

# MANAGEMENT OF INSECT PEST COMPLEX OF RICE



*Munna Yadav*

## DEPARTMENT OF AGRICULTURAL ENTOMOLOGY

**BIRSA AGRICULTURAL UNIVERSITY**  
KANKE, RANCHI – 834 006 (JHARKHAND)

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# MANAGEMENT OF INSECT PEST COMPLEX OF RICE



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*By*  
*Munna Yadav*

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FOR THE DEGREE

OF  
**DOCTOR OF PHILOSOPHY**  
**(AGRICULTURAL ENTOMOLOGY)**

Regd.No. Ph.D./BAU/6022/2015

2018



*DEDICATED*

*To My Swami Jee, Gurujan  
And Beloved Parents*

*Munna.....* 

**BIRSA AGRICULTURAL UNIVERSITY**  
**DEPARTMENT OF AGRICULTURAL ENTOMOLOGY**  
**RANCHI- 834 006 (JHARKHAND)**

*Dr. Rabindra Prasad*  
Sr. Scientist-cum-  
Assoc. Professor



Deptt. of Agricultural Entomology  
Faculty of Agriculture  
Ranchi- 834 006 (Jharkhand)

Dated:.....

***CERTIFICATE***

This is to certify that the thesis entitled, "**Management of Insect Pest Complex of Rice**" submitted in partial fulfilment of the requirements for the degree of **Doctor of Philosophy in Agriculture (Agricultural Entomology)** of the faculty of Post-Graduate studies, Birsa Agricultural University, Ranchi, Jharkhand is the record of the bonafide research work carried out by **Mr. Munna Yadav** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

It is further certified that all assistance, help or information received during the course of this investigation and preparation of the manuscript have been duly acknowledged.

**ENDORSED**

*(Devendra Prasad)*

Chairman  
Deptt. of Agricultural Entomology

*(Rabindra prasad)*

Chairman  
Advisory committee

**BIRSA AGRICULTURAL UNIVERSITY**  
**FACULTY OF AGRUCULTURE**  
**RANCHI- 834 006 (JHARKHAND)**

*(Certificate of Advisory committee members and Endorsement of Dean, Agriculture)*

***CERTIFICATE***

We, the undersigned, members of the Advisory committee of **Mr. Munna Yadav**, a candidate for the degree of **Doctor of Philosophy in Agriculture** with major in **Agricultural Entomology** have gone through the manuscript of the thesis and agree that the thesis entitled **“Management of Insect Pest Complex of Rice”** may be submitted by **Mr. Munna Yadav**, in partial fulfilment of the requirements for the degree.

---

*Dr. Rabindra Prasad*  
Chairman  
Advisory committee

**ENDORSED**

**Members of the Advisory Committee**

---

*Dr. R. Thakur*  
Dean  
Faculty of Agriculture

---

*Dr. Devendra Prasad*

---

*Dr.(Mrs.) Savita Ekka*

---

*Dr. C.S.Mahto*

# **BIRSA AGRICULTURAL UNIVERSITY**

## **RANCHI- 834006 (JHARKHAND)**

*(Certificate of approval by the Advisory committee members and External Examiner)*

### ***CERTIFICATE***

This is to certify that the thesis entitled "**Management of Insect Pest Complex of Rice**" submitted by **Mr. Munna Yadav** in partial fulfilment of the requirements for the degree of **Doctor of Philosophy in Agriculture (Agricultural Entomology)** of the faculty of Post-Graduate studies, Birsa Agricultural University, Ranchi, Jharkhand was examined and approved on.....

---

*(Rabindra Prasad)*

Chairman  
Advisory committee

---

(External Examiner)

Members of the Advisory Committee

---

*(Devendra Prasad)*

Chairman  
Deptt. of Agricultural Entomolgy

---

*(Devendra Prasad)*

---

*(Savita Ekka)*

---

*(Z.A. Haider)*

DRI-Cum-Dean, PGS.

---

*(C.S.Mahto)*

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*Place:*

*Date:*

*(Munna Yadav)*

## Abstract

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Rice is one of the most important staple food crops of India including the state of Jharkhand. The crop is usually badly affected by half of a dozen of major insect pests which cause substantial loss in yield in the state. Use of chemical insecticides is one of the most effective tool of pest management but it's injudicious usage has too many side effects. Exploration of information for formulation of effective IPM tools of rice is the need of the hours. So use of eco-friendly tools of IPM namely HPR, suitable adjustment in dates of planting and use of eco-friendly insecticides is the need of present time for sustainable management of pests without harming the environment and ecosystem. Ample informations are lacking in the literature so far. Hence, the present thesis protocol "**Management of insect pest complex of rice**" was undertaken with five objectives and executed in *kharif*, 2016 and 2017. The abstract of the experimental findings are briefly mentioned here as under. Out of 18 prevailing insect pest species in rice ecosystem, six of them occurred as major pest's complex viz. yellow stem borer, gall midge, leaf folder, gundhi bug, brown plant hopper and termite. The rice varieties viz., Suraksha, Kavya, Lalat, CR Dhan – 303, CR Dhan – 205, CR Dhan – 304, Sabhagi Dhan, IR-36 and Naveen appeared as resistant/tolerant to six major insect pest species where as Lalat emerged resistant to five major pest species and remained susceptible to leaf folder. Minimum incidence of major pests namely – YSB, gall midge, hispa, leaf folder and GLH was observed when the crop was transplanted at the earliest, but maximum incidence of gundhi bug observed at the earliest planted crop. Highest yield of rice (var. Sahbhagi Dhan) was also found when the crop was transplanted at the earliest. Efficacy of all the seven test botanical insecticides appeared to be almost at par in terms of reduction in the incidence of prevailing major insect pests viz. YSB, gall midge, hispa, leaf folder, GLH and gundhi bug. Achook (0.03 % Aza. EC) @ 2500 ml/ha proved to be the most effective in reducing the incidence of the prevailing major insect pests, which, in turn realized the highest yield of grains (49.70 q/ha) with appreciably net profit (Rs. 22,679.20/ha) and B:C ratio (3.28:1). The new ready mixed combination product viz. spinetoram 6SC plus methoxyfenozide 30SC @ 400ml/ha remained the most effective against almost all the prevailing major insect pests of rice, which, in turn found at par with the same ready mixed combination product of insecticides, spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha, flubendiamide 48SC @ 50 ml/ha and carbofuran 3G @ 30 kg/ha followed by foliar spray of triazophos 40 EC @ 1500 ml/ha against all the prevailing major insect pests of rice. The new combination product (viz. spinetoram 6SC plus methoxyfenozide 30SC @ 400ml/ha) could be also responsible for realizing the highest yield of rice grains (48.40 q/ha) with appreciably higher net profit (Rs. 19,645.20/ha) and B:C ratio (4:1). As such, integration of various IPM tools i.e., HPR (i.e. resistant varieties) coupled with early planting of the crop, need based and judicious application of the Achook0.03 (% Aza. EC @ 2500) ml/ha and judicious use of the new combination product viz. spinetoram 6SC plus methoxyfenozide 30SC @ 400ml/ha could be highly effective components (tools) as integral parts of IPM/ICM for sustainable production of rice.

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# ***INTRODUCTION***

## *Introduction*

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Rice belongs to the genus *Oryza* under tribe *Oryzaceae* in grass family Gramineae or Poaceae and origin – Indo-Burma Region. *Oryza sativa* L. is distributed all over the world with a high concentration in Asia. Rice is the staple food for over half the world's population. It provides 27 per cent of dietary energy and 20 per cent of dietary protein in the developing country.

FAO's (2016) latest forecast points to a global rice harvest of 491.4 million tonnes (milled basis) in 2015. India has the world's largest area under rice with 44.0 million ha and is the second largest producer (105.6 million tonnes) next only to China. It contributes 21.5 percent of global rice production. India grows rice only in 11% of world's agriculture area. Rice productivity of India is 2.27 tonne/ha. (DRRI Vision 2030).

According to the projections made by the Population Foundation of India, the country's population will be 1546 million by the end of 2030, 1695 million by the end of 2040 and 1824 million by the end of 2050. It is estimated that the demand for rice will be 121.2 million tonnes by the year 2030, 129.6 million tonnes by the year 2040 and 137.3 million tonnes by the year 2050. (CRRRI Vision 2050).

Food grain production analysis shows the requirement of 46 lakh tonnes of food grains for a population of 26 million against the current production of 22 lakh tonnes. Total food grain productivity is 0.93 million tonnes in current scenario while desirable productivity is 1.73 million tonnes in the state of Jharkhand. Rice covers around 16.94 lakh hectare areas out of total cultivable area of 38.00 lakh hectares with net sown area of 25.75 lakh hectares, the production and productivity are 5614.931 thousand tone and 3315 kg per hectare, respectively in the state of Jharkhand (Anonymous, 2015-16).

