolane).

**Table 4.21 EC (dSm<sup>-1</sup>) of insecticides, fungicides alone and in combination in distilled water**

Chemical	Chlorpyrifos	Cartap Hydrochloride	Chlorantraniliprole	Phosphamidon	Alone
<b>Carbendazim</b>	0.08	1.53	0.08	0.10	<b>0.05</b>
<b>Hexaconazole</b>	0.09	1.36	0.02	0.07	<b>0.06</b>
<b>Tricyclazole</b>	0.08	1.63	0.08	0.93	<b>0.22</b>
<b>Isoprothiolane</b>	0.04	1.63	0.02	0.08	<b>0.05</b>
<b>Alone</b>	<b>0.04</b>	<b>1.77</b>	<b>0.06</b>	<b>0.09</b>	

The results of EC when tested with tap water for all the insecticides and fungicides alone and in combination are presented in the Table 4.21. The EC values of insecticides alone ranged from 2.91 dSm<sup>-1</sup> (chlorpyrifos) to 4.48 dSm<sup>-1</sup> (cartap hydrochloride) whereas the EC values of fungicides alone in tap water ranged from 2.63 dSm<sup>-1</sup> (tricyclazole) to 2.94 dSm<sup>-1</sup> (isoprothiolane). However, the EC values of the insecticide and fungicide combinations in tap water ranged from 2.64 dSm<sup>-1</sup> (chlorantraniliprole + carbendazim and phosphamidon + tricyclazole) to 3.77 dSm<sup>-1</sup> (cartap hydrochloride + tricyclazole)

**Table 4.22 EC (dSm<sup>-1</sup>) of insecticides, fungicides alone and in combination in tap water**

<b>Chemical</b>	<b>Chlorpyrifos</b>	<b>Cartap hydrochloride</b>	<b>Chlorantraniliprole</b>	<b>Phosphamidon</b>	<b>Alone</b>
<b>Carbendazim</b>	2.67	3.64	2.64	2.67	<b>2.64</b>
<b>Hexaconazole</b>	2.88	3.62	2.91	2.92	<b>2.92</b>
<b>Tricyclazole</b>	2.94	3.77	2.93	2.64	<b>2.63</b>
<b>Isoprothiolane</b>	2.90	3.70	2.95	2.94	<b>2.94</b>
<b>Alone</b>	<b>2.91</b>	<b>4.48</b>	<b>2.94</b>	<b>2.88</b>	

The results obtained for all the insecticides and fungicides alone and in combination with standard hard water are presented in the Table 4.22. The EC values of insecticides alone ranged from 1.95 dSm<sup>-1</sup> (chlorpyrifos) to 3.85 dSm<sup>-1</sup> (cartap hydrochloride) whereas the EC values of fungicides alone in tap water ranged from 1.86 dSm<sup>-1</sup> (tricyclazole) to 2.46 dSm<sup>-1</sup> (isoprothiolane). However, the EC values of the insecticide and fungicide combinations in standard hard water ranged from 1.85 dSm<sup>-1</sup> (chlorpyrifos + hexaconazole) to 2.98 dSm<sup>-1</sup> (cartap hydrochloride + isoprothiolane).

**Table 4.23 EC (dSm<sup>-1</sup>) of insecticides, fungicides alone and in combination in standard hard water**

<b>Chemical</b>	<b>Chlorpyrifos</b>	<b>Cartap hydrochloride</b>	<b>Chlorantraniliprole</b>	<b>Phosphamidon</b>	<b>Alone</b>
<b>Tricyclazole</b>	1.92	2.86	2.06	1.90	<b>1.86</b>
<b>Hexaconazole</b>	1.85	2.51	2.21	2.22	<b>2.27</b>
<b>Carbendazim</b>	1.98	2.92	2.16	2.02	<b>1.98</b>
<b>Isoprothiolane</b>	2.20	2.98	2.21	2.38	<b>2.46</b>
<b>Alone</b>	<b>1.95</b>	<b>3.85</b>	<b>2.18</b>	<b>2.25</b>	

### 4.2.3 Phytotoxicity Test

Phytotoxic symptoms, like injury to leaf surface or leaf tip, yellowing, wilting were observed at higher doses of insecticides and fungicides combinations whereas no phytotoxicity was observed at recommended concentrations. However, when the per cent injury was calculated, it was below 1.0 per cent revealing no phytotoxicity as per the visual rating scale mentioned under chapter-III. This may be due to absence of much variation in the pH values when insecticides are combined with the fungicides (Table 4.23). From the above results, it is evident that the test insecticides and fungicides were compatible at recommended and higher doses.

Finally, the results pertaining to physical, chemical and phytotoxicity test revealed that there were no incompatible combinations physically and chemically and all the insecticides and fungicides alone and in combinations when sprayed at normal and double doses are non-phytotoxic. The present findings are in conformity with the Koushika *et al.* (2014) who reported that chlorantraniliprole 4.3% + abamectin 1.7% SC with other agrochemicals did not produce creamy matter or sediment at the top or bottom of the 100 ml cylinder. Similar results were obtained by Bhuvaneshwari and Krishnamraju (2013) who reported that chlorantraniliprole @ 0.3 ml l<sup>-1</sup> in combination with hexaconazole @ 2 ml l<sup>-1</sup> did not produce any phytotoxicity effects when sprayed against stem borer and leaf folder in paddy.

Similar results were obtained by different workers with different insecticide and fungicide combinations in various crops. Govindan *et al.* (2013) reported that emamectin benzoate 5% SG at 11 g a.i. ha<sup>-1</sup> was physically compatible with endosulfan, carbendazim and urea which did not produce any sedimentation at bottom and creamy layer at top of the cylinder. The findings of Kubendran *et al.* (2009) also revealed that physical compatibility of flubendiamide + thiocloprid 480% SC with other agrochemicals in terms of emulsion stability test which showed that flubendiamide + thiocloprid 480 SC @ 25 ml ha<sup>-1</sup> with diammonium phosohate (2%), quinalfos (0.05%) and copper oxychloride (0.25%) combination did not produce creamy matter or sediment at the top or bottom of the 100 ml cylinder.

**Table 4.24 Per cent leaf injury of insecticides, fungicides alone and in combination at higher dose**

S. No	Treatments	Dose (g or ml l <sup>-1</sup> )	Mean no. of symptoms observed	Mean no. of leaves observed	Per cent leaf injury
1	Chlorpyrifos 20% EC	5.0	0	0	0
2	Cartap hydrochloride 50% SP	4.0	0	0	0
3	Chlorantraniliprole 18.5% SC	0.6	0	0	0
4	Phosphamidon 25% EC	4.0	0	0	0
5	Carbendazim 50% WP	2.0	0	0	0
6	Hexaconazole 5% SC	4.0	0	0	0
7	Tricyclazole 75% WP	1.2	0	0	0
8	Isoprothiolane 40% EC	3.0	0	0	0
9	Chlorpyrifos 20% EC + Carbendazim 50% WP	5.0 +2.0	1.3	9.33	0.40
10	Chlorpyrifos 20% EC + Hexaconazole 5% SC	5.0 +4.0	1.0	6.33	0.31
11	Chlorpyrifos 20% EC + Tricyclazole 75% WP	5.0 +1.2	1.0	7.33	0.27
12	Chlorpyrifos 20% EC + Isoprothiolane 40% EC	5.0 +3.0	1.3	11.33	0.35
13	Cartap hydrochloride 50% SP + Carbendazim 50% WP	4.0 +2.0	1.3	13.66	0.50
14	Cartap hydrochloride 50% SP + Hexaconazole 5% SC	4.0 +4.0	1.3	10.33	0.45
15	Cartap hydrochloride 50% SP + Tricyclazole 75% WP	4.0 +1.2	1.0	3.66	0.3
16	Cartap hydrochloride 50% SP + Isoprothiolane 40% EC	4.0 +3.0	1.3	7.33	0

To be continued...

17	Chlorantraniliprole 18.5% SC + Carbendazim 50% WP	0.6 +2.0	1.0	2.66	0.55
18	Chlorantraniliprole 18.5% SC + Hexaconazole 5% SC	0.6 +4.0	1.3	7.66	0.66
19	Chlorantraniliprole 18.5% SC + Tricyclazole 75% WP	0.6 +1.2	1.0	9.66	0.41
20	Chlorantraniliprole 18.5% SC + Isoprothiolane 40% EC	0.6 +3.0	1.0	4.33	0
21	Phosphamidon 40% EC+ Carbendazim 50% WP	4.0 +2.0	1.3	6.33	0.50
22	Phosphamidon 40% EC + Hexaconazole 5% SC	4.0 +4.0	1.0	2.66	0
23	Phosphamidon 40% EC + Tricyclazole 75% WP	4.0 +1.2	1.0	3.66	0.40
24	Phosphamidon 40% EC + Isoprothiolane 40% EC	4.0 +3.0	1.3	8.33	0.52

### **4.3. STUDIES ON EFFICACY OF INSECTICIDES, FUNGICIDES ALONE AND IN COMBINATION ON MAJOR INSECT PESTS AND DISEASES OF PADDY**

The present investigations to assess the field efficacy of foliar sprays of insecticides, fungicides alone and in combination against the major insect pests and diseases of rice was conducted at college farm, Agricultural college, Bapatla during *kharif*, 2014. The results pertaining to the efficacy of treatments on insect pests and diseases and their impact on yield are presented under the following sections.

#### **4.3.1 Efficacy of different Pesticides Against the Rice Leaf Folder**

The incidence of leaf folders initially appeared at 20-30 days after transplantation (DAT). The population of leaf folders reached Economic threshold level (ETL) by 35 DAT. The treatments were imposed as and when the leaf folder crossed the ETL.

**4.3.1.1 Efficacy of different pesticides after first spray:** The results pertaining to efficacy of the treatments against per cent leaf damage by leaf folder on rice during first spray are presented in (Table 4.24) (Fig. 4.2).

The per cent leaf damage by *C. medinalis* a day before spraying (DBS) ranged from 25.40 to 32.16 without any significant difference among the treatment plots. A significant difference was observed between the treatments at five days after spraying (DAS) with respect to per cent leaf damage which ranged from 10.56 to 32.08. Among the treatments, chlorantraniliprole + isoprothiolane (0.3 ml l<sup>-1</sup>+1.5 ml l<sup>-1</sup>) was the best treatment by recording the lowest (10.56) per cent leaf damage which was on par with chlorantraniliprole (0.3 ml l<sup>-1</sup>) which recorded 10.57% leaf damage followed by chlorpyrifos (2.5 ml l<sup>-1</sup>) with 11.91% leaf damage. The treatments chlorantraniliprole + tricyclazole (0.3 ml l<sup>-1</sup>+0.6 g l<sup>-1</sup>), chlorpyrifos + isoprothiolane (2.5 ml l<sup>-1</sup>+1.5 ml l<sup>-1</sup>) and chlorpyrifos + tricyclazole (2.5 ml l<sup>-1</sup>+0.6 g l<sup>-1</sup>) were the next best treatments found on par with chlorpyrifos (2.5 ml/l) by recording 13.61, 13.93 and 15.59 per cent leaf damage, respectively. But, treatments isoprothiolane (1.5 ml l<sup>-1</sup>) and tricyclazole (0.6 g l<sup>-1</sup>) recorded high per cent of leaf damage (27.43 and 31.47%, respectively) because of their non insecticidal properties. However, untreated check recorded the highest per cent of leaf damage (32.08).

The per cent leaf damage ranged from 9.18 to 34.74 at 10 days after spraying (DAS), with significant differences between treatments in which the treatment, chlorantraniliprole + isoprothiolane (0.3 ml l<sup>-1</sup>+1.5 ml l<sup>-1</sup>) emerged as the best treatment by recording lowest (9.18) per cent leaf damage which was found on par with chlorantraniliprole (0.3 ml l<sup>-1</sup>), chlorpyrifos (2.5 ml l<sup>-1</sup>), chlorantraniliprole + tricyclazole (0.3 ml l<sup>-1</sup>+0.6 g l<sup>-1</sup>) and chlorpyrifos + isoprothiolane (2.5 ml l<sup>-1</sup>+1.5 ml l<sup>-1</sup>) and chlorpyrifos + tricyclazole (2.5 ml l<sup>-1</sup>+0.6 g l<sup>-1</sup>) which recorded 9.92, 10.35, 11.62, 12.12, 13.66 and 14.02 per cent leaf damage respectively. But, fungicides isoprothiolane (1.5 ml l<sup>-1</sup>) and tricyclazole (0.6 g l<sup>-1</sup>) recorded highest per cent leaf damage of 34.37 and 35.64, respectively. However, untreated check recorded the highest per cent leaf damage (34.74).

Chlorantraniliprole+ isoprothiolane (0.3 ml l<sup>-1</sup>+1.5 ml l<sup>-1</sup>) was the best treatment at 15 days after spraying (DAS), by recording lowest (7.58) per cent leaf damage which was on par with chlorantraniliprole (0.3 ml l<sup>-1</sup>) which recorded 7.95 per cent leaf damage. The treatments Chlorpyrifos (2.5 ml l<sup>-1</sup>) and chlorantraniliprole +

tricyclazole ( $0.3 \text{ ml l}^{-1} + 0.6 \text{ g l}^{-1}$ ) were found on par with chlorantraniliprole ( $0.3 \text{ ml l}^{-1}$ ) by recording 8.34 and 10.33 per cent leaf damage respectively. chlorpyrifos + isoprothiolane ( $2.5 \text{ ml l}^{-1} + 1.5 \text{ ml l}^{-1}$ ) and chlorpyrifos + tricyclazole ( $2.5 \text{ ml l}^{-1} + 0.6 \text{ g l}^{-1}$ ) which recorded 11.88 and 12.69 per cent leaf damage, respectively. But, isoprothiolane ( $1.5 \text{ ml l}^{-1}$ ) and tricyclazole ( $0.6 \text{ g l}^{-1}$ ) recorded higher per cent leaf damage of 35.08 and 38.16, respectively. However, untreated check recorded the highest per cent leaf damage (39.96) which differed significantly from all the treatments.

The mean data on percent leaf damage of five, ten and fifteen days after spraying showed a significant difference between the treatments which ranged from 9.10 to 35.59 per cent. Among the treatments, chlorantraniliprole + isoprothiolane ( $0.3 \text{ ml l}^{-1} + 1.5 \text{ ml l}^{-1}$ ) continued to be the best treatment by recording lowest (9.10) per cent leaf damage with 74.43% reduction over control (Fig. 4.3) and was on par with chlorantraniliprole ( $0.3 \text{ ml l}^{-1}$ ) with 9.48 per cent leaf damage and 73.36% reduction over control. The treatment chlorpyrifos ( $2.5 \text{ ml l}^{-1}$ ) followed the best treatment by recording recorded 10.20 per cent leaf damage and 71.34 per cent reduction over control. The treatments chlorantraniliprole + tricyclazole ( $0.3 \text{ ml l}^{-1} + 0.6 \text{ g l}^{-1}$ ), chlorpyrifos + isoprothiolane ( $2.5 \text{ ml l}^{-1} + 1.5 \text{ ml l}^{-1}$ ), chlorpyrifos + tricyclazole ( $2.5 \text{ ml l}^{-1} + 0.6 \text{ g l}^{-1}$ ) showed better results with 12.02, 13.15, 14.10 mean per cent leaf damage and 66.22, 63.05 and 60.38 per cent reduction over control, respectively. Isoprothiolane ( $1.5 \text{ ml/l}$ ) and tricyclazole ( $0.6 \text{ g/l}$ ) recorded higher per cent leaf damage of 32.29, 35.09 per cent leaf damage and lowest per cent reduction over control (27 and 1.24%), respectively since, they are fungicides. However, untreated check recorded the highest per cent leaf damage of 32.08%. The results clearly indicated that all the insecticidal treatments alone and in combination with fungicides did not differ significantly with each other with respect to reduction of leaf folder incidence. But, these were significantly different from untreated control and fungicidal treatments.

**Table 4.25 Efficacy of different pesticides against Rice Leaf folder, *Cnaphalocrocis medinalis* after first spray**

Tr. No	Treatments	Dose (ml or g l <sup>-1</sup> )	Per cent leaf folder damage					Reduction over control (%)
			1 DBS	5 DAS	10 DAS	15 DAS	Mean	
T <sub>1</sub>	Chlorpyriphos 20% EC	2.5	29.79 (33.09)	11.91 <sup>b</sup> (20.13)	10.35 <sup>b</sup> (18.73)	8.34 <sup>cd</sup> (16.79)	10.2 <sup>bc</sup> (18.55)	71.34
T <sub>2</sub>	Chlorantraniliprole 18.5 % SC	0.3	26.23 (30.80)	10.57 <sup>c</sup> (18.91)	9.92 <sup>b</sup> (18.23)	7.95 <sup>d</sup> (16.35)	9.48 <sup>c</sup> (17.83)	73.36
T <sub>3</sub>	Tricyclazole 75% WP	0.6	32.16 (34.41)	31.47 <sup>a</sup> (34.12)	35.64 <sup>a</sup> (36.65)	38.16 <sup>a</sup> (38.16)	35.09 <sup>a</sup> (36.31)	1.40
T <sub>4</sub>	Isoprothiolane 40% EC	1.5	29.38 (32.79)	27.43 <sup>a</sup> (31.55)	34.37 <sup>a</sup> (35.89)	35.08 <sup>a</sup> (36.32)	32.29 <sup>a</sup> (34.58)	9.27
T <sub>5</sub>	Chlorpyriphos 20% EC + tricyclazole 75% WP	2.5 +0.6	29.93 (33.15)	15.59 <sup>bc</sup> (23.18)	14.02 <sup>b</sup> (21.95)	12.69 <sup>b</sup> (20.82)	14.10 <sup>b</sup> (21.98)	60.38
T <sub>6</sub>	Chlorpyriphos 20% EC + isoprothiolane 40% EC	2.5 +1.5	25.40 (30.22)	13.93 <sup>bc</sup> (21.82)	13.66 <sup>b</sup> (21.67)	11.88 <sup>bc</sup> (20.09)	13.15 <sup>b</sup> (21.19)	63.05
T <sub>7</sub>	Chlorantraniliprole 18.5 % SC + tricyclazole 75% WP	0.3 +0.6	27.38 (31.52)	13.61 <sup>bc</sup> (21.58)	12.12 <sup>b</sup> (20.31)	10.33 <sup>bcd</sup> (18.63)	12.02 <sup>bc</sup> (20.17)	66.22
T <sub>8</sub>	Chlorantraniliprole 18.5 % SC + isoprothiolane 40% EC	0.3 +1.5	25.45 (30.27)	10.56 <sup>c</sup> (18.96)	9.18 <sup>b</sup> (17.59)	7.58 <sup>d</sup> (15.95)	9.10 <sup>c</sup> (17.50)	74.43
T <sub>9</sub>	Untreated check	-	28.23 (32.09)	32.08 <sup>a</sup> (34.49)	34.74 <sup>a</sup> (36.11)	39.96 <sup>a</sup> (39.21)	35.59 <sup>a</sup> (36.60)	-
	<b>F –test</b>		NS	Sig.	Sig.	Sig.	Sig.	
	<b>SEm(±)</b>		2.461	1.373	1.374	1.205	1.106	
	<b>CD (P=0.05)</b>		-	4.11	4.14	3.614	4.42	
	<b>CV (%)</b>		14.21	14.73	13.40	13.75	15.45	

\*DBS- day before spray

\*\*DAS- days after spray

\*\*\*Figures in parenthesis are Arc- sine transformed values

Means followed by same letter do not differ significantly following DMRT

**4.3.1.2 Efficacy of different pesticides after second spray :** The results with regard to the efficacy of the treatments after second spray were presented in (Table 4.25) (Fig. 4.4).