As the area under cultivation is gradually being decreased and demand for enhanced production is increasing, emphasis is being given towards intensification through higher inputs and cropping intensity. Such efforts, in turn, increase pest intensities (Hegde *et al.* 1996) and losses caused by pests remains an important constraints for achieving higher paddy yields. Thus, in recent years, importance of reducing losses gains from insect pests' greater focus. Out of nearly 1000 insect pest

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species recorded on paddy, only two dozen insect & mite pests are found as key pest in different rice ecologies in India (Prakash *et al.*, 2003).

Out of one dozen insect pests species prevailing in rice – agro- ecosystem in the state of Jharkhand, half of a dozen of them are considered as major insect pests which are responsible for causing loss in yield ranging from 20-35 percent in general in the state (Prasad *et al.*, 2006 and Krishnaiah *et al.*, 2008). Insect pest fauna cause yield loss of about 20-30% (Dhaliwal and Arora, 1996), while an average yield loss-span from 21-51% over large area in India. Total crop failure of rice due to insect pests epidemic is also regularly encountered in some or the other pockets of India.

Earlier, only in certain areas of India aforesaid insect pests were the limiting factors in the successful cultivation of rice. Now, these pest fauna continue to be the major problem in many rice growing areas of the country, though at several places armyworm, swarming caterpillar, blue beetle are of local importance and location specific pest problem in nature in the country (Krishnaiah *et al.*, 2008). During 2009, the swarming caterpillar alone caused 100% crop damage (crop loss) of rice in Jharkhand, particularly in certain areas of 6-7 western districts viz. Chatra, Garhwa, Palamau, Gumla, Lohardagga and Simdega, probably on account of occurrence of unprecedented and severe drought prevailed in the state of Jharkhand (Prasad, 2010).

Among the various biotic factors responsible for lowering down the yield of the rice in the state of Jharkhand attack of yellow stem borer (*Scirpophaga incertulas* Walker) is one of them which could cause loss in yield from 10-30%. (Prasad and Prasad, 2006; Prasad *et al.*, 2014).

Changing pattern of monsoon and subsequent release of water in irrigation canals is compelling farmers to reschedule the tie of plantings of rice as per the situation. Knowledge of insect pests incidence and their population, dynamics of pests in relation to crop phenology and calendar is very important to device efficient location specific pest management strategies.

Meagre and scanty information's are available in the literature pertaining to date of planting on the incidence of insect pests of rice. Hence, under AICRIP (ICAR), some efforts have been made to generate some valuable information by conductance of experiments on effect of planting dates on pest incidence of rice and their ultimate impact on grains yield of rice under the influence of climate change and farming practices.

Prasad and Prasad (2015) studied the impact of staggering in date of planting on incidence and abundance of major insect pests of rice in wet season in the agro-climatic condition of Jharkhand. They found that earlier (1<sup>st</sup> week of July) was the date of planting, lesser was the incidence and abundance of major insect pests viz, YSB, hispa, GLH, gall midge and leaf folder infesting rice and the intensity of attack of these pest species was found to increase with delaying in the date of transplanting latest upto the 3<sup>rd</sup> week of August. Yield realization of rice grains also followed almost similar trends. On the contrary, they also found that earlier was the date of planting, higher was the incidence and abundance of ear bug infesting rice.

Use of HPR is not only environment friendly but also it is cost effective. Resource poor farmers cannot afford the expenses incurred on the insecticidal inputs to protect their crop. They need pest resistant or tolerant rice varieties to realize better and higher yield of grains, without minimum or no pesticidal application for sustainable rice production. Use of resistant varieties of rice is highly feasible for eco-friendly management of rice pests.

Different scientists conducted field screening trails for finding out pest resistant/tolerant rice varieties/genotypes. It was found that the rice cultivars, viz. Mo-1, Co-29 and IET- 10750 remained resistant to major insect pests (white backed plant hopper, leaf folder and stem borer) of rice. These cultivars yielded 17.54-17.94% higher grain yields over presently recommended high yielding varieties like Masuri and Narmada Breeders can utilize these promising cultures as donor for developing high yielding and pest resistant varieties of rice.

Judicious use of botanical based insecticides remains the principal strategy for managing insect pests by rice growers. Within the frame work of integrated pest management (IPM) newer molecules of insecticides continue to find a proper place because of their eco-friendly value and role in addition to much needed curative action in times of impending out breaks. That is why, every year, efforts are made even under the All India Co-ordinated Rice Improvement project (AICRIP) to thoroughly screen and evaluate newly developed formulations and newer molecules of insecticides for their effectiveness against the major insect pest species in different rice agro-ecologies of the country. With the passage of time, older molecules of insecticides are going to be out of use and newer ones are coming under current/recent recommendations for placing them as an integral part of IPM.

Insecticides are used as a major crop-protection tactics in managing pests of rice, *Oryza sativa* L. (Chelliah and Bharathi, 1994) with worldwide use estimated at \$1.14billion in 1996 (International Rice Research Institute World Rice Statistics). Stem borers were the most damaging pest species in Asia until the 1960s and are still causing substantial yield loss (Litsinger *et al.*, 2005). Chemical control, however, remains the only means of achieving economical and rapid suppression of stem borer infestations (Chelliah and Bharathi, 1994). New molecules will be searched out in the context of effective against rice pests *vis-à-vis* eco-friendly molecules of the insecticides should be given top priority. Although, thiamethoxam and imidacloprid are very effective against leafhoppers and planthoppers in rice but these are not efficient against other major insect pests like leaf folder, *Cnaphalocrocis medinalis* and yellow stem borer, *Scirpophaga incertulas*, which are often associated with rice ecosystem, when the planthoppers are prevalent in damaging proportions usually after panicle initiation. Therefore, rice farmers have to necessarily choose an insecticide which could be effective against all these insect pests. Presently sprays of organophosphates like monocrotophos (500 g a.i./ha) or acephate (750 g a.i./ha) are the only choice of the rice farmers under these conditions.

Several workers (Sukhija *et al.*, 1988; Kushwaha, 1995; Singh *et al.*, 1995; Panda *et al.*, 2002; Misra and Parida, 2004; Raghu Ramudu and Misra, 2006; Sahithi and Misra, 2006 and Misra, 2010) have suggested various insecticides for the rice pest. Several studies have been conducted on the evaluation of efficacy of traditional insecticides like oranophosphates, carbamates, and growth regulators like buprofizin and ether derivatives like ethodenprox (Heinrichs *et al.*, 1982; Krishnaiah and Kalode, 1988 and Krishnaiah and Ghosh, 1990). Application of insecticides increased grain yield marginally to 29-32 per cent in irrigated paddies.

There was no insecticide which could be regarded as good killer for all pests observed that none of insecticides used under different formulations was found equally effective against all the major pests of paddy. Islam *et al.* (1988) reported that in rainfed low land rice, pesticides even though reduced the yellow stem borer incidence to some extent but in general failed to influence the grain yield. Kareem *et al.* (1988) and Dash *et al.* (1996) reported that the decimation of the predators was significantly high in insecticide treated plots. However, Sontakke *et al.* (1999) reported that the efficacy of insecticides was the highest when applied at the tillering and reproductive stage of rice crop.

However, emulsifiable concentrates of monocrotophos and chlorpyrifos appeared more economical for adoption by farmers as their application caused maximum mortality of larval and unhatched eggs.

The pest spectrum of a crop varies from region to region and season to season depending upon the variations in agro climatic situations and changing of package of practices in the region. Hence, it is essential to manage these insect pests viz. yellow stem borer, gall midge, leaf folder, rice hispa, case worm, green leaf hopper and rice gundhi bug through employment of various IPM tools. Sufficient information on all these aspects is not available in the context of Jharkhand.

The present investigation comprises of experimentations to be conducted in the two years 2016 & 2017 in the field conditions. Therefore, attempts have been made to evaluate several component/tools of pest management measures such as staggering in date of planting, use of HPR, botanical and newer molecules of chemical insecticides. Information on all these aspects of rice IPM tools is scarcely available in literatures in India in general with particular reference to Jharkhand, to reduce/minimize the yield loss for sustainable production of rice for ensuring food security.

Under the aforesaid circumstances/facts in considerations, the present investigations entitled “**Management of insect pest complex of rice.**” was proposed to be undertaken with following objectives:

1. To study on biodiversity of insect-pest species in the agro-ecosystem of rice in Jharkhand.
2. To evaluate certain rice varieties and genotypes against major insect-pests of rice.
3. To study the effect of staggering in date of transplanting on the incidence of insect-pest complex of rice.
4. To evaluate field bio- efficacy of botanical based insecticides against major insect-pests of rice.
5. To evaluate field bio- efficacy of newer molecules of insecticides against major insect-pests of rice.



*REVIEW  
OF  
LITERATURE*

## *Review of Literature*

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From a survey of literatures on various aspects pertaining to the present investigation, it reveals that not much work has been done in the past in the context of prevailing agro-ecological condition and particularly in Ranchi Jharkhand regarding the required aspects of management of insect pest complex of rice. This part of the thesis protocol comprises of the background information resulting from the previous work-done by various scientists of India and abroad in context of the objectives decided for the present investigation. Attempts have been made to cite some relevant information pertaining to the trends of pest's incidence, host plant resistance and management of the pests-species through impact of dates of planting and need based and judicious use of botanical and eco-friendly insecticide as well as that of newer molecules of insecticides and some related aspects to serve the purpose of the research protocol in order to fulfil the requirement of the set objectives.

Concerning the facts and the objectives of the present investigation entitled “**Management of insect pest complex of rice**” the reviews of literature(s) are hereby dealt under the following heads:

1. Biodiversity of insect-pest species in the agro-ecosystem of rice in Jharkhand.
2. Evaluation of certain rice varieties against major insect-pests of rice.
3. Effect of staggering in date of transplanting on the incidence of insect-pest complex of rice.
4. Evaluation of field bio- efficacy of botanical based insecticides against major insect-pests of rice.
5. Evaluation of field bio- efficacy of newer molecules of insecticides against major insect-pests of rice.

### **2. Biodiversity of insect pest species in the rice agro-ecosystem.**

#### **2.1 Status of insect pests of rice:**

The pest spectrum of the crop varies in time and space according to variations taking place in the agro-ecologies that is regulated by changes in the biotic and abiotic factors as well as ever changing farming practices.

Rice (*Oryzae sativa*.L) is one of the major food grain crops of India and grown under diverse conditions of climate, soil and water. Among various reasons/factors responsible for low production of rice, insect pest complex are major factors for

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lowering down the yield. Out of more than 100 species of insect pests known to attack rice crop, about 20 species of them are of major economic importance, (Pathak and Dhaliwal, 1981; Prasad and Prasad, 2006).

Prasad and Prasad (2006) conducted field survey in order to reckon the insect pest fauna and their natures of damages and mode of injury symptoms associated with rice-ecosystem in the state of Jharkhand. Their findings are presented in the following Table (Table-2.1 & 2.2)

Yellow stem borer, rice leaf folder, armyworm, rice gundhi bug, rice gall midge, rice whorl maggot, rice green leaf hopper, hispa, black hairy caterpillar, gall fly (i.e. rice gall midge) are some of the pests which usually attack rice crop and lower down the yield of rice up to greater extent. However, hispa, armyworm, leaf folder, black hairy caterpillar and swarming caterpillars are found to occur in sporadic mode of appearance and causes considerable extent of damage to rice crop (Prasad, 2006). In the seven western districts of Jharkhand, there was severe outbreak of swarming caterpillar which could be responsible for 60-100 percent loss of the crop in the agro climatic conditions of Jharkhand (Prasad and Prasad 2010).

Adiroubance and Raja (2010) showed high pest incidence during months of March, August–September and October-November. The favorable weather conditions for high stem borer incidence were 27.6<sup>0</sup>C, 30.1<sup>0</sup>C and 26.1<sup>0</sup>C as mean temperature and relative humidity per cent ranged between 95.9 and 65.7, 82.2 and 54.5 and 95.3 and 82.8 pertaining to navarai, kuruvai and samba season, respectively. They observed that stem borer infestation had a negative correlation with maximum temperature, minimum temperature, rainfall and evaporation and a positive correlation only with evening relative humidity during navarai season. It was also found that stem borer damage had a positive correlation with morning relative humidity, evening relative humidity and wind velocity and a negative correlation with evaporation during kuruvai season. It was also observed that a significant positive correlation with sunshine hour, morning relative humidity, evening relative humidity, dew fall and wind velocity and a significant negative correlation with minimum temperature in respect of stem borer damage during samba season.

**Table-2.1:** General account of succession and status of insect pest fauna of rice in Jharkhand

Sl. No.	Name of the insect pests	Stage of the crop attacked	Pest status
1	Rice stem borer	Nursery, vegetative	Major
2	Rice skipper	Vegetative & reproductive stages	Minor
3	Rice gall fly	Nursery and tillering stages	Major
4	Rice hispa	Vegetative stage, just after transplanting stage	Mild to severe
5	Rice case worm	Late vegetative stage	Mild to severe
6	Rice grass hopper	All stages of the crop, i.e, all round the field in the whole season.	Major
7	Rice gundhi bug	Late vegetative & at reproductive stage	Mild to severe
8	Rice leaf folder	Late vegetative to reproductive stage	Mild to severe
9	Rice green leafhopper	Late vegetative to reproductive stage	Minor to mild
10	Brown plant hopper	Late vegetative to reproductive stage	Minor
11	Rice thrips	Vegetative stage	Minor
12	Rice mealy bug	Vegetative stage ,usually occurrence was more pronounced in drought condition	Minor
13	Army worm	Vegetative and reproductive stage	Mild to severe
14	Swarming caterpillar	Soon after sowing or transplanting of the crop ; may or may not be throughout vegetative stage	Mild to severe
15	Black hairy caterpillar	Vegetative stage	Mild to severe
16	Whorl maggot	Vegetative stage	Minor
17	White grub	Early & vegetative stage	Mild
18	Termite	Seeding, seedling & vegetative stage	Mild
19	Rice root weevil	Early vegetative stage	Minor

Source: Prasad *et al.*, 2006

**Table-2.2:** General account of insect pests' incidence along with their taxonomic position associated with rice prevalent in Jharkhand

S. No	Common Name	Scientific Name	Order	Family	Damage Stage of insect pest(s)
1	Yellow rice stem borer	<i>Scirpophaga incertulas</i> Walker	Lepidoptera	Pyralidae	Larvae
2	Rice hispa	<i>Dicladisa armigera</i> Ol.	Coleoptera	Chrysomellidae	Adult & grub
3	Rice case worm	<i>Nymphula depunctalis</i> Gn.	Lepidoptera	Pyralidae	Larvae
4	Rice grass hopper	<i>Hieroglyphus banian</i> Fab.	Orthoptera	Acrididae	Adult & nymph
5	Rice gundhi bug	<i>Leptocprisa acuta</i> Th.	Hemiptera	Coredidae	Adult & nymph
6	Rice gall fly	<i>Orseolia oryzae</i> Wm.	Diptera	Cecidomyiidae	Maggot
7	Rice green leaf hopper	<i>Nephotettix nigropinctus</i> / <i>N. virescens</i>	Homoptera	Cicadillidae	Adult & Nymph
8	Brown plant hopper	<i>Nilaparvata lugens</i> Stal	Homoptera	Delphacidae	Adult & nymph
9	Rice thrips	<i>Baliothrips biformis</i> (Bogn.)	Thysanoptera	Thripidae	Adult & nymph
10	Rice mealy bug	<i>Heterococcus rehi</i> (Lind)	Homoptera	Pseudococcidae	Nymph & adult
11	Army worm (Ear cutting caterpillar)	<i>Mythimna unipunctata</i> Haw. / <i>M. separata</i>	Lepidoptera	Noctuidae	Caterpillar
12	Swarming caterpillar	<i>Spodoptera mauritia</i> Boisid	Lepidoptera	Noctuidae	Larvae
13	Whorl maggot	<i>Hydrellia griseola</i> (Fall)	Diptera	Ephydridae	Maggot
14	Termite	<i>Odontotermes obesus</i> Ramb.	Isoptera	Termitidae	Adult & young

Source: Prasad *et al.*, 2006

Soren and Prasad (2013), revealed that 14 insect pest species were found to attack rice in its different stages of crop growth almost in overlapping fashion. Out of them about half of a dozen of insect pest species were noticed as major insect pests and rest eight species as minor pests. The major pests of the crop include YSB, gall midge, hispa, leaf folder, GLH, case worm and gundhi bug.

Hembrom and Prasad (2014) conducted of two years' pest monitoring program the results of which indicated that seventeen insect pest species prevailed in the various stages of crop growth, more or less, in succession and also in overlapping manner. Out of them six pest species were observed as major prevailing insect pests and remaining insects were rated as minor and negligible economic pest in rice ecosystem. As such, the major insect pests of rice were: gall midge (*Orseolia oryzae* WM), yellow stem borer (*Scirpophaga incertulas* WLK), hispa (*Dicladisa armigera* Oliv), leaf folder (*Cnaphalocrosis medinalis* Guen) and ear bug (*Leptocorisa* spp).