The per cent leaf damage by *C. medinalis* at one day before treatment ranged from 37.33 to 42.01 without any significant difference between the treatments.

A significant difference was observed between the treatments at five days after spraying with respect to per cent leaf damage which ranged from 7.09 to 42.89. Among the treatments chlorantraniliprole + isoprothiolane ( $0.3 \text{ ml l}^{-1} + 1.5 \text{ ml l}^{-1}$ ) was the best treatment by recording the lowest (7.09) per cent leaf damage emerged as best treatment which was found on par with chlorantraniliprole ( $0.3 \text{ ml l}^{-1}$ ) which recorded 7.23% leaf damage. The treatments chlorpyrifos ( $2.5 \text{ ml l}^{-1}$ ), chlorantraniliprole + tricyclazole ( $0.3 \text{ ml l}^{-1} + 0.6 \text{ g l}^{-1}$ ), chlorpyrifos + tricyclazole ( $2.5 \text{ ml l}^{-1} + 0.6 \text{ g l}^{-1}$ ) and chlorpyrifos + isoprothiolane ( $2.5 \text{ ml l}^{-1} + 1.5 \text{ ml l}^{-1}$ ), were on par with chlorantraniliprole ( $0.3 \text{ ml l}^{-1}$ ) by recording 8.32, 9.30, 11.12 and 11.43 per cent leaf damage respectively. But, treatments isoprothiolane ( $1.5 \text{ ml l}^{-1}$ ) and tricyclazole ( $0.6 \text{ g l}^{-1}$ ) recorded higher per cent leaf damage of 34.64 and 38.11%, respectively since they are fungicides. However, untreated check recorded the highest per cent leaf damage of 42.89%.

The per cent leaf damage ranged from 4.04 to 44.49 at 10 days after spraying, with significant difference between treatments. Among the treatments, chlorantraniliprole + isoprothiolane ( $0.3 \text{ ml l}^{-1} + 1.5 \text{ ml l}^{-1}$ ) was the best treatment by recording the lowest per cent leaf damage (4.04), which was on par with chlorantraniliprole ( $0.3 \text{ ml l}^{-1}$ ) and chlorpyrifos ( $2.5 \text{ ml l}^{-1}$ ) which recorded 4.86 and 6.64 per cent leaf damage, respectively. The treatments, chlorpyrifos + isoprothiolane ( $2.5 \text{ ml l}^{-1} + 1.5 \text{ ml l}^{-1}$ ), chlorantraniliprole + tricyclazole ( $0.3 \text{ ml l}^{-1} + 0.6 \text{ g l}^{-1}$ ), chlorpyrifos + tricyclazole ( $2.5 \text{ ml l}^{-1} + 0.6 \text{ g l}^{-1}$ ) were found on par with chlorpyrifos ( $2.5 \text{ ml l}^{-1}$ ) by recording 8.02, 8.31 and 10.40 per cent leaf damage respectively. But, treatments isoprothiolane ( $1.5 \text{ ml l}^{-1}$ ) and tricyclazole ( $0.6 \text{ g l}^{-1}$ ) recorded highest per cent leaf damage of 37.62 and 40.84%, respectively. However, untreated check recorded the highest per cent leaf damage of 44.49%.

Similar trend was observed with respect to all treatments except untreated check even at 15 DAS where in chlorantraniliprole + isoprothiolane ( $0.3 \text{ ml l}^{-1} + 1.5 \text{ ml l}^{-1}$ ) stood as best treatment by recording significantly the lowest (29.4%) leaf damage proving its superiority in efficacy over other treatments which was on par with chlorantraniliprole ( $0.3 \text{ ml l}^{-1}$ ) and Chlorpyrifos ( $2.5 \text{ ml l}^{-1}$ ) which recorded 3.72 and 4.02 per cent leaf damage, respectively. The treatment chlorantraniliprole + tricyclazole ( $0.3 \text{ ml l}^{-1} + 0.6 \text{ g l}^{-1}$ ) was found on par with chlorpyrifos ( $2.5 \text{ ml l}^{-1}$ ) by recording 6.92 per cent leaf damage. The next best treatments were chlorpyrifos + isoprothiolane ( $2.5 \text{ ml l}^{-1} + 1.5 \text{ ml l}^{-1}$ ) and chlorpyrifos + tricyclazole ( $2.5 \text{ ml l}^{-1} + 0.6 \text{ g l}^{-1}$ ) which were on par with, chlorantraniliprole + tricyclazole ( $0.3 \text{ ml l}^{-1} + 0.6 \text{ g l}^{-1}$ ) by recording 8.01 and 8.99 per cent leaf damage respectively. But, isoprothiolane ( $1.5 \text{ ml l}^{-1}$ ) and tricyclazole ( $0.6 \text{ g l}^{-1}$ ) recorded higher per cent leaf damage of 40.50 and 42.95%, respectively. However, untreated check recorded the highest per cent leaf damage of 49.72 which differed significantly from all the treatments.

**Table 4.26 Efficacy of different pesticides against Rice Leaf folder after second spray**

Tr. No	Treatments	Dose (ml or g/l)	Per cent leaf folder damage					Reduction over control (%)
			1 DBS	5 DAS	10 DAS	15 DAS	Mean	
T <sub>1</sub>	Chlorpyriphos 20% EC	2.5	39.30 (38.81)	8.32 <sup>c</sup> (16.70)	6.64 <sup>d</sup> (14.83)	4.02 <sup>d</sup> (11.48)	6.32 <sup>de</sup> (14.33)	86.10
T <sub>2</sub>	Chlorantraniliprole 18.5 % SC	0.3	38.47 (38.31)	7.23 <sup>d</sup> (15.57)	4.86 <sup>d</sup> (12.69)	3.72 <sup>d</sup> (11.03)	5.27 <sup>c</sup> (13.09)	88.46
T <sub>3</sub>	Tricyclazole 75% WP	0.6	39.34 (38.84)	38.11 <sup>b</sup> (38.14)	40.84 <sup>ab</sup> (39.74)	42.95 <sup>b</sup> (40.97)	40.63 <sup>ab</sup> (39.61)	11.09
T <sub>4</sub>	Isoprothiolane 40% EC	1.5	37.33 (37.64)	34.64 <sup>b</sup> (36.07)	37.62 <sup>b</sup> (37.85)	40.50 <sup>b</sup> (39.54)	37.58 <sup>b</sup> (37.82)	17.76
T <sub>5</sub>	Chlorpyriphos 20% EC + Tricyclazole 75% WP	2.5 +0.6	40.57 (39.55)	11.12 <sup>c</sup> (19.46)	10.40 <sup>c</sup> (18.78)	8.99 <sup>c</sup> (17.43)	10.17 <sup>c</sup> (18.55)	77.74
T <sub>6</sub>	Chlorpyriphos 20% EC + Isoprothiolane 40% EC	2.5 +1.5	40.97 (39.78)	11.43 <sup>c</sup> (19.71)	8.02 <sup>cd</sup> (16.42)	8.01 <sup>c</sup> (16.40)	9.14 <sup>cd</sup> (17.40)	80.00
T <sub>7</sub>	Chlorantraniliprole 18.5 %S C + Tricyclazole 75% WP	0.3 +0.6	39.22 (38.76)	9.30 <sup>c</sup> (17.70)	8.31 <sup>cd</sup> (16.73)	6.92 <sup>cd</sup> (15.23)	8.17 <sup>cd</sup> (16.55)	82.12
T <sub>8</sub>	Chlorantraniliprole 18.5 % SC + Isoprothiolane 40% EC	0.3 +1.5	37.47 (37.72)	7.09 <sup>d</sup> (15.35)	4.04 <sup>d</sup> (11.45)	2.94 <sup>d</sup> (9.70)	4.69 <sup>e</sup> (12.16)	89.73
T <sub>9</sub>	Untreated check	-	42.01 (40.39)	42.89 <sup>a</sup> (40.93)	44.49 <sup>a</sup> (42.60)	49.72 <sup>a</sup> (44.86)	45.7 <sup>a</sup> (42.79)	-
	<b>F test</b>		Sig.	Sig.	Sig.	Sig.	Sig.	
	<b>SEm±</b>		2.25	1.02	1.13	1.119	1.251	
	<b>CD (P=0.05)</b>		NS	3.062	3.390	3.356	3.605	
	<b>CV (%)</b>		10.05	14.44	13.18	12.98	15.38	

\*DBS- day before spray

\*\*DAS- days after spray

\*\*\*Figures in parenthesis are Arc- sine transformed values

Means followed by same letter do not differ significantly following DMRT

The mean data at fifth, tenth and fifteenth day after second spraying revealed significant difference between the treatments with respect to per cent leaf damage which ranged from 4.69 to 45.70%. Among the treatments, chlorantraniliprole + isoprothiolane ( $0.3 \text{ ml l}^{-1} + 1.5 \text{ ml l}^{-1}$ ) was the best treatment by recording lowest (4.69) mean per cent leaf damage with 89.73% reduction over control (Fig. 4.5) followed by chlorantraniliprole ( $0.3 \text{ ml l}^{-1}$ ) with 2.27 mean per cent leaf damage and 88.46% reduction over control and chlorpyrifos ( $2.5 \text{ ml l}^{-1}$ ) with 6.32 mean per cent leaf damage and 86.10% reduction over control. The treatments, chlorantraniliprole + tricyclazole ( $0.3 \text{ ml l}^{-1} + 0.6 \text{ g l}^{-1}$ ), chlorpyrifos + isoprothiolane ( $2.5 \text{ ml l}^{-1} + 1.5 \text{ ml l}^{-1}$ ), chlorpyrifos + tricyclazole ( $2.5 \text{ ml l}^{-1} + 0.6 \text{ g l}^{-1}$ ) showed better results with 8.17, 9.14 and 10.17 mean per cent leaf damage and 82.12, 80.00 and 77.74 per cent reduction over control, respectively. But, isoprothiolane ( $1.5 \text{ ml l}^{-1}$ ) and tricyclazole ( $0.6 \text{ g l}^{-1}$ ) recorded higher per cent leaf damage of 37.58, 40.63% mean per cent leaf damage and 17.76 and 11.09 per cent reduction over control, respectively since, they are fungicides. However, untreated check recorded the highest per cent leaf damage of 45.70%. The results clearly indicated that all the insecticidal treatments alone and in combination with fungicides were not significantly different from each other in relation to reduction of leaf folder incidence. However, these were significantly different from untreated control and fungicidal treatments.

**4.3.1.3 Cumulative efficacy of different pesticides after two sprayings :** The data with regard to cumulative efficacy of the treatments with respect to per cent leaf damage are presented in (Table 4.26) (Fig. 4.6)

The overall cumulative efficacy of the observations recorded at five, ten and fifteen days after two sprayings inferred that chlorantraniliprole + isoprothiolane ( $0.3 \text{ ml l}^{-1} + 1.5 \text{ ml l}^{-1}$ ) was the most effective treatment among all with 6.89 mean per cent leaf damage and 83.04 per cent reduction of leaf damage over control (Fig 4.7). These results are in corroboration with Bhuvanewari and Krishnamraju (2013), who reported lower leaf folder incidence (3.7%), lower stem borer incidence (6.3% white ears), lower mean brown plant hopper population (20.01) with chlorantraniliprole 18.5% SC + hexaconazole 5% EC. Similarly, Siddardha *et al.* (2014) also reported

that chlorantraniliprole 18.5% SC was compatible with fungicide Saaf (carbendazim 12% + mancozeb 63%) and per cent mortality was 33.3% against diamond back moth *Plutella xylostella* L. in laboratory studies. Kousika *et al.* (2014) also recorded lower leaf area mined (2.07%) with chlorantraniliprole 4.3% + abamectin 1.7% SC (0.12%) and 2.27 per cent with chlorantraniliprole 4.3% + abamectin 1.7% SC + mancozeb against *Liriomyza trifolii* (Burgess) on tomato.

Chlorantraniliprole (0.3 ml l<sup>-1</sup>) and chlorpyrifos (2.5 ml l<sup>-1</sup>) are the next best treatments with 7.37 and 8.26 mean per cent leaf damage with 81.86 and 79.67 per cent leaf damage reduction over control, respectively. These were on par with each other and with chlorantraniliprole + isoprothiolane (0.3 ml l<sup>-1</sup>+1.5 ml l<sup>-1</sup>). Results obtained pertaining to the efficacy of chlorantraniliprole (0.3ml l<sup>-1</sup>) are in accordance with Suri (2011), who reported lower leaf folder damage (3.40%) and stem borer damage (1.62% dead hearts) with chlorantraniliprole @ 40 g a.i ha<sup>-1</sup>. Huang *et al.* (2011) also reported similar findings in which chlorantraniliprole (0.3 ml l<sup>-1</sup>) was superior in controlling *Chilo suppressalis* L. in rice. Similarly, Siddegowda (2009) reported that chlorantraniliprole 25% SC @ 30 g a.i ha<sup>-1</sup> recorded lower mean leaf folder incidence (12.55%), lower mean stem borer incidence (3.23% dead hearts) and lower mean brown planthopper population (108.19). Singh (2009) also revealed that chlorantraniliprole 20 SC @ 100 g a.i ha<sup>-1</sup> was effective against early shoot borer damage (0.1%) and top shoot borer damage (0.1%). Similar results were also obtained by Kumar *et al.* (2008) against *Earias vitella* (Fab.) in cotton.

**Table 4.27 Cumulative Efficacy of different pesticides against Rice Leaf folder**

Tr. No	Treatments	Dose (ml or g/l)	Mean per cent damage			Reduction over control		
			First Spray	Second spray	Cumulative mean	First spray	Second spray	Cumulative Mean
T <sub>1</sub>	Chlorpyriphos 20% EC	2.5	10.2 <sup>bc</sup> (18.55)	6.32 <sup>de</sup> (14.33)	8.26 <sup>cde</sup> (16.44)	71.34	86.1	79.67
T <sub>2</sub>	Chlorantraniliprole 18.5 % SC	0.3	9.48 <sup>c</sup> (17.83)	5.27 <sup>e</sup> (13.09)	7.37 <sup>ef</sup> (15.46)	73.36	88.46	81.86
T <sub>3</sub>	Tricyclazole 75% WP	0.6	35.09 <sup>a</sup> (36.31)	40.63 <sup>ab</sup> (39.61)	37.86 <sup>ab</sup> (37.96)	1.40	11.09	6.84
T <sub>4</sub>	Isoprothiolane 40% EC	1.5	32.29 <sup>a</sup> (34.58)	37.58 <sup>b</sup> (37.82)	34.93 <sup>b</sup> (36.2)	9.27	17.76	14.05
T <sub>5</sub>	Chlorpyriphos 20% EC + Tricyclazole 75% WP	2.5 +0.6	14.10 <sup>b</sup> (21.98)	10.17 <sup>c</sup> (18.55)	11.73 <sup>c</sup> (19.92)	60.38	77.74	71.13
T <sub>6</sub>	Chlorpyriphos 20% EC + Isoprothiolane 40% EC	2.5 +1.5	13.15 <sup>b</sup> (21.19)	9.14 <sup>cd</sup> (17.40)	11.14 <sup>cd</sup> (19.29)	63.05	80	72.58
T <sub>7</sub>	Chlorantraniliprole 18.5 % SC + Tricyclazole 75% WP	0.3 +0.6	12.02 <sup>bc</sup> (20.17)	8.17 <sup>cd</sup> (16.55)	10.09 <sup>cde</sup> (18.36)	66.22	82.12	75.17
T <sub>8</sub>	Chlorantraniliprole 18.5 % SC + Isoprothiolane 40% EC	0.3 +1.5	9.10 <sup>c</sup> (17.50)	4.69 <sup>e</sup> (12.16)	6.89 <sup>f</sup> (14.83)	74.43	89.73	83.04
T <sub>9</sub>	Untreated check	-	35.59 <sup>a</sup> (36.60)	45.7 <sup>a</sup> (42.79)	40.64 <sup>a</sup> (39.69)	-	-	-
	<b>F test</b>		Sig.	-	Sig.			
	<b>SEm±</b>		1.106	1.251	1.086			
	<b>CD (P=0.05)</b>		4.42	3.605	3.557			
	<b>CV (%)</b>		15.45	15.38	15.03			

\*DBS- day before spray

\*\*DAS- days after spray

\*\*\*Figures in parenthesis are Arc- sine transformed values

Means followed by same letter do not differ significantly following DMRT

Results regarding the efficacy of chlorpyrifos ( $2.5 \text{ ml l}^{-1}$ ) were supported by the findings of Kalitha and Ahmed (2009) who reported that Chlorpyrifos @  $1250 \text{ g a.i ha}^{-1}$  gave better results in reducing leaf folder and stem borer damage with 1.33-2.33 damaged leaves per ten hills and 0.92-1.32% dead hearts respectively. Similarly, Sarao *et al.* (2006) reported that chlorpyrifos 10 G @  $0.75 \text{ g a.i ha}^{-1}$  gave good result against leaf folder which recorded 5.73 % leaf folder damage with 52.17 per cent reduction over control. The findings of Verma and Gupta (2001) also revealed chlorpyrifos @  $250 \text{ ml a.i ha}^{-1}$  reduced the population of leaf folder (8.97 per cent) at ten days after spraying and recorded 80 per cent reduction over control. Singh and Singh (1999) reported that chlorpyrifos 20% EC @  $500 \text{ g a.i ha}^{-1}$  when applied against *C. medinalis* recorded 6.4% mean damaged leaves. Similarly, Sachan *et al.* (2006) reported that chlorpyrifos 20% EC @  $1.5 \text{ ml}$  gave best results against stem borer and leaf folder with 7.5 % dead hearts and 6.6% damaged leaves, respectively. Sontakke and Dash (2000) reported that chlorpyrifos @  $1.50 \text{ g a.i. ha}^{-1}$  significantly reduced leaf folder damage and recorded 3.4% mean per cent damaged leaves.

The treatments chlorantraniliprole + tricyclazole ( $0.3 \text{ ml l}^{-1}+0.6 \text{ g l}^{-1}$ ), chlorpyrifos + isoprothiolane ( $2.5 \text{ ml l}^{-1}+1.5 \text{ ml l}^{-1}$ ) and chlorpyrifos + tricyclazole ( $2.5 \text{ ml l}^{-1}+0.6 \text{ g l}^{-1}$ ), recorded low to medium infestation with 10.09, 11.14 and 11.73 mean per cent leaf damage (75.17, 72.58 and 71.13 per cent leaf damage reduction over control respectively). But, they were on par with chlorantraniliprole ( $0.3 \text{ ml l}^{-1}$ ) and chlorpyrifos ( $2.5 \text{ ml l}^{-1}$ ) which indicates that there was no reduction in the efficacy of insecticides when combined with fungicides in reducing leaf folder damage showing compatibility between test insecticides and fungicides in bioefficacy point of view. These results of compatibility between insecticides and fungicides at field level are similar with results of Prasad and Gupta (2012), who reported that the combination of flubendiamide 20% WDG @  $0.25 \text{ g l}^{-1}$  + isoprothiolane @  $1.5 \text{ ml l}^{-1}$  was most effective against both stem borer and leaf blast with 2.54 and 3.50 per cent infestation, respectively. Similarly, Kumar *et al.* (2011) also reported that the combination of flubendiamide + hexaconazole @  $85 \text{ g a.i. ha}^{-1}$  was effective against all infestations which recorded 16.1% sheath blight severity, 0.9% dead hearts and 0.4%

white ears due to stem borer infestation, 2.9% damage due to leaf folder infestation. Findings of Prasad *et al.* (2009) also revealed that the combination of imidacloprid 200 %SL @ 0.25 ml l<sup>-1</sup> + propiconazole 25% EC @ 1.0 ml l<sup>-1</sup> was most effective against both stem borer and leaf blast with 5.0 and 6.8% infestation, respectively. Similarly, Bhatnagar (2004) reported that the combination of cartap hydrochloride 0.05% + tricyclazole 0.04% and cartap hydrochloride 0.05% + carbendazim 0.05% recorded the minimum percentage of leaf folder damage *i.e.*, 2.7, 3.4 per cent and 3.2, 4.5 per cent as compared to 22.5 and 22.4 per cent leaf folder damage in untreated control at 35 and 45 DAT, respectively. Findings of Rao *et al.* (1999) also supported the results obtained by stating that acephate 75% SP (Starthene) in combination with hexaconazole 5% EC (Contaf) was highly effective against leaf folder (3.52% damaged leaves) and sheath blight with disease incidence (9.94%).

Isoprothiolane (1.5 ml l<sup>-1</sup>) with 34.93 mean per cent leaf damage with 14.05 per cent leaf damage reduction over control significantly differed from untreated check with 40.64 mean per cent leaf damage. However, tricyclazole (0.6 g l<sup>-1</sup>) with 37.86 mean per cent leaf damage 6.84 per cent leaf damage reduction over control was on a par with isoprothiolane (1.5 ml l<sup>-1</sup>) and also with untreated check. These results are in conformity with Singh *et al.* (2011) who reported isoprothiolane @ 1.5 ml l<sup>-1</sup> and tricyclazole @ 0.6 g l<sup>-1</sup> are least effective against leaf folder with 7.6 and 7.3 per cent leaf damage respectively and are on par with control with 7.4 per cent leaf damage.

The results pertaining to the treatments clearly indicated that all the insecticidal treatments alone and in combination with fungicides were not significantly different from each other with respect to reduction of leaf folder incidence. However, these were significantly different from untreated control and fungicidal treatments.

#### **4.3.2 Efficacy of Different Pesticides Against the Rice Leaf Blast After Spraying**

The symptoms of leaf blast appeared first at 25 days after transplantation (DAT) and the treatments were imposed at 35 DAT. The results pertaining to efficacy of the treatments against leaf blast incidence on rice are presented in (Table 4.27) (Fig 4.8).

There was no significant difference between the different treatments at one day before spraying and per cent leaf blast severity ranged from 17.77 to 23.92 per 20 hills. Significant difference was observed between the treatments with respect to per cent leaf blast incidence at 10 days after spraying which ranged from 15.85 to 36.14%. Among the treatments, tricyclazole (0.6 g l<sup>-1</sup>) was found as the best treatment by recording lowest (15.85) per cent leaf blast incidence which was on par with isoprothiolane (1.5 ml l<sup>-1</sup>) and chlorantraniliprole + isoprothiolane (0.3 ml l<sup>-1</sup>+1.5 ml l<sup>-1</sup>) which recorded 17.11 and 18.37% blast incidence, respectively. The next best treatments were chlorantraniliprole + tricyclazole (0.3 ml l<sup>-1</sup>+0.6 g l<sup>-1</sup>) and chlorpyrifos + isoprothiolane (2.5 ml l<sup>-1</sup>+1.5 ml l<sup>-1</sup>) were on par with isoprothiolane + (1.5 ml l<sup>-1</sup>) and chlorantraniliprole + isoprothiolane (0.3 ml l<sup>-1</sup>+1.5 ml l<sup>-1</sup>) by recording 20.26 and 20.44 per cent leaf blast incidence, respectively. But, the treatments chlorpyrifos (2.5 ml l<sup>-1</sup>) and chlorantraniliprole (0.3 ml l<sup>-1</sup>) recorded higher per cent blast incidence of 30.22 and 32.81, respectively since they are insecticides without fungicidal action. However, untreated check recorded the highest per cent leaf blast incidence of 36.14%.

**Table 4.28 Efficacy of different pesticides against leaf blast *Pyricularia oryzae***

Tr. No	Treatments	Dose (ml or g l <sup>-1</sup> )	Blast disease severity (%)					Reduction over control (%)
			1 DBS	10 DAS	20 DAS	30 DAS	Mean	
T <sub>1</sub>	Chlorpyriphos 20% EC	2.5	17.77 (24.89)	30.22 <sup>a</sup> (33.34)	39.26 <sup>a</sup> (38.79)	54.81 <sup>a</sup> (47.79)	41.43 <sup>a</sup> (39.97)	9.18
T <sub>2</sub>	Chlorantraniliprole 18.5% SC	0.3	20.22 (26.72)	32.81 <sup>a</sup> (34.91)	42.22 <sup>a</sup> (40.54)	51.56 <sup>a</sup> (45.92)	42.19 <sup>a</sup> (40.45)	7.51
T <sub>3</sub>	Tricyclazole 75% WP	0.6	18.15 (25.20)	15.85 <sup>d</sup> (23.42)	11.85 <sup>d</sup> (20.05)	7.70 <sup>c</sup> (16.06)	11.8 <sup>b</sup> (19.84)	74.13
T <sub>4</sub>	Isoprothiolane 40% EC	1.5	17.79 (24.84)	17.11 <sup>cd</sup> (24.44)	13.48 <sup>d</sup> (21.52)	10.59 <sup>bc</sup> (18.80)	13.95 <sup>b</sup> (21.58)	69.42
T <sub>5</sub>	Chlorpyriphos 20% EC + Tricyclazole 75% WP	2.5 +0.6	23.92 (29.29)	23.70 <sup>bc</sup> (29.06)	20.74 <sup>b</sup> (27.06)	13.93 <sup>b</sup> (21.86)	19.45 <sup>b</sup> (25.99)	57.36
T <sub>6</sub>	Chlorpyriphos 20% EC + Isoprothiolane 40% EC	2.5 +1.5	21.63 (27.68)	20.44 <sup>c</sup> (26.80)	19.85 <sup>bc</sup> (26.42)	11.70 <sup>bc</sup> (19.94)	17.72 <sup>b</sup> (24.38)	61.15
T <sub>7</sub>	Chlorantraniliprole 18.5 % SC + Tricyclazole 75% WP	0.3 +0.6	20.41 (26.80)	20.26 <sup>c</sup> (26.69)	22.07 <sup>b</sup> (28.03)	10.61 <sup>bc</sup> (18.96)	17.64 <sup>b</sup> (24.56)	61.33
T <sub>8</sub>	Chlorantraniliprole 18.5 % SC + Isoprothiolane 40% EC	0.3 +1.5	18.96 (25.73)	18.37 <sup>cd</sup> (25.35)	16.70 <sup>cd</sup> (22.12)	13.86 <sup>b</sup> (21.76)	16.31 <sup>b</sup> (22.07)	63.80
T <sub>9</sub>	Untreated check	-	18.37 (25.33)	36.14 <sup>a</sup> (36.96)	41.92 <sup>a</sup> (40.36)	58.81 <sup>a</sup> (50.12)	45.62 <sup>a</sup> (42.48)	0
	F test		NS	Sig.	Sig.	Sig.	Sig.	
	SEm±		1.281	1.404	1.458	1.456	1.928	
	CD (P=0.05)		-	4.211	4.373	4.365	8.48	
	CV (%)		13.36	12.27	13.58	14.00	16.63	

\*DBS- day before spray

\*\*DAS- days after spray

\*\*\*Figures in parenthesis are Arc- sine transformed values

Means followed by same letter do not differ significantly following DMRT

At 20 days after spraying (DAS), a significant difference between the treatments was observed with respect to per cent leaf blast incidence which ranged from 11.85 to 41.92%. Among the treatments, tricyclazole (0.6 g l<sup>-1</sup>) found to be the best treatment by recording lowest (11.85) per cent leaf blast incidence which was on par with isoprothiolane (1.5 ml l<sup>-1</sup>) which recorded 13.48% leaf blast incidence followed by chlorantraniliprole + isoprothiolane (0.3 ml l<sup>-1</sup>+1.5 ml l<sup>-1</sup>) which recorded 16.70% leaf blast. The treatment chlorpyrifos + isoprothiolane (2.5 ml l<sup>-1</sup>+1.5 ml l<sup>-1</sup>) was on par with chlorantraniliprole + isoprothiolane (0.3 ml l<sup>-1</sup>+1.5 ml l<sup>-1</sup>) by recording 19.85 per cent leaf blast incidence. The treatments chlorpyrifos + tricyclazole and chlorantraniliprole +tricyclazole (0.3 ml l<sup>-1</sup>+0.6 g l<sup>-1</sup>) were on par with each other and also with chlorpyrifos + isoprothiolane (2.5 ml l<sup>-1</sup>+1.5 ml l<sup>-1</sup>) by recording 20.74 and 22.07 per cent leaf blast severity, respectively. But, Treatments chlorpyrifos (2.5 ml l<sup>-1</sup>) and chlorantraniliprole (0.3 ml l<sup>-1</sup>) recorded higher per cent blast severity (39.26 and 42.22, respectively) since they are insecticides. However, untreated check recorded the highest per cent leaf blast incidence of 41.92%.

The per cent leaf blast incidence at 30 days after spraying (DAS) revealed a significant difference observed between the treatments and the severity ranged from 7.70 to 58.81%. Among the treatments, tricyclazole (0.6 g l<sup>-1</sup>) emerged as the best treatment by recording lowest (7.70) per cent leaf blast incidence which was on par with isoprothiolane (1.5 ml l<sup>-1</sup>) with 10.59% leaf blast incidence followed by chlorantraniliprole + tricyclazole (0.3 ml l<sup>-1</sup>+0.6 g l<sup>-1</sup>) with 10.61% leaf blast incidence, chlorpyrifos + isoprothiolane (2.5 ml l<sup>-1</sup>+1.5 ml l<sup>-1</sup>) with 11.70% leaf blast incidence. The treatments chlorantraniliprole + isoprothiolane (0.3 ml l<sup>-1</sup>+ 1.5 ml l<sup>-1</sup>) and chlorpyrifos + tricyclazole (2.5 ml l<sup>-1</sup>+0.6 g l<sup>-1</sup>) were found on par with each other and also with isoprothiolane (1.5 ml/l), chlorantraniliprole + tricyclazole (0.3 ml/l+0.6 g/l) and chlorpyrifos + isoprothiolane (2.5 ml l<sup>-1</sup>+ 1.5 ml l<sup>-1</sup>) by recording 13.86 and 13.93 per cent leaf blast severity respectively. But, treatments chlorpyrifos (2.5 ml l<sup>-1</sup>) and chlorantraniliprole (0.3 ml l<sup>-1</sup>) recorded highest per cent blast incidence of 54.81 and 51.56, respectively since they are insecticides. However, untreated check has recorded the highest per cent leaf blast incidence of 58.81%.

The mean data of per cent blast incidence recorded on 10, 20 and 30 days after spraying revealed that tricyclazole ( $0.6 \text{ g l}^{-1}$ ) was superior over other treatments by recording 11.8 per cent blast incidence with 74.13 per cent disease incidence reduction over control (Fig. 4.9). These results are in accordance with Dutta *et al.* (2012) who reported that tricyclazole 75% WP proved effective in management of rice blast disease with 12.85% leaf blast incidence. Bhat and Anwar (2004) also reported that tricyclazole 75% WP @  $0.6 \text{ g l}^{-1}$  significantly reduced the blast disease incidence (15.60%) with suppression of 71.31 % over control. Similarly, the findings of Prajapati *et al.* (2004) support the present results which revealed that tricyclazole 75% WP @  $0.6 \text{ g l}^{-1}$  reduced the leaf blast incidence (1.65%) with 70% reduction over control. Tirmali (2001) reported that tricyclazole reduced the neck blast incidence (37.3%) with 52.05 per cent reduction over control.

Isoprothiolane ( $1.5 \text{ ml l}^{-1}$ ) recorded 13.95 mean per cent blast incidence and 69.42 disease incidence reduction over control and was on par with the best treatment. These results are in acceptance with Singh *et al.* (2011) who reported that isoprothiolane @  $1.5 \text{ ml l}^{-1}$  was effective after tricyclazole @  $0.6 \text{ g l}^{-1}$  in controlling blast incidence with 22.6 and 17.6 % neck blast incidence in the year 2008 and 2009, respectively. Similarly, findings were also reported by Kumar *et al.* (2011) in which isoprothiolane @  $1.5 \text{ ml l}^{-1}$  was an effective chemical in reducing rice blast disease (24% leaf blast severity) after tricyclazole (21% leaf blast severity). The reports of Sharma and Srivastava (2010) were in agreement with present results who reported that isoprothiolane @  $1.5 \text{ ml l}^{-1}$  was an effective chemical in reducing rice blast disease with 4.74 leaf blast severity compared to 24% in untreated control.

The treatments chlorantraniliprole + isoprothiolane ( $0.3 \text{ ml l}^{-1} + 1.5 \text{ ml l}^{-1}$ ), chlorantraniliprole + tricyclazole ( $0.3 \text{ ml l}^{-1} + 0.6 \text{ g l}^{-1}$ ), chlorpyrifos + isoprothiolane ( $2.5 \text{ ml l}^{-1} + 1.5 \text{ ml l}^{-1}$ ) and chlorpyrifos + tricyclazole ( $2.5 \text{ ml l}^{-1} + 0.6 \text{ g l}^{-1}$ ) followed the best treatment by recording 16.31, 17.64, 17.72 and 19.45 mean per cent blast incidence and 63.80, 61.33, 61.15 and 57.36 per cent disease incidence reduction over control, respectively. These results are in accordance with Prasad and Gupta (2012), who reported that the combination of flubendiamide 20% WDG @  $0.25 \text{ g l}^{-1}$  +

isoprothiolane @ 1.5 ml l<sup>-1</sup> was most effective against both stem borer and leaf blast with 2.54 and 3.50 per cent infestation, respectively. Similarly, Bhatnagar (2004) reported that combination of cartap hydrochloride 0.05% + tricyclozole 0.04% recorded minimum incidence of neck blast disease *i.e.*, 0.7% as against 3.8% in untreated control. Singh *et al.* (2011) also reported that tricyclazole + flubendamide showed 17.7% neck blast disease incidence followed by tricyclazole + fipronil with 18.8% neck blast incidence and isoprothiolane + flubendamide with 20.1% neck blast incidence compared to tricyclazole alone with 20% blast incidence. Reddy *et al.* (1999) reported that application of beam +indofil M-45 @ 0.5+ 1.5 g l<sup>-1</sup> controlled neck blast and recorded incidence of 11.23% compared to beam @ 0.6 g l<sup>-1</sup> alone with 3.73% neck blast incidence. Similarly, Kumar *et al.* (2011) reported that isoprothiolane 1.5 ml l<sup>-1</sup> + flubendamide 0.5 g l<sup>-1</sup> recorded 20% leaf blast severity compared to isoprothiolane alone treatment with 24% leaf blast severity.

Treatments chlorpyrifos (2.5 ml l<sup>-1</sup>) and chlorantraniliprole (0.3 ml l<sup>-1</sup>) are the least effective treatments with 41.43, 42.1 against blast because of non fungicidal properties by recording mean per cent blast incidence and 9.18 and 7.51 mean percent reduction of blast severity over control.

From the above findings it is clear that all fungicidal treatments are almost similar in their bioefficacy in controlling the blast disease when used alone or in combination with insecticides. All individual fungicidal treatments were statistically on par with themselves and also with combination treatments and there was no significant difference between individual treatments and when combined with insecticides implying compatibility between the test insecticides and fungicides in their bioefficacy in controlling leaf blast disease.

#### **4.4 EFFECT OF INSECTICIDAL TREATMENTS ON YIELD**

Significant difference between the treatments was observed with respect to yield. The yield ranged from 2.00 t ha<sup>-1</sup> to 5.39 t ha<sup>-1</sup> (Table 4.28) (Fig. 4.10)

Significantly highest (5.39 t ha<sup>-1</sup>) yield was recorded in chlorantraniliprole + isoprothiolane (0.3 ml l<sup>-1</sup>+1.5 ml l<sup>-1</sup>) which was on par with all the other insecticide and fungicide combinations tested in the present investigation *i.e.*, chlorantraniliprole

+ tricyclazole (0.3 ml l<sup>-1</sup>+0.6 g l<sup>-1</sup>), chlorpyrifos + isoprothiolane (2.5 ml l<sup>-1</sup>+ 1.5 ml l<sup>-1</sup>) and chlorpyrifos + tricyclazole (2.5 ml l<sup>-1</sup>+0.6 g l<sup>-1</sup>) which recorded 5.07, 4.85 and 4.77 t ha<sup>-1</sup>, respectively. These results in accordance with Bhuvanawari and Krishnamraju (2013), who reported that chlorantraniliprole @ 0.3 ml/l in combination with hexaconazole @ 2 ml l<sup>-1</sup> gave less incidence (8.3%) and severity of sheath blight (12.8%) and also less stem borer and lesser leaf folder and recorded 5.6 t ha<sup>-1</sup> of grain yield of rice. Similarly findings of Kumar, (2011) revealed that isoprothiolane + fipronil, isoprothiolane + flubendamide, tricyclazole + fipronil and tricyclazole + flubendamide gave satisfactory yields of 4.97, 5.19, 5.14 and 5.17 t/ha, respectively whereas Singh *et al.* (2011) reported that Isoprothiolane + fenoxanil yielded 3.8 t ha<sup>-1</sup>.

The next best treatments were chlorantraniliprole (0.3 ml l<sup>-1</sup>), chlorpyrifos (2.5 ml l<sup>-1</sup>), isoprothiolane (1.5 ml l<sup>-1</sup>) and tricyclazole (0.6 g l<sup>-1</sup>) which recorded 4.24, 4.10, 3.98 and 3.70 t ha<sup>-1</sup> of yield, respectively. However, significantly lowest yield (2.00 t ha<sup>-1</sup>) was recorded in untreated check.