Kumar and Prasad (2017) aforesaid result that out of 17 insect pest species, prevailing in rice ecologies in the state of Jharkhand, gall midge, yellow stem borer, leaf folder, green leaf hopper and case worm appeared as mild to severe pest species, hispa and gundhi bug as moderate (mild) pest; whereas other insect pest species viz. grass hopper (*H.baniana*; *Oxya chinesis*), black hairy caterpillar (*N.simplex*), termite (*O.obesus*), mealy bug (*B.rehi*), thrips (*S.biformis*), white grub (*H.spp.*) BPH (*N.lugens*) remained the pest of negligible and minor economic importance in medium and low land transplanted rice ecologies in Jharkhand, region of India.

### **2.1.1 Rice stems borer: *Scirpophaga incertulas* (Walker)**

Out of half of a dozen of major insect pests species prevailing in the rice-ecologies in the state of Jharkhand, stem bore(s) is one of the them. There are five species of stem borer in India. The stem borers attack rice crop throughout the growth period from nursery up to harvest. The damage results in characteristic symptoms of 'dead heart' or 'white ears' depending on the stage of the crop. During vegetative phase, the stem borer larvae emerge from the egg masses laid on leaves and enter the tiller to feed inside, resulting in the characteristic damage of 'dead heart'. In the damaged plants, the central leaf whorl does not unfold, turns brownish and dries out although the lower leaves remain green and healthy. The affected tillers do not grow further and eventually dry. The dead heart comes out easily when pulled and emits foul smell. At reproductive stage, the damage is characterized by whitish, erect and chaffy panicles, which are very conspicuous in field and are called 'white ears'.

However, the stem borer damage may occur during the grain filling stage also, leading to stoppage of further grain filling and resulting partially filled grains. There are five species of stem borers distributed throughout India. Among these, yellow stem borer (YSB), *Scirpophaga incertulas* (Walker) is the most important, widespread, dominant and destructive. The other borers are, pink stem borer, *Sesamia inferens* (Walker) occurring mostly in rice wheat cropping systems of north-west, white borer, *Scirpophaga innotata* (Walker) common in southern region particularly in Kerala, dark headed stem borer *Chilo polychrysus* (Meyrick) and striped stem borer, *Chilo suppressalis* (Meyrick) in states of West Bengal and Assam respectively. In southern parts of India where rice is cultivated throughout the year, there are usually 3 generations during *kharif* season and 2 generations during *rabi* season. Similar is the case in most parts of western states like Orissa, West Bengal and the North East states like Assam etc. However, in north western parts of India, where one crop season of rice is prevailing, the yellow stem borer completes 2-3 generations during *kharif* and enters into quiescent stage or diapauses in larval stage during October –November immediately after rice is harvested. It remains in the stage throughout the winter months to February–March. With rise in the temperature during March, the diapauses is broken, the larva pupates and emerges as an adult from April beginning and onwards periods.

Yellow stem borer (*Scirpophaga incertulas* Walker) is the most destructive and widely occurring insect pest of rice at all stages of the crop (Bandong and Litsinger, 2005). Prasad *et al.*, (2004) reported that yellow stem borer incidence was higher during heading stage. It is the most dominant species in tropical lowland and deep water rice (Ravi *et al.*, 2008), in Haryana (Lal, 2006 and Joshi *et al.*, 2009), in Punjab (Singh *et al.*, 2008), in West Bengal (Saha *et al.*, 2005 and Chakraborty and Ghosh, 2010), in Assam (Pujari *et al.*, 2008), in Uttar Pradesh (Singh *et al.*, 2005; Sachan *et al.*, 2006 and Mishra *et al.*, 2012), in Andhra Pradesh (Kumari and Pasalu, 2003 and Varma *et al.*, 2004), in Karnataka (Kumar, 2005), in Madhya Pradesh (Varma *et al.*, 2004), in Orissa (Panigrahi, 2011), in Jharkhand (Prasad and Prasad, 2006) and in Bihar (Rai *et al.*, 2006) and infests the crop from seedling to maturity and hibernate in rice stubbles.

Rahman (2007) recorded that among the insect pests, the yellow stem borer (*Scirpophaga incertulas*) was the most dominant throughout the crop season, followed by the dark-headed striped borer (*Chilo polychrysus*) and pink borer

(*Sesamia inferens*) in Mymensingh (Bangladesh). Yellow stem borer is a monophagous species with exclusive host specificity to the genus *Oryza*. The extent of damage caused by the yellow stem borer in rice ranges from 5 to 10 per cent (Kumari and Pasalu, 2003) or 38 to 80 per cent (Karthikeyan and Purushothaman, 2003) or 15 to 16 per cent (Prasad, 2003) or 38 to 80 per cent (DRR, 2011).

Chakraborty and Ghosh (2010) observed that in general, the least number of active eggs of YSB was noted in January and the highest in November. The temperature, relative humidity, rainfall and sunshine hours also had significant impacts on the YSB egg masses.

DRR (2011) reported that yellow stem borer was the most dominating species at Nellore, Nawagam, Rajendranagar, Pantnagar and Faizabad where it accounted for 99 to 100 per cent of the population.

Mandal *et al.*, (2011) reported that the catching of *Scirpophaga incertulas* moth was commenced as early as 32<sup>nd</sup> standard week (2<sup>nd</sup> week of August) with its peak during 37<sup>th</sup> standard week, while incidence of deadheart started at 34<sup>th</sup> standard week (4<sup>th</sup> week of August) and reached the peak at 38<sup>th</sup> standard week (3<sup>rd</sup> week of September).

Sharma *et al.*, (2011) recorded maximum population of *S. incertulas* Walker in the month of September. The value of multiple correlations for the insect was 0.949. Meteorological factors were also responsible for the dynamics of the populations of insects.

Mishra *et al.*, (2012) revealed that the insect maintained a low population in months of July to August and November. Relatively higher numbers of moths were in month of September exhibiting their peak activity in 2<sup>nd</sup> or 3<sup>rd</sup> week. The moth population of yellow stem borer showed positive correlation with minimum and maximum temperatures and negative correlation with rainfall. But relative humidity showed negative correlation in 2007 and positive in 2008.

Mishra *et al.*, (2012) studied on the stem borer complex in Faizabad and revealed that only two stem borer species viz. yellow stem borer (*Scirpophaga incertulas* Walker) and pink stem borer (*Sesamia inferens* Walker) were prevalent in different rice ecosystems (upland, irrigated and shallow water).

### **2.1.2 Gall midge: *Orseolia oryzae* Wood Mason (Diptera: Cecidomyiidae)**

Rice gall midge is a dipterous insect pest of rice. The maggot of rice gall midge is the damaging stage of the insect pest. The maggot enters inside the young

rice plant and starts feeding on growing point of plants. As a result, the merismatic tissue grows and encloses the feeding insect inside. The merismatic tissue as it grows, turns into a pale green tubular structure called “**silver shoot.**” The larvae (maggot) pupate inside the silver shoot and emerges as adult from the top portion of silver shoot. The damaged tiller does not bear panicle. The crop under severe infestation is stunted with more numerous tillers. These new tillers are also eventually attacked resulting in almost 80 to 90 % loss under severe infestation if the weather conditions are congenial for the pest species.

The extent of damage is more serious during *kharif* or wet season, although, gall midge started infesting *Rabi* rice also in some of the coastal rice growing tracts. For proper egg hatching of gall midge, 90-100% humidity is essential. High humidity and a thin film of water are required for larval dispersal and entry into the plant. The female adult is a mosquito like dipterans fly with reddish abdomen. The male is slightly smaller in size with brownish abdomen. The adult life span is one to four days. The mating occurs immediately after emergence and eggs are laid any where on the foliage. The eggs are microscopic, cigar shaped and the egg period is about three to four days. The optimum temperature for rice gall midge is 22 to 26°C. Gall midge is more severe, in late planted conditions. Although a number of gall midge resistant varieties are released, their spread is hampered due to the problem of biotypes of the pest meaning thereby resistant rice varieties against one-biotype of the same species may exhibit as susceptible for another bio-type of the gall midge (*O. oryzae*). Currently, there are six biotypes of rice gall midge prevalent in our country.

Vayasiere Galland (1951) reported that *Pachydiplosis oryzae* infests young tillers during period of June–September.

Descampe (1956) reported that infestation begins towards the end of July and increases until October, when rice fields begin to dry up.

Murthy (1957) opined that infestation increases with lateness of sowing or transplanting.

Panda (1976) reported that rice gall midge resulted not only by the formation of silver shoots but in the stuning of tiller as well.

Peak number of gall midge occurred in the rice fields in mid September in Thailand and in mid October in India (Hidaka *et.al.*, 1977).

Rajamani *et al.*, (1979) recorded *Orseolia oryzae* infestation before booting or panicle formation stage in Oct –Nov. The symptom showed profuse tillering, drastic

reduction in internode lengths and stunting which resulted in a clustering of leaves of the top resembling the symptom of bunchy top virus causing bunchy top of rice.

Rizvi and Singh (1980) observed in Faizabad district of UP that infestation of rice gall midge was heaviest from late August to mid October.