The treatments followed the same trend with respect to incremental yield over control (per cent increase over control) (Fig. 4.11) where in chlorantraniliprole + isoprothiolane (0.3 ml l<sup>-1</sup>+1.5 ml l<sup>-1</sup>) recorded highest (62.80%) incremental yield followed by chlorantraniliprole + tricyclazole (0.3 ml l<sup>-1</sup>+0.6 g l<sup>-1</sup>), chlorpyrifos + isoprothiolane (2.5 ml l<sup>-1</sup>+1.5 ml l<sup>-1</sup>), chlorpyrifos + tricyclazole (2.5 ml l<sup>-1</sup>+ 0.6 g l<sup>-1</sup>), chlorantraniliprole (0.3 ml l<sup>-1</sup>), chlorpyrifos (2.5 ml l<sup>-1</sup>), isoprothiolane (1.5 ml l<sup>-1</sup>) and tricyclazole (0.6 g l<sup>-1</sup>) which recorded 60.44, 58.71, 58.02, 52.71, 51.16, 49.61 and 45.86 per cent of incremental yield over control.

The results pertaining to chlorantraniliprole and chlorpyrifos are in accordance with results obtained by Suri (2011) who reported that chlorantraniliprole @ 40 g a.i/ha recorded the moderate yield of 3.5 t ha<sup>-1</sup> and chlorpyrifos 20% EC recorded 3.6 t ha<sup>-1</sup>. Similarly, Siddegowda (2009) reported that chlorantraniliprole @ 60 g a.i. ha<sup>-1</sup> recorded the yield of 4.4 t ha<sup>-1</sup> and chlorpyrifos 20% EC recorded yield of 3.6 t/ha. However, the findings of Sontakke and Dash (2000) revealed that chlorpyrifos @ 500 g a.i. ha<sup>-1</sup> recorded highest yield (5.9 t ha<sup>-1</sup>) which are in agreement with the results obtained in the present investigations.

The results pertaining to tricyclazole and isoprothiolane are in accordance with Singh *et al.* (2011) who reported that isoprothiolane @ 1.5 ml t ha<sup>-1</sup> recorded a moderate yield of 3.7 t ha<sup>-1</sup> and tricyclazole @ 0.6 g l<sup>-1</sup> recorded 3.9 t ha<sup>-1</sup>. Similarly, Kumar *et al.* (2011) also recorded highest yield with both tricyclazole @ 0.6 g l<sup>-1</sup> (4.9 t ha<sup>-1</sup>) and isoprothiolane @ 1.5 ml/lit (4.7 t/ha). Similarly, from the reports of Bhatnagar (2004) and Bhat and anwar (2004) it is evident that tricyclazole @ 0.6 g l<sup>-1</sup> recorded the grain yield of 4.8 t ha<sup>-1</sup> and 4.57 t ha<sup>-1</sup>, respectively.

**Table 4.29 Efficacy of insecticides on yield of paddy**

S. No	Treatments	Dose (ml or g l <sup>-1</sup> )	Yield (t ha <sup>-1</sup> )	Increase over control (%)
T <sub>1</sub>	Chlorpyrifos 20% EC	2.5	4.10 <sup>bcd</sup>	51.16
T <sub>2</sub>	Chlorantraniliprole 18.5 % SC	0.3	4.24 <sup>bcd</sup>	52.71
T <sub>3</sub>	Tricyclazole 75% WP	0.6	3.70 <sup>d</sup>	45.86
T <sub>4</sub>	Isoprothiolane 40% EC	1.5	3.98 <sup>cd</sup>	49.61
T <sub>5</sub>	Chlorpyrifos 20% EC + Tricyclazole 75% WP	2.5 +0.6	4.77 <sup>abc</sup>	58.02
T <sub>6</sub>	Chlorpyrifos 20% EC + Isoprothiolane 40% EC	2.5 +1.5	4.85 <sup>ab</sup>	58.71
T <sub>7</sub>	Chlorantraniliprole 18.5 % SC + Tricyclazole 75% WP	0.3 +0.6	5.07 <sup>a</sup>	60.44
T <sub>8</sub>	Chlorantraniliprole 18.5 % SC + Isoprothiolane 40% EC	0.3 +1.5	5.39 <sup>a</sup>	62.80
T <sub>9</sub>	Untreated control	-	2.00 <sup>e</sup>	-
	F test		S	
	SEm±		0.267	
	CD (P=0.05)		0.80	
	CV (%)		14.22	

Means followed by same letter do not differ significantly following DMRT

## Chapter II

# REVIEW OF LITERATURE

The literature pertaining to the various aspects of seasonal abundance and compatibility of insecticides and fungicides as per the objectives has been reviewed and presented in this chapter.

### 2.1 STUDIES ON SEASONAL INCIDENCE OF INSECT PESTS AND DISEASES OF PADDY

#### 2.1.1 Correlation of Weather Factors with the Incidence of Insect Pests of Paddy

Weather factors are the major regulating causes for the insect pest populations under field circumstances. Abiotic factors such as temperature, relative humidity, and rainfall and wind velocity may affect the distribution, growth, survival, behaviour, movement, reproduction, population dynamics and outbreaks of insect pests of rice. Certain support and others disfavour their multiplication and movement, therefore, it sometimes, results in serious outbreaks of the different insect pests (Hyslops, 1941).

Neetam and Gupta (2015) reported that rice leaf folder, *C. medinalis* was observed with maximum infestation of 25.3% during third week of September in *kharif*. The peak activity was associated with a maximum temperature of 30.6<sup>0</sup> C and a minimum temperature of 21.7<sup>0</sup> C with 90.5% and 45.4% morning and evening relative humidity, respectively with associated rainfall of 57.9 mm. Further, they reported a significant and positive correlation between leaf infestation and maximum temperature ( $r= 0.537$ ) whereas the correlation was significant and negative between leaf infestation and evening relative humidity (RH) ( $r= -0.523$ ).

Ram *et al.* (2014) reported that the leaf folder was observed from second fortnight of July (29<sup>th</sup> standard week) till harvest of the crop. The larval population was low during July to fourth week of August and varied between 0 to 1.90 larvae per hill. The pest population increased from end of August and reached its peak (5.10 larvae per hill) during 38<sup>th</sup> standard week *i.e.*, second fortnight of September. They also reported negative correlation between weather parameters and larval population during crop season *i.e.*, *kharif*, 2011.

Sandeep *et al.* (2014) reported that the population of brown planthopper, increased with the vegetative stage of crop and reached highest in third week of October. The incidence of the pest was severe in the last week of September to last week of October. They also observed a positive correlation between population of BPH and temperature and RH whereas a negative correlation was observed with rainfall.

Chakraborty and Chandradeb (2011) reported that abiotic factors such as minimum temperature, temperature gradient, maximum relative humidity and average relative humidity had significant positive influence on *C. medinalis* population. Minimum relative humidity and sunshine hours have a negative influence. In addition, other factors such as maximum temperature, relative humidity gradient, average RH, number of rainy days and rainfall imparted an insignificant positive effect on population development.

Findings of Patel *et al.* (2011) revealed leaf folder incidence from 36<sup>th</sup> standard week and reached its peak level (3.12 larvae per plant and 3.20 per cent damaged leaves) during 43<sup>rd</sup> standard week in *kharif*, 2005 while the larval population (0.53 larva per plant) and per cent damaged leaves (0.72) by rice leaf folder initiated from 13<sup>th</sup> standard week and reached to its peak level (1.51 larvae per plant and 1.75 per cent damaged leaves) during 15<sup>th</sup> standard week in summer 2006.

Ahmed *et al.* (2010) reported that initial population of leaf folder adults were observed during 26<sup>th</sup> standard week with its peak (45 adults) during 33<sup>rd</sup> standard week whereas the incidence of larvae on rice leaves commenced in

27<sup>th</sup> standard week and reached its maximum (19 larvae/10 hills) during 36<sup>th</sup> standard week. They also stated that only RH ( $r = 0.793$ ) and minimum temperature ( $r = 0.513$ ) had a significant positive effect on light trap catch of adults whereas there was no correlation between weather parameters and leaf infestation of leaf folder.

Prasad *et al.* (2010) conducted survey to know the incidence of white backed plant hopper (WBPH) during *kharif* in different paddy ecosystems of Uttara Kannada district (Karnataka) and reported that the incidence of WBPH commenced from September and reached its peak during November (865 nymphs and adults per hill) in Mundgod, followed by Sirsi (854) and Banavasi (678.60). The correlation studies made on WBPH population revealed a negative and significant relationship with maximum temperature while it was positive and significant with minimum temperature, morning and evening RH.

Goyal and Mahal (2009) observed the effect of different constant temperatures on rate of multiplication of *C. medinalis* under laboratory conditions and reported that the period of development was in a decreasing trend. The threshold temperature, calculated by the method of mean temperature, was 16.2<sup>o</sup> C while the thermal constant for egg to adult stage was calculated as 646.07<sup>o</sup> D.

Raja (2007) noticed that the mean temperatures of 27.6<sup>o</sup> C, 25.3<sup>o</sup> C and 30.96<sup>o</sup> C were favorable for high rice leaf folder incidence which corresponds to *Navarai* (2005), *Kuruvai* (2006) and *Samba* (2006) seasons respectively. Relative humidity ranged between 66.43 and 96.14% in *Navarai* (2005), 30.21 and 86.14% in *Kuruvai* (2006) 43.29 and 74.43% in *Samba* (2006) were the favorable conditions for severe rice leaf folder incidence.

Seven rice insect pest species appeared in light trap during 1999 to 2003 at Punjab. All pests started appearing in April but their population did not increase during May-June due to high temperature and low relative humidity and attained peak during warm and humid months of August-September and declined with the fall in minimum temperature and evening RH as per the reports of Singh *et al.* (2007).

A study on the pest-weather interaction of major insect pests in rice ecosystem in Pakistan showed that the population of rice leaf folder, attained peaks in September with 7.75 larvae per 20 hills. The maximum and minimum temperature and rain fall played a vital role for bringing an 82.99% change in the population of leaf folder as reported by Sabir *et al.* (2006).

The mean moth catches of stem borer adults through sex pheromones attained two peaks with its first peak (4.78) during 3<sup>rd</sup> week of August and second (9.77) during 2<sup>nd</sup> week of September in *kharif*, 2003 as reported by Singh *et al.* (2006).

Sachan *et al.* (2006) revealed the incidence of different insect species during the crop seasons of 2000 to 2002 which include *S. incertulas* (July to October), leaf folder (August and September) and BPH (August and September) as the major pests damaging the crop. The minor pests includes gundhi bug, *L. acuta*. (September and October), green leafhopper (August and September) and grass hoppers, *Hieroglyphus banian* Fab. (August to October).

During the year 2002-2003, in Kashmir region, Bhagat and Raina (2006) observed various insects damaging agricultural crops and other economically important plants wherein the trapping yielded more than 2383 insect individuals, belonging to five orders (Coleopteran, Hemiptera, Homoptera, Lepidoptera and Orthoptera), with 54 species, belonging to 37 genera under 16 families.

Vijaykumar and Patil (2006) observed that BPH started appearing in the month of October and continued till the harvest of the crop during *kharif*, 2001 and reported that the population varied from 0.00 to 18.00, 0.00 to 22.00, 0.00 to 21.00, 2.00 to 24.00 and 3.00 to 26.00 in Raichur, Manvi, Sindhanoor, Sirguppa and Gangavati locations respectively. The peak population was recorded during second fortnight of November in Raichur, Manvi and Sindhanoor and during first fortnight of November in Sirguppa and Gangavati. The results of the correlation studies made between BPH populations and abiotic factors revealed a non-significant negative correlation.

Field experiments conducted at Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur during *kharif* 2002 and 2003 to observe the incidence of white backed planthopper and rice leaf folder and their relationship with weather parameters revealed that major activity period of *S. furcifera* and *C. medinalis* was confined between August to December with three to four peaks which indicated completion of three generations during main cropping season with their highest weekly peaks during third week of September and November. The results further indicated that higher rainfall, lower mean maximum temperature and higher RH are very favourable weather factors for development of these pest species as reported by Sharma *et al.* (2004).

The paddy leaf folder moth catches were higher in October, exhibiting the peak activity in the first week of the month followed by September. The correlation studies between light trap and net sweep collection with weather parameters on population build up showed that maximum, minimum temperatures and RH at morning were highly significant. Maximum and minimum temperatures had negative impact on population build up, while the RH at morning had a positive impact. The correlation between net sweep and light trap collection was very high (0.866) showing that either of them was enough to monitor the leaf folder population under field conditions as per Khan and Ramamurthy (2004).

The activity of *C. medinalis* lasted from second week of August to the second week of October during 2000 while it lasted from the last week of August to the second week of October during *kharif*, 2001. However, the peak activity was observed in the second fortnight of September during both the cropping seasons as per the reports of Alvi *et al.* (2003).

Under the conditions of minimum and maximum temperatures of 18.7 and 29<sup>0</sup> C, respectively, 62 to 86% of RH, 113.7 total sunshine hours together with 765.9 mm rainfall, the infestation of *C. medinalis* was 78% which corresponds to 36 numbers of average catch per week in var. *Pusa Basmati* as reported by Rai *et al.* (2000). They also reported that among weather factors, temperature, RH and rainfall were negatively correlated while sunshine hours were positively correlated with the pest build up.

Ruique *et al.* (1999) studied the relationship between the abundance of the most harmful generation of *C. medinalis* and rainfall and reported that the most harmful generation and number of immigrants of fifth generation of *C. medinalis* was positively correlated with the number of rainy days during early and mid-June and the amount of rainfall.

Pawan *et al.* (1996) reported that the infestation of rice leaf folder, varied from 1.4 to 33.2% in rice from July to October with peak infestation coinciding with the panicle initiation stage of the crop. Further, the percentage of infested leaves having live caterpillars were maximum during the first fortnight of September and resulted in maximum damage in the second fortnight of September and also that the weather parameters *viz.*, temperature, RH and rainfall failed to exhibit any correlation with the extent of damage.

Dhaliwal *et al.* (1988) reported that the incidence of leaf folder was higher on the late transplanted rice compared to early planted crop and the infestation was high on fine grain scented rice *Palman-370* (34.4% damaged leaves) on July 15<sup>th</sup> while it was minimum on *Basumathi-370* (18.6% damaged leaves) during the same period.

A study on the influence of temperature and rainfall on the incidence of leaf folder by Chatterjee (1987) revealed that maximum damaged leaves (74.6%) were noticed in September when the rainfall was 750.00 mm as against 3.6% damaged leaves recorded during May with a rainfall of 178.8 mm.

The light trap data on the incidence of leaf folder revealed that the incidence was severe in both seasons *i.e.*, from September to November during *kharif* and December, February and March during *rabi* with economic thresholds exceeding during September, October and November in 1984 as per the reports of Krishnaiah *et al.* (1986).

Mohan and Janarthan (1985) conducted an experiment to study seasonal abundance by monitoring population through a modified Robinson light trap. The data indicated that the leaf folder peak activity occurred in October and March.

Kushwana and Singh (1984) reported that leaf folder infestation began in early August and continued until mid October favoured by heavy rainfall in late July and August and damaged upto 60-70 per cent leaves during *kharif*, 1983 and damage was particularly high on the late transplanted crop.

Verma *et al.* (1984) reported the outbreak of leaf folder in Uttar Pradesh with high populations of the pest not only in the Tarai but also in the hilly regions (up to 1500 m altitudes) recording 60 per cent of rice leaves damage in farmer's fields. They also reported that population began to appear in the field in July and remained until October and completed four to five generations during the period damaging both the early sown and upland crops severely.

Saroja and Raju (1983) reported that early crop planted between 5<sup>th</sup> August and 5<sup>th</sup> September was heavily damaged by leaf folder, because maximum tillering and early flowering coincided with the peak populations of the pest in October- November and less leaf damage (below 20 per cent) in the crops planted between 20<sup>th</sup> September and 5<sup>th</sup> November.

The reports of Upadhyay *et al.* (1975) revealed that the highest leaf folder population densities in light trap catches of 231 and 103 moths were recorded during October 1973 and 1974 respectively, while it was 414 during November, 1971. They concluded that during 1971 and 1973, initiation of build up as well as increase in population continued up to the period till RH remained high and the difference between maximum and minimum temperature remained narrow. Similar trend was also observed in 1974, but population build-up was much low probably due to the RH did not rise beyond 77 per cent.

### **2.1.2 Correlation of Weather Factors with the Disease Incidence of Paddy**

Paatro and Madhuri (2014) reported that the highest incidence of neck blast of 72.67 and 67.00 per cent was noticed in the susceptible genotypes VR-708 and KM-252 respectively in June 16<sup>th</sup> sown crop, where minimum temperature of 26.1<sup>o</sup> C, maximum temperature of 32.36<sup>o</sup> C, RH of 89.9 per cent and a very high amount of rainfall prevailed whereas the highest incidence of leaf blast (grade-4) was recorded in June 16<sup>th</sup> sown VR-708. Their investigations also revealed that increased leaf and neck blast was due to increased temperature, significantly high amount of rainfall and high RH

Studies on the effect of weather factors on fluctuations of spore population of *Pyricularia grisea* T.T Hebert and the occurrence of the disease during growing seasons of 2006–2007 by Sedigheh *et al.* (2009) at weather stations of Rasht, Lahijan and Anzali in Guilan province revealed that weather factors such as precipitation, maximum temperature, RH (min) and sunshine hours are the most important factors predicting rice blast in Guilan and enough precipitation, increased daily RH (min), decreased daily maximum temperature and sunshine hours resulted in increased spore population and blast occurrence during next 7- 10 days.

Kapoor *et al.* (2004) observed rice blast severity during 1997, 1998 and 1999 in Kangra district, Himachal Pradesh. In all the three years, temperature (18-28<sup>0</sup> C) and RH (more than 9 h >90%) during crop season were within the optimum range which favoured disease development. Analyses of 13 years (1984-1996) weather data revealed that the number of days with RH of >90% during July to September, number of rainy days in a week and cloudiness were most critical factors in the development of rice blast epidemics during blast years of 1984 and 1992.

The influence of meteorological factors on development of rice blast disease was studied by Padmanabhan *et al.* (1969) and reported that a coincidence of low night temperature of 20-26<sup>0</sup> C and below with high relative humidity of 90 per cent and above during the susceptible stage of crop growth (seedling, tillering and neck emergence) accompanied by rice blast outbreak.

### **2.1.1 Correlation of Natural Enemies with Insect Pests of Paddy**

Nearly 350 species of the spiders were reported to occur in the rice ecosystem in south and South East Asia. About two third of them were reported from the temperate asian countries such as Philippines (82), Japan (90), Taiwan (75), China (61) and Korea (32) (Barrion and Litsinger, 1995).

Jayakumar and Sankari (2010) identified a total of five spiders, namely *Lycosa pseudoannulata* L, *Callitrichia formosana* L, *Tetragnatha javanas* L, *Argiope catenulata* L. and unidentified *Plexippus* species from all the six different technique plots with their population maximum (20.93%) in Integrated Crop Management whereas the population was minimum in Seedling Throwing (8.58%). They also reported that population of spiders showed positive correlation with rice pests *N. lugens* and *L. acuta* and negative correlation with *C. medinalls*.

Preap *et al.* (2001) reported two most important spiders *i.e.*, hunting spider (*Araneus inustus* L.) and wolf spider (*Pardosa pseudoannulata* L.) against brown plant hopper who have the same killing ability in dense prey populations, but predation is higher for *Pardosa* at low prey density. They further reported that under uncaged field environments (where more than just BPH prey are available) with a spider/BPH ratio 1:3 to 1:11, BPH mortality was 78-91% and within 15 days in permanent cages, spiders caused 100% BPH mortality at an average predator/ prey ratio of 1:5 to 1:14 whereas at a ratio of 1:18 or higher there was some BPH survival in cages.

According to Gunathilagaraj and Kumar (1997), the predatory wealth of the leaf folder was as high as 81 species and the relative order of their predominance is Coleoptera (25 species), Hymenoptera (12 species), Odonata (8 species), Hemiptera (7 species), Orthoptera (5 species) and Dermaptera (2 species).

## **2.2 STUDIES ON PHYSICAL, CHEMICAL COMPATIBILITY AND PHYTOTOXIC EFFECTS OF INSECTICIDES AND FUNGICIDES**

Kousika (2014) reported that chlorantraniliprole 4.3% + abamectin 1.7% SC with agrochemicals did not show any phytotoxic effects. Physical compatibility in terms of emulsion stability test revealed that chlorantraniliprole 4.3% + abamectin 1.7% SC (0.12%) with boron (0.5%), potassium nitrate (1%) and mancozeb (0.2%) in combination did not produce creamy matter or sediment at the top or bottom and there was no reduction in the efficacy of these insecticides and fungicides when used as tank mix.

Chlorantraniliprole @ 0.3 ml l<sup>-1</sup> in combination with hexaconazole @ 2 ml l<sup>-1</sup> (6.3% WE) gave less incidence (8.3%) and severity of sheath blight (12.8%) and also less stem borer (3.2) and lesser leaf folder damaged leaves per hill (1.9) followed by pymetrozine @ 0.5 g l<sup>-1</sup> + validamycin @ 2 ml l<sup>-1</sup> (9.6%, 15.0% and 1.2/hill, 12.5/hill white ears respectively) and did not show any phytotoxic effects in any combination as per the studies of Bhuvanewari and Krishnamraju (2013).

Kumar *et al.* (2011) stated that when nine combinations of four fungicides (isoprothiolane 40 EC, kitazin 48 EC, tricyclazole 75% WP and hexaconazole 5% EC) and four insecticides (indoxocarb 15% EC, cartap hydrochloride 50% SP, flubendamide 20% WG and fipronil 5% SC) were used against major pests and diseases of paddy, no combination has shown phytotoxic effects on rice plants showing perfect compatibility between insecticides and fungicides without any antagonistic effects

Flubendiamide + thiacloprid 480 SC @ 25 ml ha<sup>-1</sup>, 50 ml ha<sup>-1</sup> and 100 ml ha<sup>-1</sup> concentrations did not show any phytotoxic effects like injury to leaf tip and leaf surface, wilting, vein clearing, necrosis, epinasty and hyponasty in leaves, panicles and capsules on cardamom plants. Further, physical compatibility of flubendiamide + thiacloprid 480% SC with other agrochemicals in terms of emulsion stability test revealed that flubendiamide + thiacloprid 480% SC @ 25 ml/ha with diammonium phosphate (2%), quinalfos (0.05%) and copper oxychloride (0.25%) combinations did not produce creamy matter or sediment at the top or bottom of the 100 ml cylinder as reported by Kubendran *et al.* (2009). Combination of flubendiamide with fungicide, micro and macro nutrients did not inflict any phytotoxic effect on tomato (Kubendran *et al.*, 2008).

Sharma and Sood (2008) reported that when different combinations of fungicides *viz.*, tricyclazole 75% WP and iprobenphos 48% EC and insecticides *viz.*, indoxocarb 15% EC and cartap hydrochloride 50% SP used against blast and whorl maggot did not show any phytotoxic effects in any of the combinations.

Reddy and Muralidharan (2007) used Lustre 37.5% SE, a combination product of flusilazole (12.5%) and carbendazim (25%) to control sheath blight in rice and observed no phytotoxicity symptoms.

Flubendiamide 480 SC at 48 g a.i. ha<sup>-1</sup> is physically compatible which did not produce any creamy layer in combination with endosulfan, carbendazim, magnesium sulphate and urea under emulsion stability test and did not exhibit any phytotoxic symptoms on cotton when it was sprayed as tank mix to cotton plants as observed by Thilagam (2006).

Rajeswaran *et al.* (2004) stated that carbosulfan 25% EC @ 250 g a.i. ha<sup>-1</sup>, methyl-O-demeton 25% EC @ 250 g a.i. ha<sup>-1</sup>, carbendazim 50% WP @ 500 g a.i. ha<sup>-1</sup> and magnesium sulphate @ 5.0% alone and in combination maintained stability in emulsion stability test which shows their physical compatibility and further, there was no development of phytotoxic symptoms like injury to leaf surface and leaf tip, wilting, vein clearing, necrosis, epinasty and hyponasty by foliar application of carbosulfan (even at 1000 g a.i.ha<sup>-1</sup>) alone and in combination with methyl-O-demeton and magnesium sulphate..

Krishnaiah and Reddy (1992) stated that when different combinations of insecticides and fungicides used against brown planthopper and sheath blight of paddy, no phytotoxicity was observed in any of the combination used.

## **2.3 STUDIES ON BIOEFFICACY OF FOLIAR SPRAYS OF INSECTICIDES AND FUNGICIDES ALONE AND IN COMBINATION ON MAJOR INSECT PESTS AND DISEASES OF PADDY**

### **2.3.1 Bioefficacy of Insecticide and Fungicide Combinations**

Pal *et al.* (2013) reported that the combination product RIL-060/F, 8.5% WG containing 3.5% flubendamide + 5% hexaconazole was tested for its efficacy against sheath blight and stem borer of rice during *kharif*, 2010 and 2011. The combination product was found biologically as effective as individual treatments in controlling sheath blight and stem borer and increased the grain yield by 66.4% as compared to 35.3% in hexaconazole and 46.7% in flubendamide treated plots.

Prasad and Gupta (2012) stated that insecticidal and fungicidal treatments alone were effective against stem borer and leaf blast, respectively, whereas the combination treatments were effective against both stem borer and leaf blast. The combination of flubendiamide 20% WDG @ 0.25 g l<sup>-1</sup> + isoprothiolane @ 1.5 ml l<sup>-1</sup> was most effective against both stem borer and leaf blast with 2.54 and 3.50 per cent infestation, respectively and fetched average grain yield of 23.53 q ha<sup>-1</sup>. It was closely followed by flubendiamide 20% WDG @ 0.25 g l<sup>-1</sup> + carpropamid @ 1.0 ml l<sup>-1</sup> with 2.35% stem borer infestation, 4.03% leaf blast disease severity with 22.5 q ha<sup>-1</sup> grain yield.

Biswas (2012) stated that flubendiamide 3.5% and hexaconazole 5% @ 2 g lit<sup>-1</sup> combination effectively reduced sheath blight severity of 24.4% and stem borer damage (white ears 2.5%) and hexaconazole 5% @ 2 g lit<sup>-1</sup> alone showed sheath blight severity of 20.5% and stem borer damage (white ears 3.3%) in *khariif*, 2010. Hence combining hexaconazole with flubendiamide did not inhibit the biological activity of hexaconazole against sheath blight disease and the effectiveness of flubendiamide against stem borer.

Kumar *et al.* (2011) stated that the combination of flubendiamide + hexaconazole @ 85 g a.i. ha<sup>-1</sup> was effective against all infestations which recorded 16.1% sheath blight incidence, 0.9% dead hearts and 0.4% white ears due to stem borer infestation, 2.9% damage due to leaf folder infestation in *khariif*, 2009 followed by tricyclozole + fipronil and kitazine + indoxacarb. Effect of these combination treatments was equal to the effect of fungicide and insecticide when sprayed alone at the same dosage.

Singh *et al.* (2011) reported that tank mix application of fungicides (tricyclazole and isoprothiolane) with insecticides (fipronil and flubendiamide) was found biologically as effective as individual treatments in controlling leaf blast and leaf folder incidence. Tricyclazole + flubendiamide showed 17.7% blast disease incidence followed by tricyclazole + fipronil with 18.8% blast incidence when compared to tricyclazole alone with 20% blast incidence. Similarly for leaf folder tricyclazole + fipronil showed 0.7% damage followed by isoprothiolane + fipronil with 0.8% leaf damage when compared to fipronil alone with 1.5% leaf infestation.

Sharma and Srivasthava (2010) observed that combination treatment of flubendiamide @ 0.25 g l<sup>-1</sup> and isoprothilane @ 1.5 ml l<sup>-1</sup> was effective against whorl maggot and blast disease. The efficacy of flubendiamide to whorl maggot and isoprothilane to leaf blast in combination was not affected, which proved their compatibility and safer usage as combinations for the control of rice pests.

Siddegowda (2009) reported that Virtako 40% WG, a combination of chlorantraniliprole + thiomethoxam @ 60 g a.i. ha<sup>-1</sup> recorded lowest leaf infestation of 5.12, 7.43 and 11.01% on 10, 20 and 30 days after spraying respectively when compared to individual chemicals viz., chlorantraniliprole 25% EC @ 30 g a.i. ha<sup>-1</sup> and thiomethoxam 25% WG @ 30 g a.i. ha<sup>-1</sup> with leaf infestation of 5.01%, 8.42%, 12.73% and 25.97%, 17.86% and 19.98% on 10, 20 and 30 days after spraying respectively.

Prasad *et al.* (2009) stated that the combination of imidacloprid 200% SL @ 0.25 ml l<sup>-1</sup> + propiconazole 25% EC @ 1.0 ml l<sup>-1</sup> were most effective against both stem borer and leaf blast with 5.0 and 6.8% infestation, respectively and fetched average grain yield of 21.47 q ha<sup>-1</sup> followed by imidacloprid 200 SL @ 2.5 ml l<sup>-1</sup> + validamycin 3% SL @ 2.5 ml l<sup>-1</sup> with 5.5% stem borer infestation, 6.7% leaf blast severity and 21.47 q ha<sup>-1</sup> grain yield.

Chandar and Palta (2008) conducted experiment at Indian Agricultural Research Institute, New Delhi to know the field efficacy of insecticides against rice leaf folder. They reported that insecticide granules and foliar applications with sole compounds and combination products had showed significantly less incidence of the leaf folder and the best treatments were thiomethoxam +  $\lambda$ -cyhalothrin, spinosyn and deltamethrin with 3.6, 4.0 and 5.0% folded leaves respectively.

Sharma and Sood (2008) evaluated two fungicides viz., tricyclazole 75% WP @ 0.06% and iprobenphos 48% EC @ 0.2% and two insecticides indoxcarb 15% EC @ 0.006% and cartap hydrochloride @ 0.008% as separate treatments and in combination as a tank mix against blast and whorl maggot. They reported that tank mixing of fungicides with insecticides did not reduce the efficacy of fungicides against blast and that of insecticides against whorl maggot.

Vasanthabhanu *et al.* (2007) reported that the combination of imidacloprid + validamycin has recorded the lowest number of planthopper population, lowest per cent disease index (sheath blight) *i.e.*, 36.5 per 20 hills and 18.3% at 85 and 70 DAT, respectively in *kharif*, 2005, 85.3 and 31.9% at 70 and 80 DAT, respectively in *kharif*, 2006 followed by thiomethoxam + validamycin which recorded 33.5 per 20 hills of planthopper population at 85 DAT and 29.1% disease index at 70 DAT in *kharif*, 2005, 73 per 20 hills of planthopper population and 32.5% disease index at 80 DAT in *kharif*, 2006.

Reddy and Muralidharan (2007) reported that Lusture (37.5% S.E) @ 240 g a.i. ha<sup>-1</sup>, a combination product of flusilazole (12.5%) and carbendazim (25%) showed a high degree of compatibility with sheath blight severity of 8% when compared with individual treatments *viz.*, flusilazole 40% EC @ 80 g a.i ha<sup>-1</sup> and carbendazim 50% WP @ 160 g a.i. ha<sup>-1</sup> with sheath blight severity of 21.7% and 15.0%, respectively.

Roshanlal (2007) revealed that phosphamidon 40% SL @1250 ml in combination with carbendazim 50% WP was most effective in management of rice yellow stem borer with 6.63 per cent dead hearts compared to individual treatment phosphamidon with 11.24 per cent dead hearts and untreated check with 16.40 per cent dead hearts.

Varadarsan *et al.* (2006) reported that the combination of lamdacyhalothrin 0.025% + copper oxychloride 0.25%; monocrotophos 0.075% + copper oxychloride 0.25%; chloropyrifos 0.04% + copper oxychloride 0.25%; quinolfos 0.05% + copper oxychloride 0.25% and monocrotophos 0.075% + copper oxychloride 0.25% recorded 4.34 per cent thrips damage on capsule, 114.82 per cent shoot borer damage 0.0041 per cent capsule borer damage, 0.0041 per cent clump rot damage and 1.58 per cent leaf blotch incidence after 3<sup>rd</sup> spray, respectively in cardamom.

Rajeswaran *et al.* (2005) stated that carbosulfan 25% EC @ 250 g a.i. ha<sup>-1</sup> exhibited high degree of compatibility with methyl-O-demeton 25% EC @ 250 g a.i. ha<sup>-1</sup>, carbendazim 50% WP @ 500 g a.i. ha<sup>-1</sup> and magnesium sulphate 5.0% and also that spraying of carbosulfan recorded 3.66 aphid population and 0.66

thrips population per 30 leaves. The combinations carbosulfan + methyl-O-demeton; carbosulfan + carbendazim and carbosulfan + magnesium sulphate recorded 1.46, 4.33, 7.00 aphid population and 0.33, 1.00, 1.67 thrips population per 30 leaves, respectively.

The combination of cartap hydrochloride 0.05% + tricyclozole 0.04% and cartap hydrochloride 0.05% + carbendazim 0.05% recorded the minimum percentage of leaf folder damage *i.e.*, 2.7, 3.4 per cent and 3.2, 4.5 per cent compared to 22.5 and 22.4 per cent leaf folder damage in untreated control at 35 and 45 (DAT), respectively and also the combination of cartap hydrochloride 0.05% + tricyclozole 0.04% recorded minimum incidence of neck blast disease *i.e.*, 0.7 as compared to 3.8 in untreated control as reported by Bhatnagar (2004).

Reddy and Krishnaiah (2003) reported that imidacloprid, silafluofen alone and in combination with fungicides hexaconazole, thifluzamide, epoxyconazole recorded 100 per cent mortality of brown plant hopper nymphs at one and four days after treatment and also opined that prophylactic spray was better than the curative spray in checking the sheath blight incidence with the combination of thifluzamide 0.002% + imidacloprid 0.005% and thifluzamide 0.002% + silofluofen 0.02% recorded 1.5 and 1.8 per cent disease incidence, respectively.

Combination of hexaconazole + monocrotophos (500 ml + 500 ml) in grapes was significantly superior against powdery mildew incidence, thrips and flea beetle damage which recorded 15.00, 4.20 and 20.85 per cent damage, respectively and there was no development of phytotoxic symptoms by spraying hexaconazole alone and in combination with monocrotophos and carbendazim as per the reports of Varalakshmi *et al.* (2000).

Rao *et al.* (1999) reported that acephate 75% SP (Starthene) in combination with hexaconazole 5% EC (Contaf) was highly effective against leaf folder (3.52% damaged leaves) and sheathblight with disease incidence (9.94%) followed by acephate 75% SP + propiconazole 25% EC (Tilt) against leaf folder with (4.35 damaged leaves) and sheath blight with disease incidence (16.08 %) and recorded highest grain yield of 4913 kg ha<sup>-1</sup> as against 3841 kg ha<sup>-1</sup> recorded in untreated control.

Reddy *et al.* (1999) reported that application of Beam @ 0.6 g l<sup>-1</sup> controlled neck blast and recorded 3.73% incidence followed by 11.23 and 11.83 per cent in beam + indofil M-45 @ 0.5+ 1.5 g l<sup>-1</sup> and ediphenphos @ 1.25 g l<sup>-1</sup>, respectively. Highest yield of 7500 kg ha<sup>-1</sup> was noticed in beam @ 0.6 g l<sup>-1</sup>, an increase in yield of 63 per cent over check.

Combinations (189) of fungicide ziram with insecticide phosphamidon, herbicide propanil and macronutrient urea showed biological compatibility and also exhibited synergistic effect when tested against *Helminthosporium oryzae* under *in vitro* conditions as reported by Lal and Pandey (1995).

Krishnaiah and Reddy (1992) stated that the combination of monocrotophos 0.05% + IBP 0.048%, carbaryl 0.05% + IBP 0.048%, ethofenprox 0.01% + carbendazim 0.05%, ethofenprox 0.01% + thiophanate-methyl 0.07% and ethofenprox 0.01% + IBP 0.048% recorded 100% mortality of brown planthopper three days after spray and also the combination of monocrotophos 0.05% + carbendazim 0.05%, carbaryl 0.05% + carbendazim 0.05% and ethofenprox 0.01% + carbendazim 0.05% recorded zero per cent sheath blight disease index.

### **2.3.2 Bioefficacy of Individual Insecticides and Fungicides**

Abro *et al.* (2013) reported that cartap hydrochloride 4G was the most effective insecticide with minimum per cent infestation (4.37% DH) followed by carbofuran 3 G (7.08% DH), fipronil 4.95% EC (8.68% dead hearts) and control (38.53% DH).

Nativo 75% WG, tricyclazole 75% WP and difenconazole 250% EC were proved effective in management of rice blast disease with 10.15%, 12.85% and 11.46% disease incidence, respectively. However, control of neck blast by the fungicides followed the order difenconazole 250% EC, propiconazole 250% EC and Nativo 75% WG with 11.63%, 14.29% and 18.98, respectively as reported by Dutta *et al.* (2012).

Satapathy and Mukherjee (2012) reported that cartap hydrochloride 50% SP @ 1 kg a.i. ha<sup>-1</sup> was the best in reducing stem borer incidence with 1.79 per cent dead hearts and 1.89 per cent white earheads over other treatments and untreated check with 4.46 per cent dead hearts and 6.94 per cent white earheads.

Chlorantraniliprole @ 40 g a.i ha<sup>-1</sup> provided an effective control of stem borers (1.62% dead hearts and 2.00% white ears) and leaf folder (3.40%) and was statistically on a par with chlorpyrifos 20% EC in controlling stem borer (1.61% dead hearts and 2.00% white ears) and leaf folder (3.27) as reported by Suri (2011).