Reissing *et al.*, (1985) stated that gall midge have attained major status throughout Asia.

Ukwungwu and Joshi (1992) revealed that damage caused by the African rice gall midge (AFRGM), *Orseolia oryzivora* Harris and Gagn (Cecidomyiidae) is an important limiting factor of rice production in Africa. This pest earlier had a minor status, now it has become the important pest of rice crop.

Tomeva and Anchev (1998) found that the insect of the order Diptera are part of the rice entomo fauna. The qualitative and quantitative composition of the dipterous insect fauna in rice was investigated at three localities in the Koncani region, Yugoslavia, during 1987 & 1988.

Jacob (2002) conducted a light trap study on field population of rice gall midge (*Orseolia oryzae*) for 10 seasons (*Rabi* 1993 to *Kharif* 1998) at Moncompu; Kerela, India indicated a population fluctuation during the *Rabi* season. The peak population of gall midge occurred in February and September during *Rabi* and wet seasons.

Prasad (2011) reported that rice gall midge is again emerging as major pest in Jharkhand.

Temperature (max & min) had positive correlation and sun-shine hours had negative correlation with incidence of gall midge meaning their by cloudy hours had positive correlation with the incidence of gall midge in Ranchi region (Kumari 2018).

### **2.1.3 Rice hispa: *Dicladispa armigera* Oliver (Coleoptera: Chrysomelidae)**

This is a coleopterous insect pest in rice ecology particularly in wet season. The adult (beetle) and grub stages of the insect pest is damaging for rice crop. The adults of rice hispa (*Dicladispa armigera* Olivier) are shining black beetles with spines on forewings. Both adult and grubs damage the crop. The adult scrap the chlorophyll content on the upper side and lower side of leaves. The grubs mine in between two epidermal layers and feed on the chlorophyll content. In severe infestations, the crop gets dried with whitish appearance without any green colour. In case of epidemics, about 25-50 beetles may be present on a single hill. This pest is more serious in young stages of the crop growth either in nursery or in early

transplanted conditions. The adult beetles lay eggs singly either on lower surface or on upper surface of leaves covered with brownish material. The egg period is about six to seven days. The emerging grubs directly enter between two epidermal layers and grow there. The total larval period (five instars) last for 15-18 days. The pupation occurs in the larval mine in between the two epidermal layers and the pupal period last for four to five days. Hispa used to be a sporadic pest previously. However it is occurring regularly in many sub Himalayan areas and also in North Eastern states.

Basu and Banerjee (1957) showed that rice plants just after transplanting were found to be more prone to hispa damage than those of other stages of the crop.

Dhaliwal *et al.*, (1983) found hispa incidence to be increased with increased N level from 0 -100 kg/ha.

Rice hispa is a sporadic and occasional leaf feeding pest .Average loss to crop yield caused by rice hispa varied from 6.0-65.0% (Anonymous, 1995).

Kumar *et al.*, (2003) conducted a survey during *kharif* season of 1994/99-1998-99 in the major rice growing areas of North Canara district of Karnataka, India. The population of hispa (*D. armigera*) was high during early stage of crop during 1996/97-1998/99.

Rao *et al.*, (2004) studied on population build up of rice hispa, *Di cladispa armigera* Oliv. and reported that the maximum population of adults and grubs were found in the month of August when the crop was in the mid tillering stage. They also found that minimum temperature and relative humidity were significantly and positively correlated with the adult and grub population.

#### **2.1.4 Rice leaf folder: *Cnaphalocrocis medinalis* Guenee**

The pest is also termed as rice leaf roller.

There are six species of leaf folders attacking rice crop but the most important one is *Cnaphalocrocis medinalis* (Guenee).As the very name indicates, the larvae after emerging from eggs, folds the leaves with the help of silken thread secreted from salivary glands, remain inside and feed on the chlorophyll content of the leaves leaving only the lower epidermis. As a result, the photosynthetic activity of the plant is affected resulting in loss of grain yield. The loss in yield is more significant when larvae feed on boot -leaf compared to other lower leaves of the plants. There are 5 larval instars, which are completed in 18 -25 days depending on the temperature. The pupation occurs inside the folded leaf and the pupal period last for 5-7 days. The adult emerges and after mating starts laying of eggs takes place singly or in groups of 2-3

either on the lower side or upper side of the leaf or sometimes on leaf sheath. The egg period lasts for 4-6 days. The pupation of leaf folder, increased tremendously at higher nitrogen levels. As farmer tends to apply more than recommended nitrogen, leaf folder is becoming more serious in many of the irrigated rice growing deltaic tracts in many states. Of late, the population of leaf folder is increasing in plots treated with either phorate or carbofuran granules (Krishnaiah *et al.*, 2008).

Velusamy and Subramanian (1974) who worked on the bionomics of the rice leaf folder in the laboratory and field reported that the pest occurred throughout the year where there is continuous cropping of rice, generally reaching peak during Oct.-Nov. and April.

Chatterjee, (1979) observed that leaf folder attack was the most severe on the edges of forest reserves and on plains near the Himalayan foothill.

Natarajan *et al.*, (1980) reported that the leaf folder was abundant in late planted rice crop.

Dhaliwal *et al.*, (1983) also found increase in leaf folder incidence when nitrogen dose was increased in rice agro ecosystem.

Kumar *et al.* (2003) conducted experiment for field studies in A.P., India, during *rabi* season of 1998-99 to determine the effect of incidence of leaf folder. The leaf folder showed a significant negative correlation with morning relative humidity.

Miyashita and Kawanishi,(2003) opined that the larvae of the rice leaf roller, *Cnaphalocrocis medinalis* was found to feed on rice leaves from the vegetative growth period until panicle formation was completed. The larvae of the fifth instar usually pupated, regardless of the variety and position of leaves.

Kumar (2003) conducted a survey during *kharif* season of 1994/99 - 1998/99 in major rice growing areas of North Canara district of Karnataka, India. The leaf roller (*Cnaphalocrocis medinalis*) was the major pest noticed in the district.(4.2-6.8 damaged leaf per hill) during 1995/96 -1997/98.

#### **2.1.5 Green leaf hopper: *Nephotettix* spp. (Hemiptera: Cicadellidae)**

Rice green leaf hopper is also known as Jassid. There are two species of green leafhopper occurring in rice viz. *Nephotettix virescens* (Distant) and *Nephotettix nigropictus* (Stal). Both the leafhoppers suck the sap from phloem as well as xylem. But unlike planthoppers, green leafhoppers do not cause hopper burn. These two insects are economically important as vectors of rice tungro disease (RTD). They transmit RTD from one plant to another and act as vectors of the disease. Rice is the

main host for *N. virescens* although it can also feed on some grassy weeds occurring on rice bunds. *Nephotettix nigropictus* feeds mainly on *Leersia hexandra* and other weed hosts and occasionally feeds on rice crop. RTD is transmitted from weed hosts to rice crop mainly through *N. nigropictus* while the transmission among the rice plants is mainly by *N. virescens*. GLH lay their eggs either in the midrib of leaves or in the leaf sheath. The nymphs of *N. nigropictus* are brownish to pinkish in colour while the nymphs of *N. virescens* are light green in colour. *N. nigropictus* has a conspicuous black spot on the head, which is absent in case of *N. virescens*. The optimum conditions for multiplication of *N. virescens* and *N. nigropictus* are about 25°C temperature and 80% RH. Both the insects are more numerous during September and October months of kharif. Another GLH species called *N. cincticeps* (Uhler) is present in Japan and Korea and it is not prevalent in India.

Alam (1964) revealed that excessive sap feeding of rice plants due to green leaf hopper (*Nephotettix species*) may also result in hopper burn of rice plants. This is the most typical symptoms in case of the severe attack of the pest to the crop.

Natarajan *et al.* (1998) stated that heavy rains were negatively correlated with GLH *Nephotettix spp.*

Kumar *et al.*, (2003) conducted survey during kharif season of 1994/99 - 1998/99 in the major rice growing areas of North Canara district of Karnataka, India. Green leaf hopper & white leaf hopper (*Cofana spectra*) was also noticed in minor form in the rice agro-ecology.

Prasad and Prasad (2006) reported that green leaf hopper is a regular pest of rice in the agro-climatic conditions of Jharkhand. Its attack indicated in the late vegetative stage of the crop. Its attack usually attains its peak almost during the months of October and November. However, periods of activity of this insect pest is from August to November.

#### **2.1.6 Gundhi bug: *Leptocorisa acuta* Thunb. (Hemiptera: Alydidae)**

Gundhi bug is also known as ear bug or ear head bug or gundhi bug of rice.

There are mainly two species of gundhi bug viz., *Leptocorisa acuta* (Thunberg) and *Leptocorisa oratorius*. The nymphs as well as adults emit a characteristic offensive odour in infested fields, which can be very easily recognized as a signal of presence of gundhi bug in rice fields. The nymph and adult feed on developing milky grains causing brown spots and results in damaging the quality of the grain. At times, it becomes more serious and can cause heavy losses. The eggs are

laid in rows on upper or lower side of leaves. There are five nymphal instars, which last for 25 to 30 days.

Prakash *et al.*, (1995) reported that grain viability is also reduced by infestation of gundhi bug.

Prakash and Rao (2000) reported that rice gundhi bug, *Leptocorisa spp.* (Coreidae: Hemiptera) is a serious pest of upland rice and early maturing rice growing tracts of India. Both the nymphs and adults suck the milky juice from rice grains. The affected grain remains chaffy, unfilled and secondarily contaminated by various pathogenic fungi causing grain discoloration.

Prakash and Rao (2000) studied, under natural condition, about *Leptocorisa acuta* infestation in rice fields in India as well as in the CRRI farm (in India).

Shivkumar *et al.*, (2003) conducted a field experiment during *kharif* 1992 in Sriniketan, West Bengal, India to evaluate the potential of arthropod predators in controlling the insect pests of rice. Five cultivars of rice, namely IR36, IR 50, IET 4094, IET 444, IET 5656 with early and late transplanting were studied in this regard. It was found that gundhi bug preferred cultivar IR 50 & IR 36.

#### **2.1.7 Case worm: *Nymphula depunctalis* (Guenee)**

Case worm *Nymphula depunctalis* (Guenee) is a sporadic pest and occurs usually in young crop located in stagnant water. The attack is usually patchy and not continuous. The larva cuts the leaves into small bits and makes them into tubular cases of approximately its own body size. The larva remains inside the case and feeds on leaves, by scrapping the chlorophyll content. As a result, the plant growth and vigour are seriously affected. If the leaves are disturbed, the cases along with larvae fall on water surface. This is the characteristics symptom of case worm attack. The larva is aquatic and can breathe with gills. Stagnant water in field for longer period or intermitten rainfall or in late transplanted crop conditions are highly congenial for population build-up of the pest species.

Krishnlaiah *et al.*, (2008), reported that rice case worm, (*Nymphula depunctalis* Guen.) which previously remained localized and sporadic pest is now a regular and serious pest of late transplanted paddy in Uttar Pradesh, Madhya Pradesh, Jharkhand and Bihar.

Prasad *et al.*, (2018) reported that late planting, stagnant water in the field cloudy weather conditions and continuous drizzling or raining for longer period are highly favourable for higher incidence of the result. In the favourable agro-climatic

condition, the pest was found to cause severe damages to rice crop, irrespective varieties.

#### **2.1.8 Grass hopper: *Hieroglyphus banian* Fab.**

Grass hoppers are polyphagous insect pest. It also feed on rice.

Jhala and Sisodiya (2003) reported an outbreak of *Hieroglyphus spp.* which was hitherto only a minor pest, occurred in Aug. 2003 in Balashinor, Virpur & Kapadwanj, taluka of Keda district, Lunawada, Kadana, Khanpur & Sahera Taluks of Panchmahal district, Gandhinagar district, Malpur, Himmatnagar and Idar Taluks of Sabarkantha district and in some areas of Banaskantha district (all in Gujarat, India). The pest caused severe defoliation of fodder sorghum, maize, pearl millet and fodder grasses. It also damage rice, soyabean, pigeonpea in some of areas of that very region/locality.

Prasad and Prasad (2006) reported that rice grass hopper is a regular pest of rice in the agro-climatic conditions of Jharkhand. Its attack usually attains its peak almost during the months of October and November. However; periods of activity of this insect pest is from August to November in the rice agro ecology. Severities of damage caused by the pest to the foliage were more pronounced near the bunds and peripheral areas of rice fields.

#### **2.1.9 Armyworm: *Mythimna separata* Walker**

The insect pest usually occurs in massive scale like army's attack. so, it is called army worm. Army worm, *Spodoptera mauritia* (Boisd) and cutworm, *Mythimna separata* (Walker) comes under the noctuid group of pest occurring sporadically in rice and are most important insect pest(s) among the other insects of this group. *Spodoptera mauritia* (Boisd.) is a gregarious pest. It used to cause severe losses of rice crop before the green revolution era. This pest moves from one field to another field in large numbers like an army and almost completely defoliates the rice crop in the fields they invade. Hence the name army worm, Cut worms, at times become serious and feed on the foliage during initial stages of crop growth. After flowering, the larvae climb and cut the ear-heads resulting in falling of the entire ear head or a part of the ear-head, resulting in very serious losses to the crop. The infestation may occur just before harvest leading to falling of even matured grains in huge quantum.

Kumar *et al.*, (2003) conducted field survey on the incidence of pest of rice under rainfed low land ecosystem. The armyworm (*Mythimna separata* Walker) incidence was high during 1995/96 and 1997/98 (1.5-1.9 larvae per hill).

Spodoptera species is commonly known as army worm and *Mythimna* spp. are termed as ear cutting caterpillar or climbing cut worm. *Spodoptera* spp. usually prevails in the vegetative stage and *Mythimna* spp. occurs in the reproduction stage or even just before harvesting of the crop (Prasad and Prasad 2006).

#### **2.1.10 Mealy bug: *Brevinnia rehi* (Lindinger)**

Mealy bug is a common pest in upland and dry areas and in fields with uneven surface and where plant stand is not uniform and patchy. These mealy bugs are covered by a distinct waxy and powdery coating. Ants frequently visit the mealy bug infested plant and help in the dispersal of bugs from one plant to another. Both the adults and nymph suck the plant sap resulting in the stunted growth and curved yellowish leaves. In severe infestations, plants dry up and panicles do not emerge from the boot leaf. Damage occurs in patches and is severe under moisture stress conditions. As such, drought-light situation favours the incidence of the pest. Hence, summer rice crop are more prone to attack of the pest.

#### **2.1.11 Rice thrips: *Stenchaetothrips biformis* (Bagnall)**

Rice thrips (*S.biformis*) occur during the seedling stage and in early transplanted crop. The nymphs and adults suck the sap from the leaves. Due to this feeding, initially yellow streaks appear on the leaves and later they curl longitudinally from the margins inwards. The affected plants have sharp pointed leaf tips resembling needles, which finally dry up. The plants become lanky and present a sick appearance. Dry weather conditions are congenial for population build up of the pest. Hence, usually upland rice are more prone to attack of this pest.

#### **2.1.12 Brown plant hopper: *Nilaparvata lugens* (Stal.)**

Brown plant hopper emerged as a major pest of rice in India only after 1972, when large scale adoption of short-saturated high yielding and high nitrogen responsive varieties occupied major areas in deltaic areas of A.P., Tamil Nadu, Kerala and Karnataka, although this pest was notorious in parts of China, Japan, North and South Korea even during early parts of 20<sup>th</sup> century. In those country *japonicas* rice were traditionally grown with high fertilizer levels. The microclimate of rice crop which existed in *japonicas* rice varieties in those countries also started prevailing in India, Philippines, and Indonesia etc. which are tropical countries, after large scale

adoption of dwarf varieties. Although the microclimate in these tropical countries is not precisely delineated, shady atmosphere, high humidity, improper aeration, coupled with optimum temperature of 25-30<sup>0</sup>C appears to be responsible for rapid buildup of BPH causing heavy losses. Heavy nitrogen application associated with dwarf varieties also appeared to be responsible for major BPH epidemics in tropical countries. Adult BPH are dimorphic, winged as well as half winged males and females along with nymphs occur as mixed population in fields. Both adult and nymphs suck sap from the base of the tillers, resulting in yellowing and drying of the plants. At early stage of attack, round yellowish patches appear which soon turn brownish due to the drying up of the plants. The patches of the infestation spread in concentric circles within the field and in severe cases the affected field gives a burnt appearance known as “hopper burn”. The hopper populations can multiply very fast and migrate over long distances causing widespread infestation in short time. Apart from causing direct damage, BPH also acts as a vector of grassy stunt virus. The life cycle of the insect is completed within 20- 25 days depending on temperature. There are usually 3-4 overlapping generations during the crop season. The winged adults settle in the crop after 15-20 days of transplanting. But the population is usually very low. It is of the order of 2-5 insect per 100 hills. Hence, farmer cannot recognize its presence. It is only during 3<sup>rd</sup> or 4<sup>th</sup> generation, of the insect pest prevailing in the field, we can see the population in the damaging proportions. By that time, the crop comes to the flowering phase. That is the reason why farmers think that BPH attack rice crop only at flowering phase (Krishnaiah *et al.*, 2006).

Prasad *et al.*, (2018) reported that since last four five years, BPH was attaining as major insect pest of rice but sporadically in the state of Jharkhand. Earlier, the pest was of only academic in the rests only in the state.