Dhawan *et al.* (2010) evaluated thiocyclam hydrogen oxalate 4 G @ 300, 400 and 500 g a.i. ha<sup>-1</sup> and compared with cartap hydrochloride @ 1000 g and fipronil @ 45 g a.i. ha<sup>-1</sup> against leaf folder and reported that thiocyclam @ 300 g a.i. ha<sup>-1</sup> with 9.95% damaged leaves was on a par with cartap hydrochloride @ 1000 g and fipronil @ 45 g a.i. ha<sup>-1</sup> with 7.72 and 8.92% damaged leaves, respectively.

Singh *et al.* (2009) found that chlorantraniliprole 20% SC @ 100 a.i ha<sup>-1</sup> was best treatment with significantly low cane sett damage with minimum infestation of 1.1% against early shoot borer and was on par with fipronil 0.3 G @ 25 kg ha<sup>-1</sup> and chlorpyrifos 20% EC @ 3.5 l ha<sup>-1</sup> with 2.2 and 6.6% infestation, respectively.

Three field experiments conducted by Karthikeyan *et al.* (2008) during *kharif* 2003, *rabi* 2003 and *rabi* 2004 in Kerala revealed that phosphamidon 10 G @ 1000 g a.i. ha<sup>-1</sup> was significantly superior with 10.9% dead hearts over imidacloprid 350% SC @ 25 g a.i. ha<sup>-1</sup> with 14.9% dead hearts and was on a par with monocrotophos 36% SC @ 500 g a.i. ha<sup>-1</sup> with 12.6% dead hearts.

Nalini *et al.* (2008) reported that cartap hydrochloride 50% SP and spinosad 2.5% EC caused 96.27 and 95.63 per cent larval mortality of *Marasmia exigua* (Butler) and are highly effective than other new test insecticides *viz.*, emamectin benzoate 5% SG @ 12.5 g a.i. ha<sup>-1</sup>, indoxacarb 14.5 SC @ 72.5 g a.i. ha<sup>-1</sup>, acetamiprid 20% SP @ 50 g a.i. ha<sup>-1</sup>, lufenuron 5.4% EC @ 30 g a.i. ha<sup>-1</sup> and monocrotophos 36% SL @ 315 g a.i. ha<sup>-1</sup> with 91.66, 90.95, 62.17, 60.39, 58.80% larval mortality, respectively.

Sarao *et al.* (2006) reported that among granular insecticides evaluated against leaf folder, fipronil @ 0.045 with 8.84 per cent leaf folder damage and chlorpyrifos @ 1.0 kg a.i ha<sup>-1</sup> with 12.10 per cent leaf folder damage effectively controlled leaf folder and was at par with cartap hydrochloride @ 1.0 kg a.i. ha<sup>-1</sup> with 9.82 per cent leaf folder damage.

Sahithi and Misra (2006) reported that cartap hydrochloride 50% SP @ 500 g a.i. ha<sup>-1</sup> at 20 and 41 days after planting gave superior control of yellow stem borer (2.5% dead hearts) with highest grain yield of 3.8 t ha<sup>-1</sup> compared to control (14.5 dead hearts and 2.3 t ha<sup>-1</sup>) whereas phosphamidon 40% DL and triazophos 40% EC gave optimum control of stem borer with 2.7% and 2.6% dead hearts and grain yield of 3.2 t ha<sup>-1</sup> and 3.1 t ha<sup>-1</sup>, respectively.

Prajapathi *et al.* (2004) reported that tricyclazole (@ 0.0045%) with leaf blast (1.65%) and neck blast (17.28 %) was significantly superior over other chemicals tested *viz.*, carbendazim (@ 0.05%), bitertinol (@ 0.025), propiconazole (@ 0.025%) and cyproconazole (@ 0.1%) with leaf blast (2.43, 2.65, 3.38 and 3.47) and neck blast (38.42, 45.30, 56.52 and 64.31), respectively.

Bhat and Anwar (2004) reported that among the test fungicides against blast and sheath blight disease, tricyclazole 75% WP @ 0.06% with 15.60% disease severity proved to be more effective against blast compared to check (54.38% disease severity) whereas hexaconazole 5% EC (24.27% disease severity) was effective against sheath blight followed by carbendazim 50% WP @ 1% with 26.59% disease severity.

Tirmali *et al.* (2001) reported that tricyclazole 75% WP was very effective in controlling neck blast with 37.6% neck blast severity compared to other test fungicides *viz.*, carpropamid 300% SC, tebuconazole 250% EW and epo-carb 250% EC with 44.6, 41.9 and 40.3 neck blast severity, respectively.

Verma and Gupta (2001) revealed that chlorpyrifos 20% EC @ 250 ml a.i. ha<sup>-1</sup> was effective against rice leaf folder with 80.0 per cent population reduction over untreated control.

Srinivas (2001) inferred that chlorpyrifos 10 G @ 10 kg a.i. ha<sup>-1</sup> was effective against rice leaf folder with 5.68 per cent leaf damage while the untreated check recorded 10.00 per cent damaged leaves. Seetharamu (2003)

concluded that chlorpyrifos 20 EC @ 2.5 ml l<sup>-1</sup> was effective against rice leaf folder with 66.96 per cent reduction of population and was superior to ethofenprox 10% EC (50.85%) and fipronil 0.4 G (50.73%).

Sontakke and Dash (2000) reported that chlorpyrifos 15 G @ 1.50 g a.i. ha<sup>-1</sup>, quinolphos 5 G @ 1 g a.i. ha<sup>-1</sup> and fipronil 0.3 G were effective against leaf folder with 10.61, 11.32 and 10.81 per cent leaf damage, respectively while the untreated check recorded 28.95 per cent damaged leaves.

Panda *et al.* (1999) stated that chlorpyrifos @ 0.5 kg a.i. ha<sup>-1</sup> was effective against rice leaf folder with 2.8 and 8.7 per cent damaged leaves at 37 and 59 DAT, respectively whereas Singh and Singh, (1999) reported that chlorpyrifos and profenophos were effective against rice leaf folder incidence with 2.86 and 3.01 per cent leaf damage at 50 DAT and 4.64 and 4.76 at 70 DAT, respectively.

Chlorpyrifos 20% EC and profenophos 50% EC @ 500 g a.i. ha<sup>-1</sup> were the most effective treatments in reducing the leaf folder damage and increased grain yield over control by 32.3% and 46.9%, respectively as per the reports of Singh and Singh (1999).

Ambetgar (1996) reported that chlorpyrifos @ 0.5 kg a.i. ha<sup>-1</sup> was most effective against rice leaf folder with 11.1 and 10.08 mean per cent leaf damage after two sprayings at 25 and 32 days, respectively whereas Kumar *et al.* (1998) inferred that chlorpyrifos @ 1250 and 1000 g a.i. ha<sup>-1</sup> was most effective against rice stem borer and leaf folder.

Chlorpyrifos @ 0.5 kg a.i. ha<sup>-1</sup> was found effective against rice leaf folder with 8.0 and 7.2 per cent damaged leaves during *kharif* and *rabi* of 1988 and 1989, respectively as reported by Rajendran (1993). However, Wang *et al.* (1995) reported that chlorpyrifos @ 450 g a.i. ha<sup>-1</sup> and chlorpyrifos @ 450-600 ml recorded 90% control of the rice leaf folder at the egg hatching stage.

Chlorpyrifos 20% EC @ 0.5 kg a.i. ha<sup>-1</sup> was found to be effective against leaf folder damage with 1.99 and 7.62 per cent leaf damage at 15 and 30 days after treatment respectively (Anirudh *et al.*, 1991). Naik *et al.* (1993) elucidated that chlorpyrifos @ 0.5 kg ha<sup>-1</sup> recorded 96.7 per cent mortality of leaf folder larvae under laboratory conditions.

Mangalsain *et al.* (1987) revealed that chlorpyrifos was the most effective insecticide against rice leaf folder (16.6 damaged leaves per 10 hills) at 65 DAT followed by monocrotophos (18.6 damaged leaves per 10 hills).

Chlorpyrifos 20% EC @ 0.5 kg a.i. ha<sup>-1</sup> was most effective as foliar spray against leaf folder with 2.00 and 2.16 per cent leaf damage in two consecutive years as per the reports of Garg (1985).

## Chapter V

# SUMMARY AND CONCLUSIONS

The results pertaining to the present study “**COMPATIBILITY OF RECOMMENDED INSECTICIDES AND FUNGICIDES FOR THE MANAGEMENT OF MAJOR INSECT PESTS AND DISEASES OF PADDY**” are summarized in this chapter.

A bulk plot of 200 m<sup>2</sup> with rice variety, *Samba mashuri* (BPT-5204) was maintained without any insecticidal application and the insect counts from light trap were also recorded to study the incidence of insect pests of paddy. Weather parameters *viz.*, maximum temperature, minimum temperature, morning and evening relative humidity and rain fall were also recorded simultaneously to know their influence on incidence of insect pests and diseases.

Under field conditions in a bulk plot, paddy leaf folder, leaf blast disease and natural enemies like spiders, dragonfly and damselfly were observed. The insect pests like leaf folder adults, green leafhoppers and brown planthoppers were observed in the light trap catches.

The incidence of leaf folder infestation started initially during 39<sup>th</sup> standard week with 12.95 per cent leaf folder infestation and attained peak during 48<sup>th</sup> standard week with 18.31 per cent leaf folder infestation per 50 hills. Later, again infestation got declined and there was no infestation from 50<sup>th</sup> standard week till the end of crop season. There was no significant correlation was existed between leaf folder infestation and weather parameters tested.

The leaf blast incidence started initially during 43<sup>rd</sup> standard week with 1.55 per cent severity that gradually increased and reached a peak during 48<sup>th</sup> standard week with 14.66 per cent severity per 50 hills. Later, the incidence got declined gradually and reached minimum during 51<sup>st</sup> standard week with 2.55 per cent severity per 50 hills.

The correlation between the leaf folder infestation and all the weather parameters tested was non-significant. But, a significant and negative correlation existed between blast severity and maximum temperature ( $r = -0.561$ ), minimum temperature ( $r = -0.632$ ) and a significant and positive correlation with mean relative humidity ( $r = 0.672$ ) and blast incidence. However, the correlation with other parameters tested was non-significant.

Brown plant hopper catches in light trap started appearing from 25<sup>th</sup> October (15.00) and gradually increased and attained peak during 9<sup>th</sup> November (5400) thereafter, the catches gradually decreased by 24<sup>th</sup> November (156.33) and once again the population increased gradually and attained 2<sup>nd</sup> peak during 3<sup>rd</sup> December (2145) and finally, the population decreased towards the end of crop season. The correlation between trap population and all weather parameters tested was non-significant.

Green leafhopper catches in light trap started appearing from 31<sup>st</sup> October (11.33) and gradually increased and attained peak during 15<sup>th</sup> November (2328.67) thereafter, the population gradually decreased by 27<sup>th</sup> November (224.67) and once again the population increased gradually and attained 2<sup>nd</sup> peak during 15<sup>th</sup> December (4731.33) and finally, the population decreased towards the end of crop season. A significant and positive correlation existed between green leafhopper catches and morning relative humidity (0.478) and evening relative humidity (0.465) whereas the correlation was non-significant with other weather parameters.

The leaf folder adult catches in light trap started appearing from 6<sup>th</sup> November (1.33) and gradually increased and attained peak at 12<sup>th</sup> December (20) and decreased towards the end of crop season. A significant and positive correlation existed between the leaf folder adult catches and morning relative humidity (0.486) whereas the correlation was non-significant with maximum temperature (-0.354), minimum temperature ( $r = -0.186$ ), rainfall (-0.254) and evening relative humidity (0.268).

Physical compatibility of the insecticide and fungicide combinations under lab conditions was tested by following emulsion stability test and specific gravity test and the results obtained indicated that all the insecticides, fungicides alone and in combination were compatible irrespective of the type of water used (normal tap water, distilled water and standard hard water) as there was no sedimentation at the bottom and creamy layer at the top of the measuring cylinder with no much variation in their specific gravity values.

The parameters pertaining to chemical compatibility like pH and EC of the insecticides, fungicides alone and in combinations were measured in which no much difference in the values of pH, EC were observed when the insecticides and fungicides were combined indicating that the insecticides and fungicides in combination are compatible chemically.

The pot culture experiments conducted under green house conditions for assessing the phytotoxicity of the insecticides and fungicides alone and in combination implied that they are non-phytotoxic when sprayed alone or in combination both at recommended and double the recommended dose as they could not produce any phytotoxic symptoms. Though, slight injury to leaf was observed at higher concentrations, the per cent injury was less than one which inferred them non phytotoxic as per the scale.

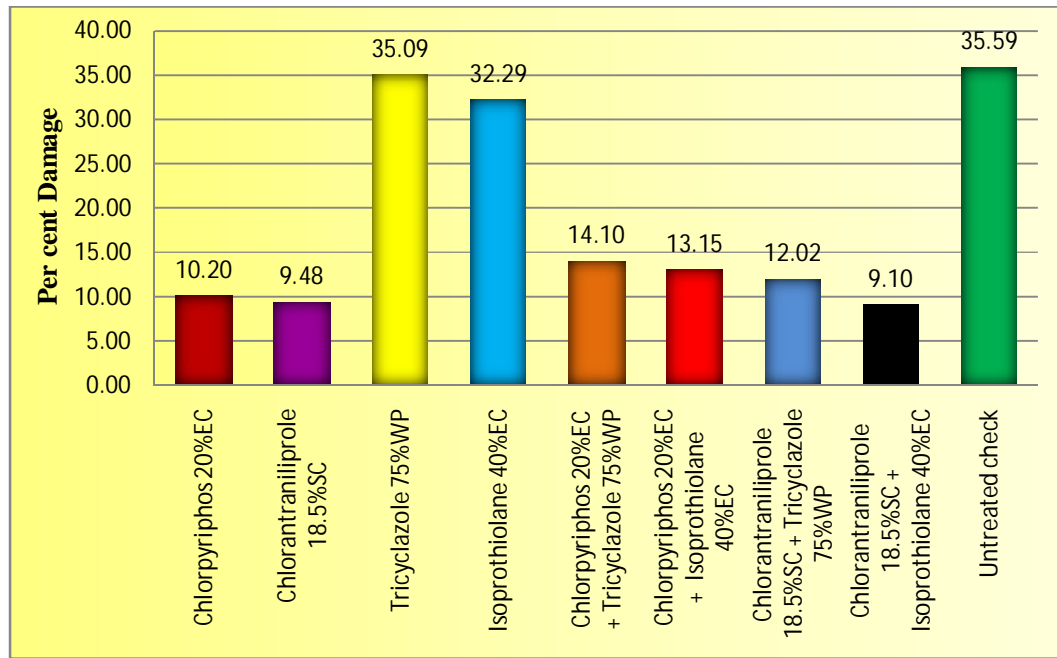
A field experiment with BPT-5204 variety was conducted to evaluate the field efficacy of foliar sprays of insecticides, fungicides alone and in combination against the major insect pests and diseases of rice at college farm, Agricultural college, Bapatla during *kharif*, 2014. Leaf folder and leaf blast, were observed during the crop season. Two insecticidal treatments (chlorantraniliprole @ 0.3 ml l<sup>-1</sup> and chlorpyrifos @ 2.5 ml l<sup>-1</sup>) and two fungicidal treatments (tricyclazole @ 0.6 g l<sup>-1</sup> and isoprothiolane @ 1.5 ml l<sup>-1</sup>) with an untreated control were replicated thrice in a simple randomized block design. Treatments were imposed at 30 days interval starting from 35 days after transplanting as the leaf blast and leaf folder reached the ETL. Observations were taken on the day before spraying and on 5<sup>th</sup>, 10<sup>th</sup> and 15<sup>th</sup> day for leaf folder and on 10<sup>th</sup>, 20<sup>th</sup> and 30<sup>th</sup> after spraying for leaf blast, from 20 hills selected at random in each plot.

All the insecticide and fungicide treatments alone and in combination were found superior over untreated check. Amongst them, chlorantraniliprole + isoprothiolane ( $0.3 \text{ ml l}^{-1} + 1.5 \text{ ml l}^{-1}$ ) was the most effective treatment to control leaf folder infestation with 83.04 per cent leaf damage reduction over control and tricyclazole ( $0.6 \text{ g l}^{-1}$ ) was superior in reducing leaf blast severity with 74.13 per cent disease reduction over control.

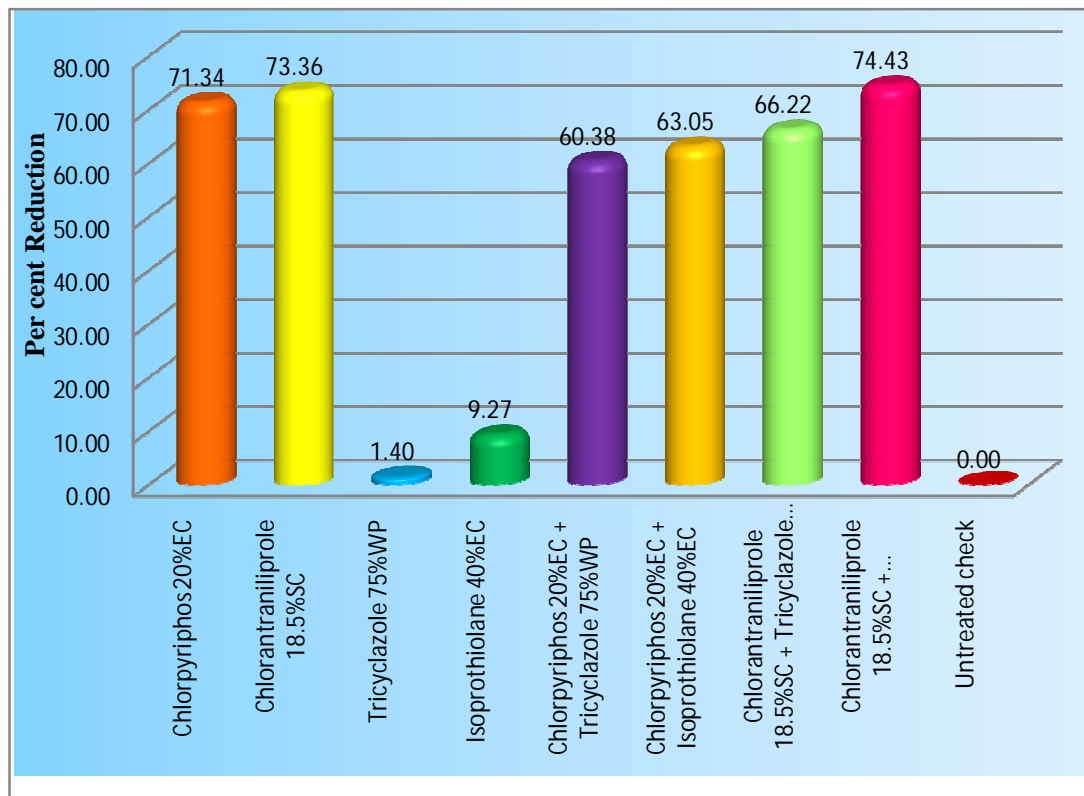
## CONCLUSIONS

- The correlation between weather factors, brown plant hopper catches and leaf folder infestation under field conditions was non-significant.
- The green leaf hopper catches in light trap were maximum during 2<sup>nd</sup> fortnight of November to 2<sup>nd</sup> fortnight of December. A significant and positive correlation existed between green leafhopper trap catches and relative humidity (both morning and evening) and the correlation was non-significant with other weather parameters.
- The leaf folder adult catches were peak during 1<sup>st</sup> fortnight of December. The adult catches had a non-significant correlation with maximum temperature, minimum temperature and rainfall and a significant and positive correlation with morning relative humidity.
- Leaf blast severity attained peak during 48<sup>th</sup> standard week (November 26<sup>th</sup> -2<sup>nd</sup> December) and had a significant and negative correlation with maximum and minimum temperature whereas the correlation was significant and positive with morning relative humidity.
- All the insecticides and fungicides are physically and chemically compatible as there was no formation of sediment at the bottom and the creamy layer at the top in distilled water, tap water and hard water with no much variation in specific gravity, pH and EC values.

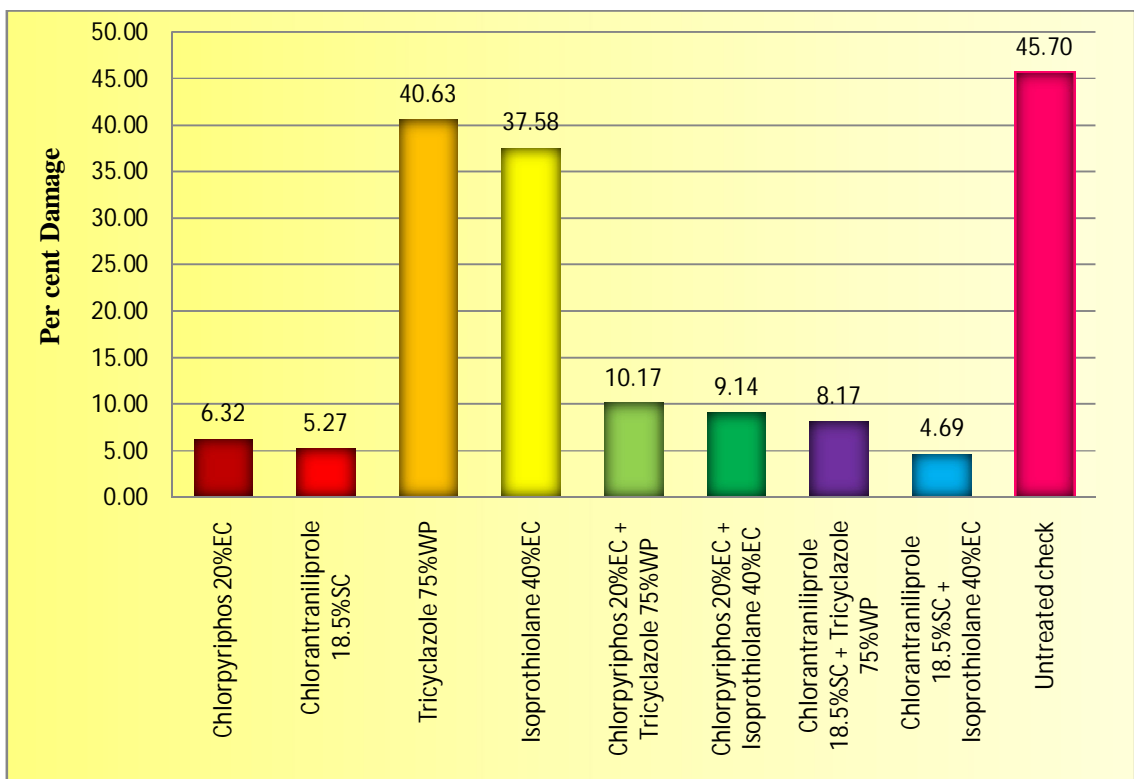
- Phytotoxicity was not observed when insecticides and fungicides tested were mixed and applied to potted plants at both recommended and higher dose (double).
- The efficacy of insecticides was not reduced when mixed with fungicides against insect pest suppression and *vice-versa* illustrating a perfect compatibility physically, chemically and biologically between the test insecticides and fungicides.



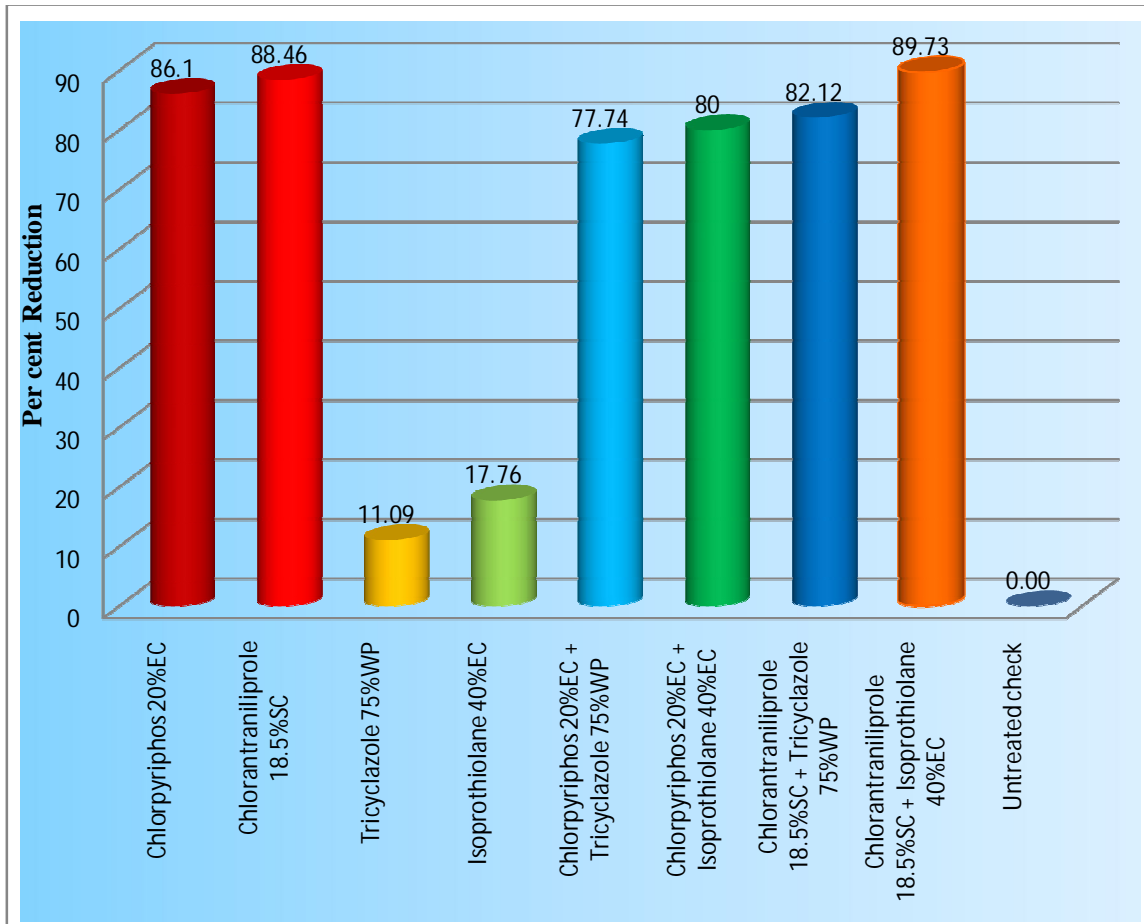
**Fig. 4.2 Efficacy of treatments (mean) after first spray against rice leaf folder *Cnaphalocrossis medinalis* L.**



**Fig. 4.3 Mean per cent reduction of leaf folder infestation over control after first spray**



**Fig.4.4** Efficacy of treatments (mean) after second spray against rice leaf folder *Cnaphalocrosis medinalis* L



**Fig. 4.5 Mean per cent reduction of leaf folder infestation over control after second spray**

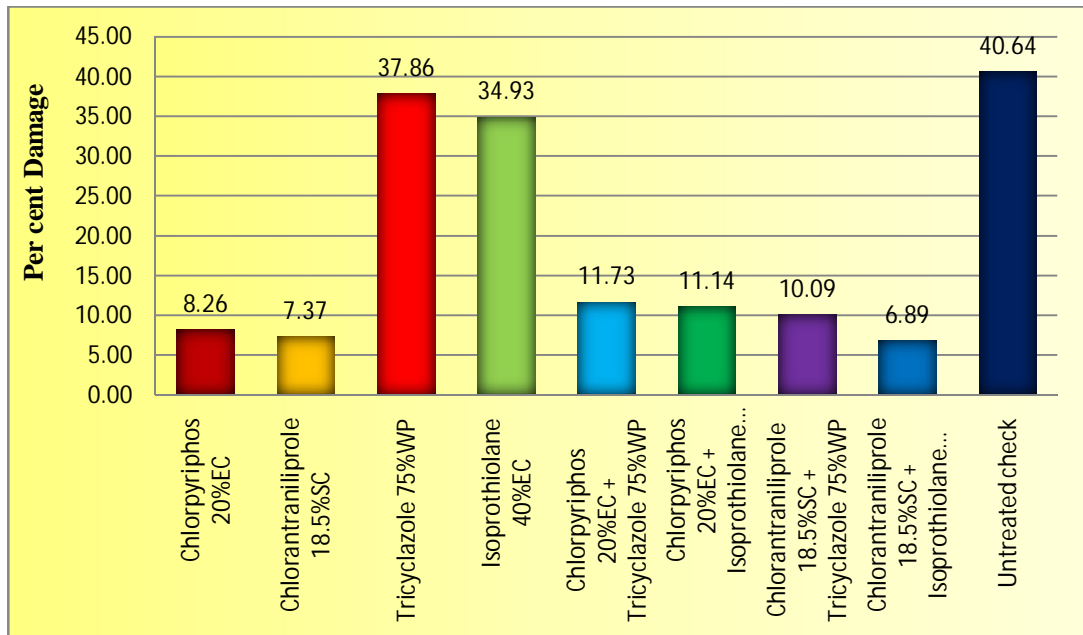


Fig. 4.6 Efficacy of treatments (cumulative mean) against rice leaf folder *Cnaphalocrosis medinalis* L.

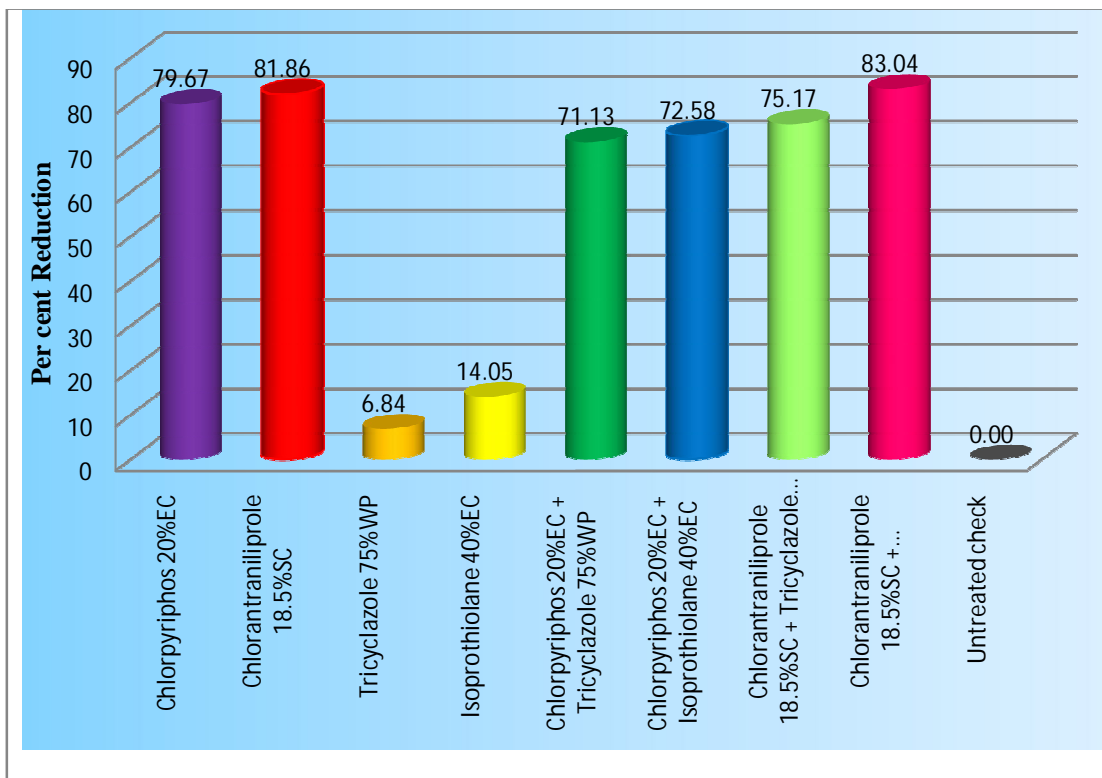


Fig. 4.7 Per cent reduction (cumulative mean) of leaf folder infestation over control

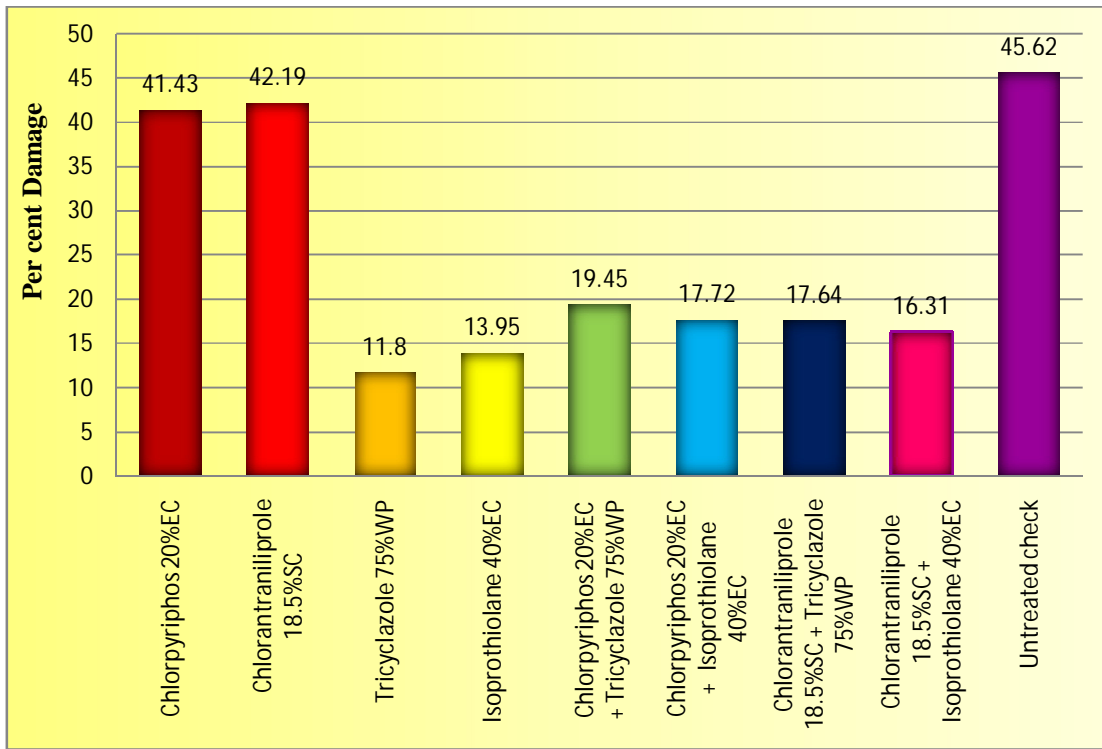


Fig. 4.8 Efficacy of treatments (mean) against rice leaf blast, *Pycularia oryzae*