#### **2.1.13 White backed plant hopper: *Sogatella furcifera* (Horvath)**

White backed plant hopper (WBPH) used to be confined to North –Western belt of Punjab, Haryana, and Western Utter Pradesh. Later, the pest has spread to almost all areas where rice is grown and started occurring together with BPH in many deltas of the Southern states. This has emerged as a serious pest in areas particularly where rice varieties resistant to BPH are grown. The partially cleared ecological niche due to low population of BPH on resistant varieties appeared to have triggered the multiplication of WBPH on those varieties. WBPH is relatively smaller in size compared to BPH with conspicuous white spots on dorsal thorax, hence, the name

white backed plant hopper. The nature of damage and the biology of WBPH are similar to BPH. Both nymph and adult suck sap from phloem and cause drying up of plants. Unlike BPH, it does not cause sudden and severe hopper burn. WBPH is not known to transmit any of the virus disease of rice. The ecological conditions like high humidity (90 to 100%), optimum temperature (22-27<sup>0</sup>C) is very similar to BPH. The most significant difference between BPH and WBPH is that WBPH tends to be more numerous during early stages of crop growth i.e., up to 40 DAT, while BPH multiplies faster later on in many of the deltaic areas WBPH is confined mostly to *kharif* season while BPH occurs during both *kharif* and *rabi* season.

#### **2.1.14 Termite: *Odontotermes obesus* (Ramb.)**

The insect appeared as a negligible pest for rice grown in transplanted ecologies. Very low pest incidence ranging from 4.50 to 10.50 percentage of dead heart (DH) was noticed in the medium land. In the low land 2.50 to 7.50 percent plant damage due to termite was recorded during July to August. However in upland, direct seeded rice are more prone to attack of termites. Prasad *et al.*, (2006) opined almost similar views.

#### **2.1.15 White grub: *Holothrichia spp.***

The pest appeared as a pest of very negligible form ranging from 0.55 percent plant damage (1<sup>st</sup> fortnight of August) to 1.78 % plant damage in 1st fortnight of October. Prasad *et al.*, (2006) also observed the occurrence of the pest almost in similar fashion. In upland situation, the pest attack is more pronounced, wherein farmers used to place heaps of FYM or used to grow ground-nut crop.

### **2.2 Host plant resistance for management of insect pest complex of rice.**

HPR is an important tool of IPM, because pest can be easily managed by raising pest resistant or tolerant variety with either no use or minimum use of pesticides on need based basis for sustainable crop production.

Use of HPR is not only environment friendly but also it is cost effective. Resource poor farmers cannot afford the expenses incurred on the insecticidal inputs to protect their crop. They need pest resistant or tolerant rice varieties to realize better and higher yield of grains without minimum or no pesticidal application for sustainable rice production. Hence, an attempt has been made to collect information from the available literatures pertaining to host plant resistance (HPR) so as to get a feed back in this context and regard.

#### **2.2.1 Rice stems borer: *Scirpophaga incertulas* (Walker)**

Singh, *et al.*, (1998) evaluated 20 AVT and 35 IVT entries of Basmati group of rice against the infestation of brown plant hopper (BPH), white back plant hopper (WBPH) and yellow stem borer (YSB : as white ear heads) during 1997-98 by using SES (Standard Evaluation Systems developed by IRRI) scale at crop research station, Masodha, Faziabad. The general pest pressure was sufficiently high enough to evaluate the entries during the period of evaluation. IET 15819, 158234 and 15829 were highly resistant and IET 15813 was susceptible to yellow stem borer at maturity of stage of the crop.

Mann and Shukla (1999) screened seventy genotypes of rice in an experiment for resistance to yellow stem borer (*Scirpophaga incertulas*). HKR 90-413 and OR 1302-15-1 were resistant at the dead heart and white ear stage. Six genotype were resistant at white ear stage but moderately resistant at dead heart stage. Eleven genotype were resistant at dead heart stage but moderately resistant at white ear stage. Forty six genotypes were susceptible at white ear stage though they were moderately resistant at dead heart stage of the crop.

Forty-five rice cultivars were screened against stem borer (*Chilo suppressalis*), whorl maggot (*Hydrellia philippinal*) and leaf folder *Cnaphalocrocis medinalis*. Four cultivars, viz. NDR 1025-2, NDR-2022, NDR 2024 and NDR 4010 were free from stem borer; six cultivars, NDR 1058-1-4, NDR 1025-2, IET 13310, NDR 2070, Saroja 52 and NDR 4105 were free from whorl maggot and four cultivars viz., NDR 1058-1-4, IET 13310, NDR 2025-2, and Mashuri, were free from leaf folder as reported by Gupta *et al.*, (2002).

Abrol *et al.*, (2003) evaluated twenty coarse and nineteen fine grain rice cultivars for relative resistance to yellow stem borer, *Scirpophaga incertulas*, and pink stem borer, *Sesamia inferens*, under field conditions (Pakistan, 1996). Among the fine grain cultivars Basmati 15-3 was most susceptible cultivar to the borer species.

Prasad (2010) observed that the transplanted rice crop was infested with three major pests viz. YSB (Yellow stem borer), GM (gall midge) and leaf folder. Two entries viz. Suraksha and Ajay remained moderately resistant to all the three pest species as all the three pest species were found to damage below 10% in these two varieties of rice.

Patel and Singh (2017) conducted field experiment to study the seasonal incidence of YSB. Transplanting of eight paddy varieties (PR-113, HKR-47, NDR-359,

Sarju-52,PS-4,PS-5,PS-15 and PS-21) was done on 11th July 2016 during *Kharif* season for investigating the seasonal incidence of rice stem borer, *Scirpophaga incertulas* (Walker) on different varieties of paddy. Dead heart started from 32th standard week and continued upto 38th standard week, while white ear head was recorded on 35th standard week and it reached peak in 45th standard week. On the basis of peak infestation period, the maximum dead heart was recorded on PS-15(30.3%) while, minimum dead heart was found in HKR-47(14.6%) variety of paddy. The white ear head percent was ranged from 27% to 44.9%. Varietal reaction did not play a prominent role for the high or low stem borer incidence. Relationship of weather parameters indicated that they play a major role in creating the variation in *S. incertulas* prevalence. Temperature and relative humidity conducive during the cropping season, wide variation was recorded in the amount of rainfall and its distribution in along with the variation in sunshine hour. High rainfall during, August with low sunshine hours in September, followed by gradual decrease of rainfall with increase in sunshine hours towards October resulted in more *S. incertulas* incidence.

### 2.2.2 Gall midge: *Orseolia oryzae* Wood Mason (Diptera: Cecidomyiidae)

Pasalu *et al.*, (2004) reported that more than 100 insects have been recorded as pests of rice of which a dozen are of economic significance in India. They reported that CR-143, Eswarakora, Leuang 152, Ob 677, Rb 10, Ptb 18, Rb 21 and Siam 29 could be excellent donors for breeding gall midge resistant varieties of rice. As per their reports, Sneha, Pothana, Kakatia, Erramallelu, Kavya, RD202, Kama, Ruchi, Smridhi, Usha, Asha, MDU-3, Bhuban, Samalei, Orugalla, Abhaya, Shaktiman, Surekha, Suraksha, Daya, Pratap, Udaya, IR-36, Tara, Kshira, Neela, Lalat, Phalgun, Mahaveer, Vibhava, Divya, Dhanya, Lakshmi, Vita-am, Kunti and Triguna are released rice varieties of rice, which are resistant against gall midge (*O.oryzae*). They also revealed that Ptb 2 and W 1263 are excellent donor for breeding stem borer resistant rice varieties and Lalat, Vikramarya, Khaira and Nidhi are varieties of rice which are resistant to GLH (green leaf hopper). They found that TKM6 is promising donor for breeding stem borer resistant rice varieties.

Rani *et al.*, (2007) recorded that the variety MDU 3 treated with FYM, Azospirillum, Phosphobacterium, SSB, lignite flyash and neem cake recorded the lowest percent (1.92 % SS) of silver shoot and gall midge incidence was significantly less in the var. MDU 3 treated with FYM, Azospirillum, Phosphobacterium, SSB,

lignite flyash and neem cake. The adoption of IPM technology also accrued higher monetary benefit (Rs.2.75-3.73) against unit cost of pest management operation.

Prasad *et al.*, (2008 a) reported that judicious application of the recommended insecticides viz. monocrotophos 36WSC @ 1390ml/ha alternated with (chlorpyrifos 20 EC) @ 2.5lit/ha per spray supplemented with the host plant resistance (HPR) could be a promising IPM strategy for realizing substantially higher grains yield with possible minimum environmental hazards and maximum health safety.

Prasad (2010) reported that the transplanted rice crop was infested with three major pest viz. YSB, GM and leaf folder. Two entries viz. Suraksha and Ajay remained moderately resistant to all the three pest species as all the three pest species were found to cause damage below 10% in these two varieties in the state of Jharkhand.