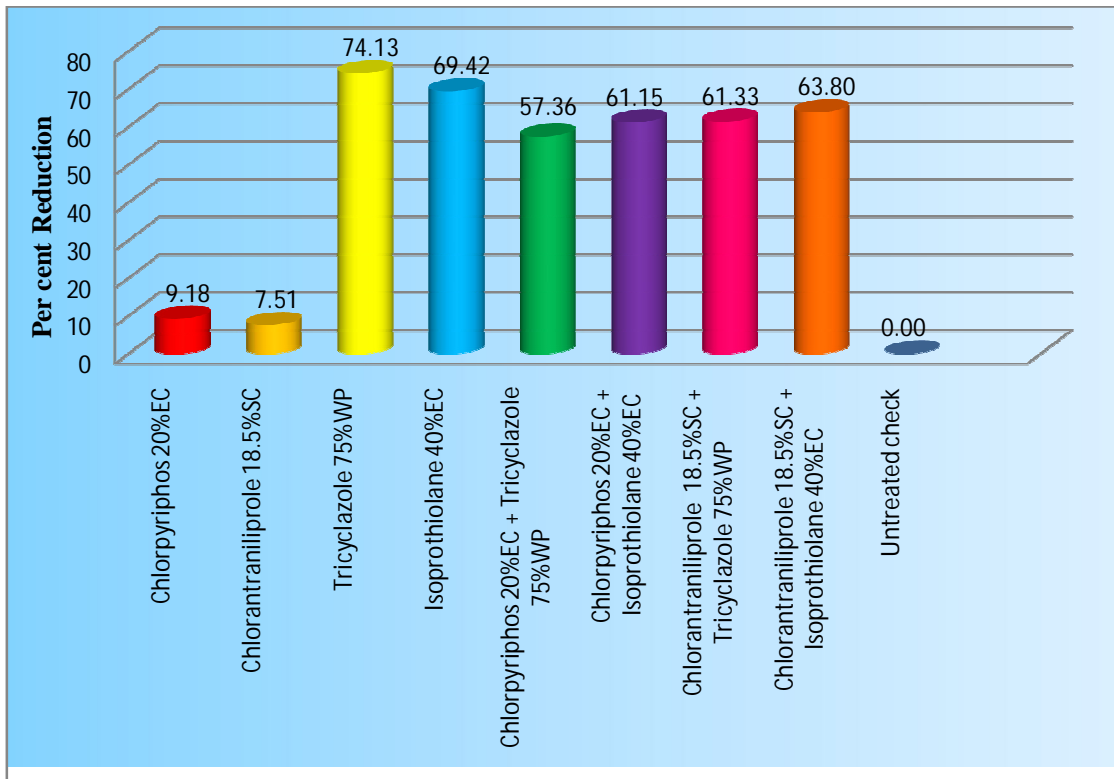
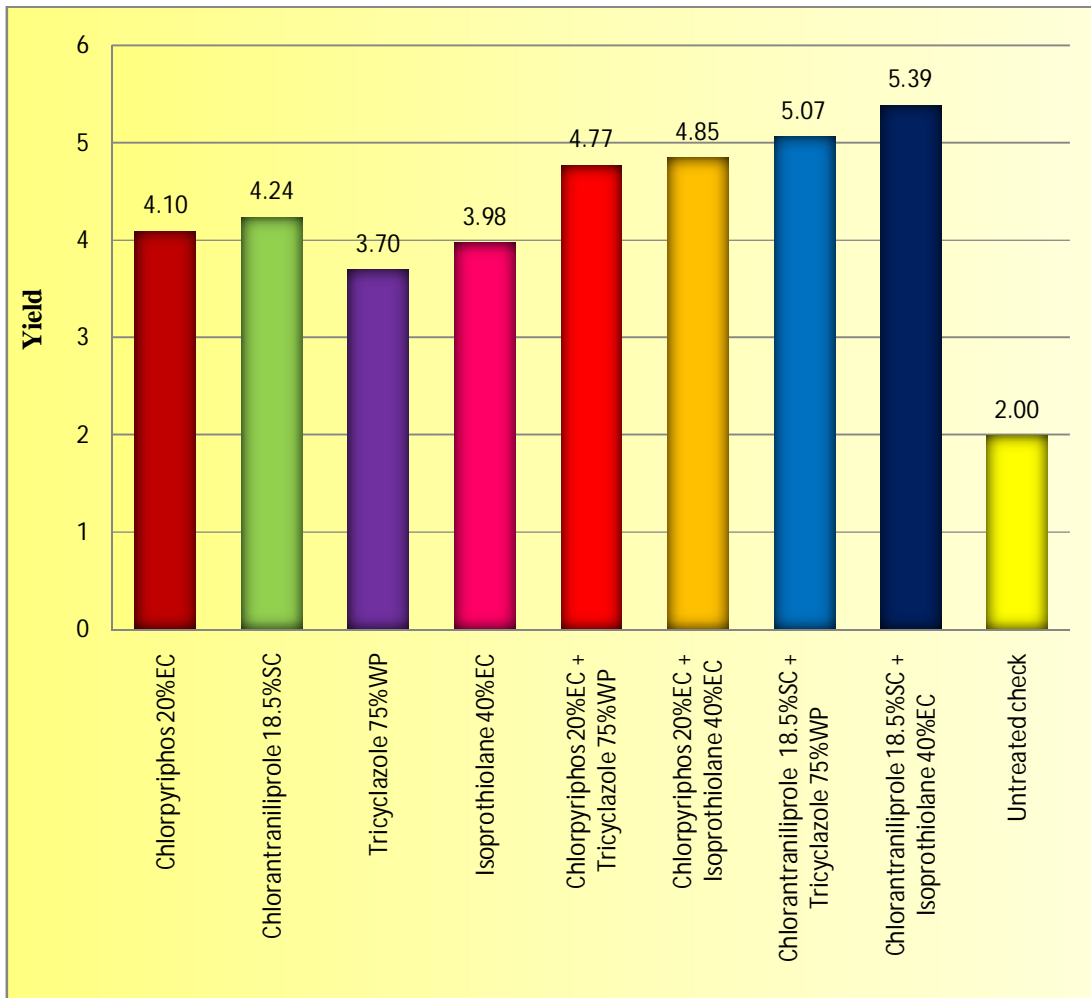
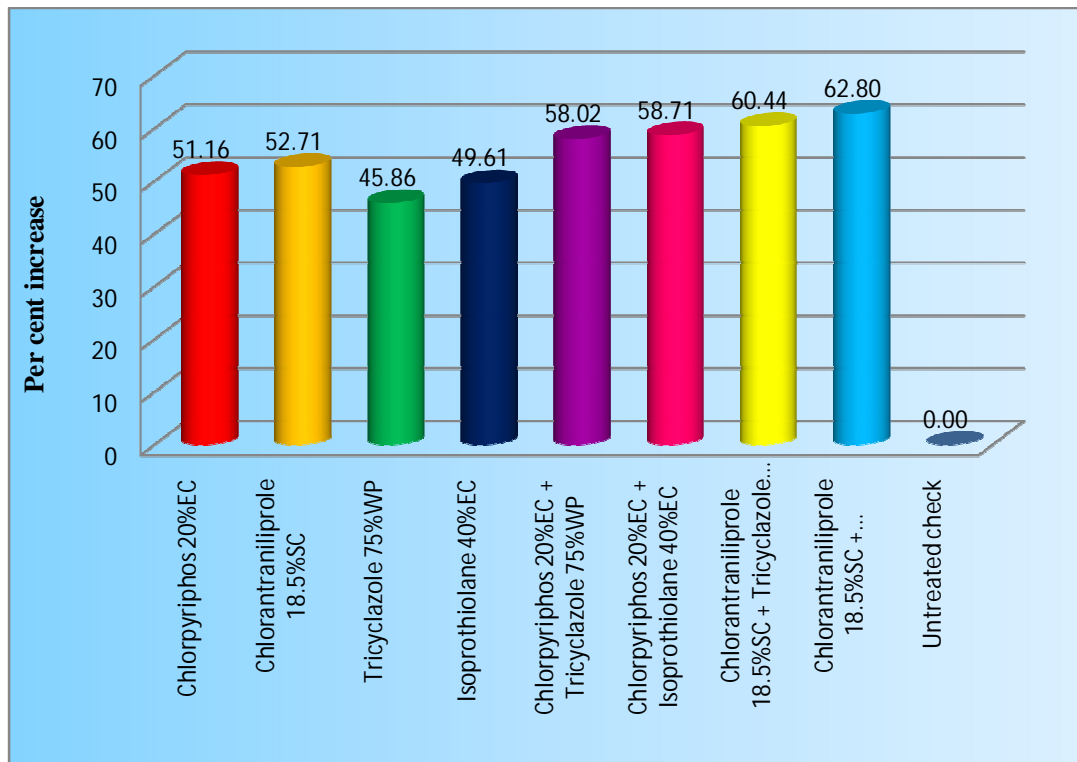


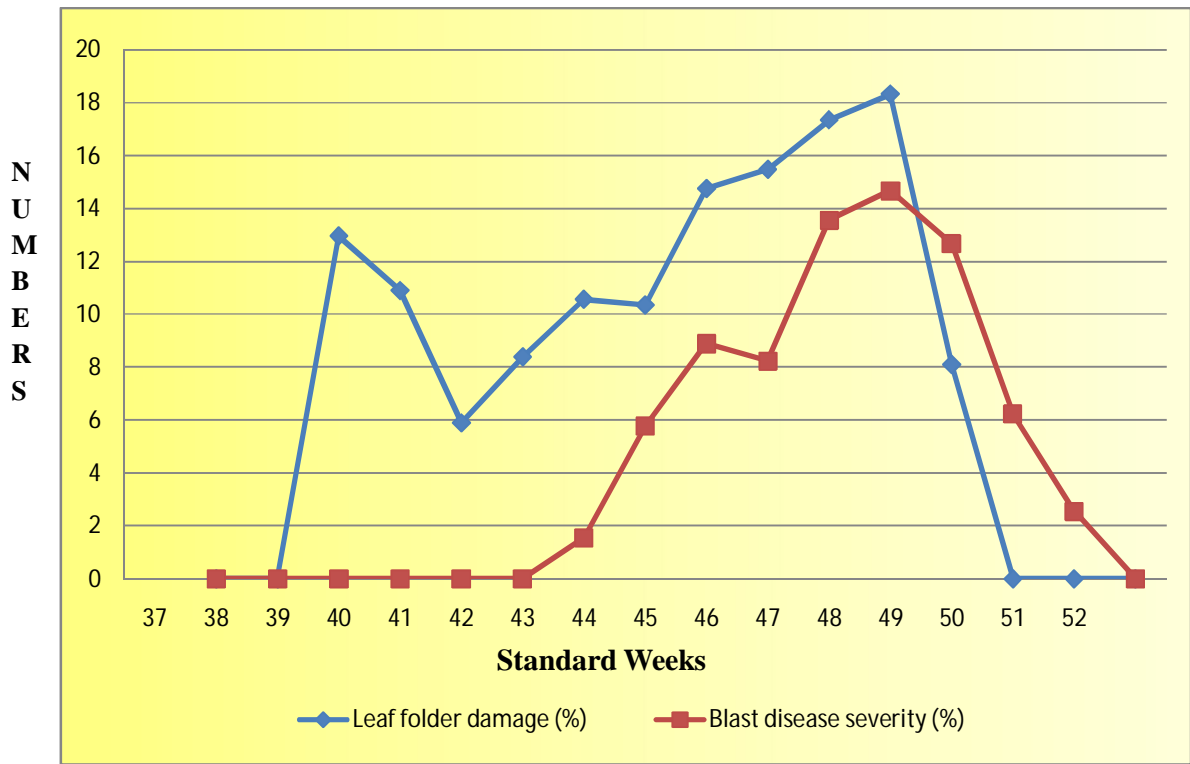
Fig. 4.9 Mean per cent reduction of leaf blast incidence over control



**Fig. 4.10 Efficacy of treatments on the yield of paddy**



**Fig. 4.10 Per cent increase of yield over control**



**Fig. 4.1** Incidence of leaf folder infestation and leaf blast severity during *kharif*, 2014



**Plate 3.1 Light trap installed near the field**

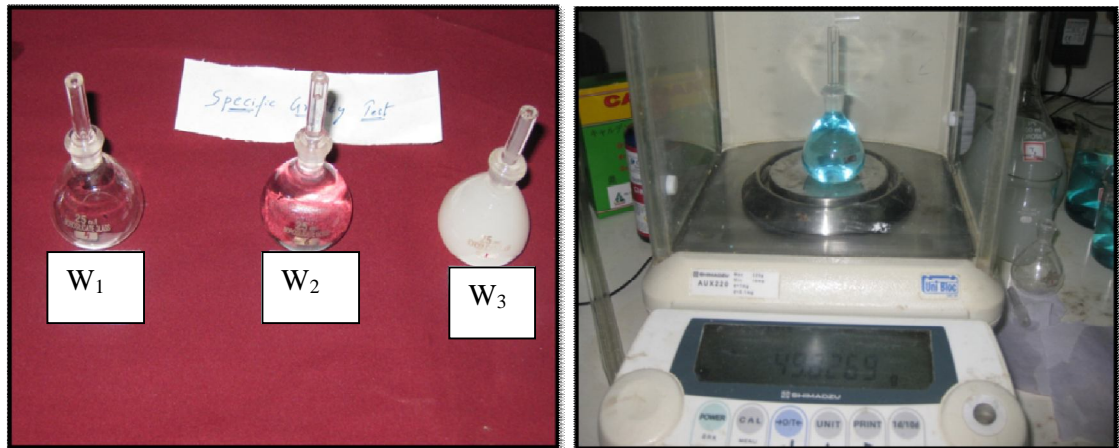


**a) Leaf tip drying symptom observed in Chlorpyrifos + Carbendazim combination at higher dose**



**b) Yellowing symptoms observed in Chlorpyrifos + Hexaconazole combination at higher dose**

**Plate 4.5 Results of phytotoxicity test**



**Plate 3.2: Specific gravity test to assess compatibility between insecticide and fungicide combinations**



**Plate 3.3: Emulsion stability test to assess compatibility between insecticide and fungicide combinations**



**Plate 3.6: An overview of the experiment plot**



**Plate 3.4: Potted plants under green house for phytotoxicity studies**



**Plate 3.5: Spraying of insecticide and fungicide combinations to test the phytotoxicity of pesticide mixtures on potted plants of Paddy**



a) Long jawed spider, *Tetragnatha maxillosa*

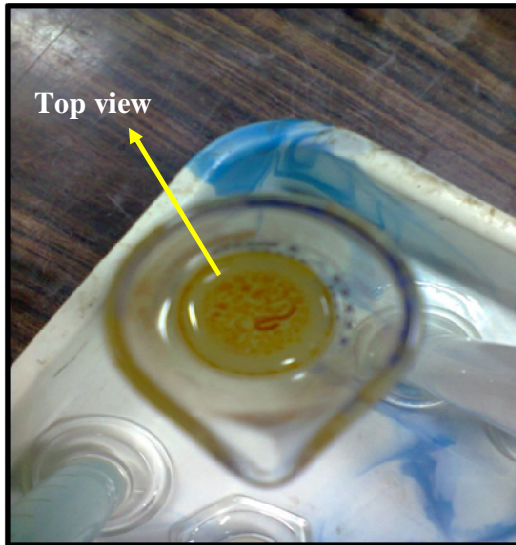


b) Damselfly



c) Dragon fly

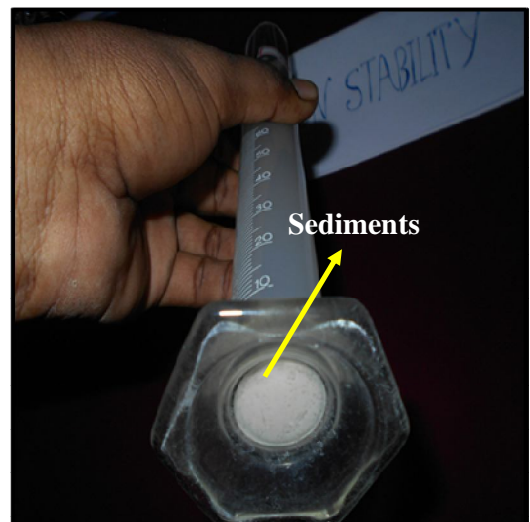
**Plate 4.2: Natural enemies observed in the field**



a) Oily emulsion observed in chlorpyrifos + tricyclazole combination



b) Creamy layer (< 1.0 ml) observed in chlorpyrifos + hexaconazole



c) Sediment (< 1.0 ml) at the bottom observed in cartap hydrochloride + carbendazim

**Plate 4.3: Results of emulsion stability test in tap water and standard hard water**



**Plate 4.4: pH and EC analysis to test the chemical compatibility of insecticides and fungicides**



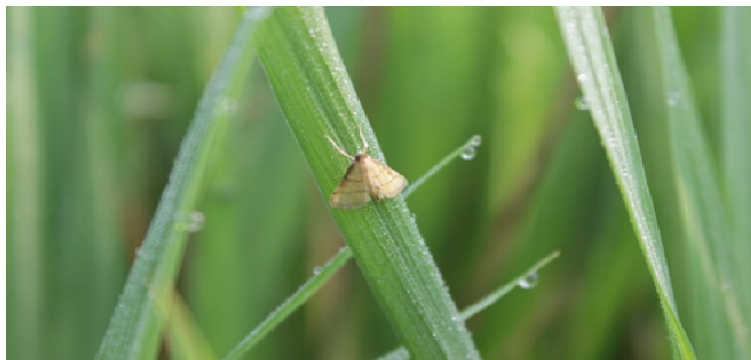
**Plate 4.6: Larvae of Leaf folder and its infestation**



a) An adult GLH, *Nephotettix virescens*

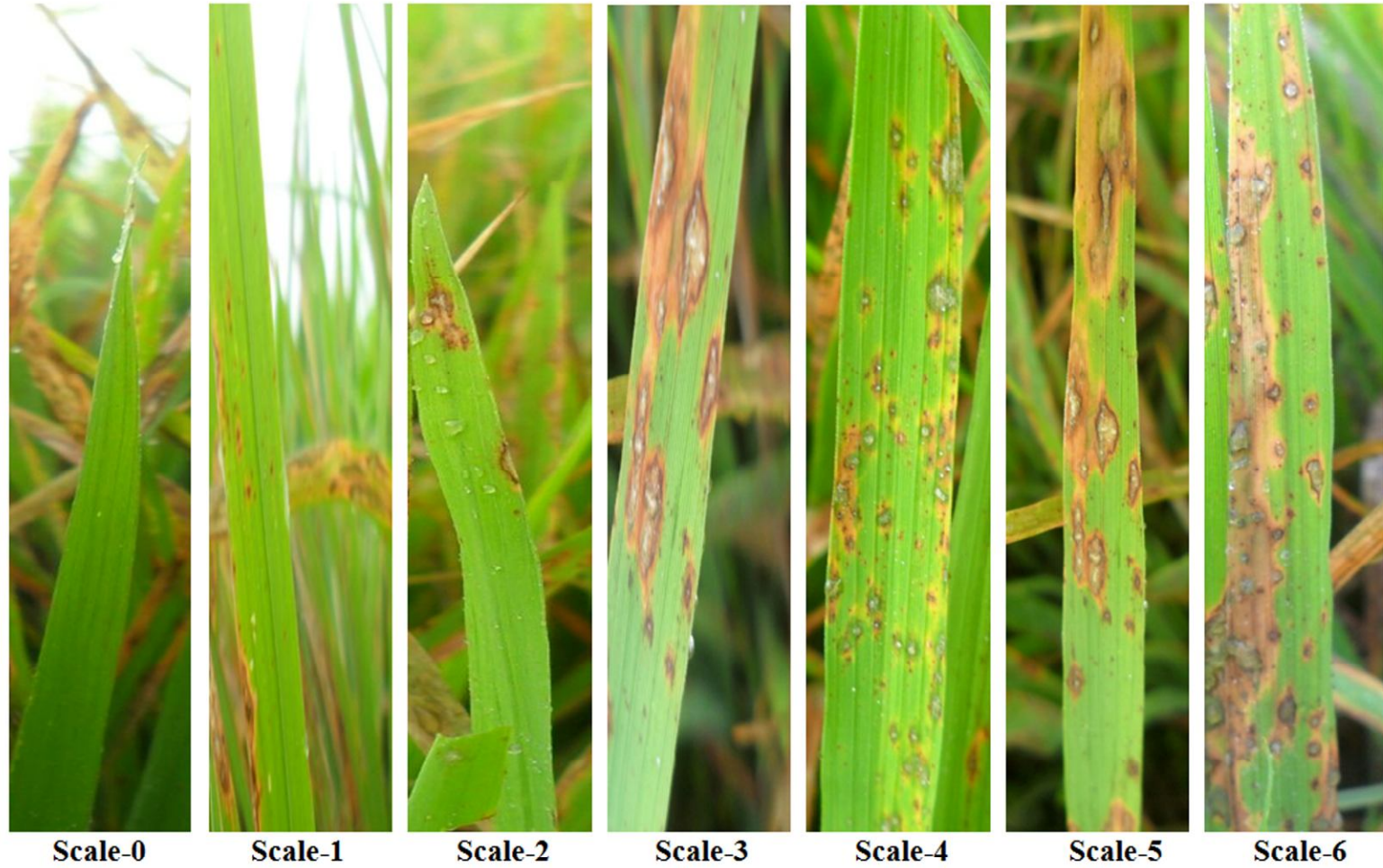


b) Adult of BPH, *Nilaparvata lugens*



c) Adult moth of Leaf folder, *Cnaphalocrocis medinalis*

**Plate 4.1: Insect pests observed in the field**



**Plate 4.7: Different grades of leaf blast symptoms on paddy leaf caused by *Pyricularia oryzae* observed in the field**