Prasad (2010) found that 6 entries remained free from the attack of gall midge. These entries were: ARC 6605, MR 1523, RP 2068-18-5. Jhitpiti, INRC 3021 and Aganni in the agro climatic conditions of Ranchi region of Jharkhand state.

Prasad and Prasad (2011) conducted field experiment during wet season of 2009 and 2010 in the farmers field in the gall midge endemic areas Simdega district of Jharkhand to screen out certain popular rice varieties against gall midge. They found that five rice varieties viz. Naveen, Lalat, BVD -203, BG 380-2 and IR-36 exhibited as moderately resistant to gall midge which, in turn, gave rise to the higher grain yields to the tune of 43.59, 38.29, 33.58, 34.56 and 32.07q/ha. The popular hybrid rice variety PA-6444 appeared to be tolerant to gall midge as it gave rise to the higher yield of 41.41q/ha, despite of suffering from relatively higher incidence of silver shoot, SS(18.11%) and hill (plant) infestation(HI)with the pest to the tune of 54.06 percent. The susceptible varieties viz. IR-64 and Birsamati registered highest pest incidence of SS(%) to the extent of 23.63 and 39.86 percent, which resulted to the considerably lowest grains yield of 16.94 and 18.60 q/ha respectively in gall midge endemic area (i.e. Simdega) of the agro-climatic conditions of Jharkhand.

### **2.2.3 Rice hispa: *Dicladispa armigera* Oliver (Coleoptera: Chrysomelidae)**

Bentur *et al.*, (2011) reported that Sahyadri, Suraksha, Bidhan Dhan-2, Sabita, IR-64 and PTB-33 proved to be resistant against rice hispa.

Soren and Prasad (2013) found that the minimum leaf damage caused by hispa (HDL) in case of Kavya at both the dates of observation (30 and 45 DAT). The maximum pest incidence (29.60% HDL) was registered in case of TN-1,IR-64 and

Pusa Basmati-1 also received somewhat higher leaf damage caused by hispa, to the tune of 23.40 and 18.38 percent HDL%.

Hembrom and Prasad (2014) found that the rice genotypes viz; BG-380-2 (4.85% LDH), Kavya (5.15% LDH) and Suraksha (5.38 % LDH) emerged as highly promising and resistant to hispa (*D. armigera*) and highest attack of the pest to was noticed in case of TN-1 followed by IR-64, MTU-7029 and Pusa Basmati-1.

Kumar and Prasad (2017) revealed that the minimum incidence leaf damage was recorded in case of Suraksha at all the three dates of observations viz. 30, 40 and 50 DAT amounting 1.50, 2.30 and 2.90 percent of leaf damage respectively. Suraksha remained almost at par with the rice variety Kavya, receiving 2.40, 3.80 and 4.60% LDH at the respective dates of observations. The other rice varieties, viz. BG-380-2, IR-36 and Naveen emerged as moderately resistant receiving mean leaf damage to the term of 9.30, 11.30 and 10.14% LDH, respectively.

#### **2.2.4 Rice leaf folder: *Cnaphalocrocis medinalis* Guenee**

Dhaliwal, *et al.*, (1979) observed that infestation of *C.medinalis* increased with increasing nitrogen levels and was heaviest in PR422, PR2993, PR476 and lowest in Palman 579, PR 106 and PR 484. They also reported that the leaffolder generally had more preference towards scented varieties as compared to short and medium duration non aromatic varieties.

Dhaliwal (1980) reported, on the basis of screening 334 entries that none of the cultivar was free from leaffolder damage .Though IET 6251 recorded the lowest damage, caused by leaffolder.

Gowda *et al.*, (1981) found that the percentage of leaf damage caused by leaf folder from 10.6 to 100 percent and was lowest in ARC 25(10.6%) followed by KMP113 (11.8%) and KMP 58 (28.7%).

Dhaliwal *et al.*, (1983) also found increase in leaf folder incidence when nitrogen dose was increased in rice agro ecosystem.

Dhaliwal *et al.*, (1984) evaluated 39 entries in field during kharif and found that IR 9224-1177-2-3-3 showed resistant reaction against leaf folder.

Rajendran and Velusamy (1987) identified 12 cultivars resistant to leaf folder viz. BKNBR 1088-83, RP 2199-41-25-30-55, RP 2199-249-209, PTB-12, RP 2035-48-54-6, RP 2235-85-62-8, RP 2235-115-75-40, RP 2235-136-65-10, TNAULFR 8311324, TNAULFR 832042 and T 2005 exhibited as leaf folder resistant varieties.

Saroja, *et al.*, (1987) observed that rice variety DPI 1091/5 was highly resistant to *C.medinalis*.

Chitra *et al.*, (1998) reported that growing resistant cultivars would be able to reduce the pesticide load and thus can be of greater value for a eco-friendly future.

Forty–five rice cultivars were screened against stem borer (*Chilo suppressalis*), whorl maggot (*Hydrellia philippinal*) and leaf folder *Cnaphalocrocis medinalis*. Four cultivars, viz. NDR 1025-2, NDR-2022, NDR 2024 and NDR 4010 were free from stem borer; six cultivars, NDR 1058- 1-4, NDR 1025-2, IET 13310, NDR 2070, Saroja 52 and NDR 4105 were free from whorl maggot and four cultivars viz., NDR 1058-1-4, IET 13310, NDR 2025-2, and Mashuri, were free from leaf folder as reported by Gupta *et al.* (2002).

Prasad *et al.*, (2006) opined that Lalat is relatively more prone to attack of rice leaf folder.

Hembrom and Prasad (2014) were reported that Kavaya, BG- 380-02 and Suraksha emerged as promising and resistant against leaf folder. The highest incidence of the pest was noticed in case TN-1 and followed by Lalat, IR- 64 and MTU- 7029

Kumar and Prasad (2017) revealed that the minimum leaf damage caused by the pest (*Cnaphalocrocis medinalis*) to the tune of 1.50, 2.40,3.70and 4.50 percent LDLF was recorded at 50, 60, 70 and 80 DAT with mean of 3.02% LDLF, Kavaya, BG-380-2 and IR-36 remained almost at par in this regard. The highest incidence of the pest was found in case of TN-1 receiving LFDL of 17.50, 19.30, 24.50 and 25.70 percent with maximum mean leaf damage of 21.75% LDLF. The scented rice varieties viz. Birsa Mati, Pusa with the overall mean leaf damage upto 14.25, 17.55 and 16.45% LDLF Basmati-1 and BVS-1 remained moderately susceptible to leaf folder.

### **2.2.5 Green leaf hopper: *Nephotettix spp.* (Hemiptera: Cicadellidae)**

Angeles and Khush (2000) studied inheritance of green leaf hopper (*Nephotettix virescens*) in five rice cultivars. These cultivars were known to have dominant genes for resistance which are independent of Glh 1, Glh2, Glh3, Glh5 and Glh 9(t). Allelism tests with Glh 11(t) showed that the dominant genes in the five cultivars segregated independently of Glh 11(t). Allele test revealed that cultivars Hashikalmi, Ghaiya, ARC 10313 and Garia have the same gene for resistance which is designated as Glh 12(t).

Soren and Prasad (2013) found that Kavya, IR-36, Lalat, IR-36 and Navin proved to be highly promising against the attack of green leaf hopper. On the other hand, TN-1 was found to be highly prone to the attack of GLH, which was followed by Pusa Basmati-1.

Hembrom and Prasad (2014) reported that the rice variety, TN-1 was received the highest level of the pest population amounting to 60.38 and 56.51 GLH /10 hills during 2011 and 2012, respectively. The rice varieties viz RD.-202, MTU 1010, BVS-1 and Lalat harboured relatively lesser population of pest to the extent of 19.48 to 25.60 GLH/10 plants (hills).

Kumar and Prasad (2017) revealed that the rice varieties, BG-38-2, IR-36 and Naveen exhibited as moderately resistant green leaf hopper (GLH) and TN-1, Badshah Bhog, BVS-1, Arize- 6444 and BR-9 appeared as susceptible to green leaf hopper.

## **2.2. 6 Gundhi bug: *Leptocorisa acuta* Thunb. (Hemiptera: Alydidae)**

Chitra *et al.*, (1998) reported that growing resistant cultivars would reduce the pesticide load and thus can be of greater value for a eco- friendly future.

Gundhi bug preferred the rice cultivars IR 50 and IR 36 as reported by Sivakumar *et al.*, (2003).

A field experiment was conducted by Shitiri *et al.*, (2014) during the wet season of 2011 at the experimental farm of ICAR Complex for North East hill region, Jharnapani, Medziphema, Nagaland using Split Plot Design to study on the effect of cultivars and botanicals on the incidence of major insect pests in lowland rice. A rice variety, Ranjit and two rice cultivars, Miracle rice and Jalukie special were selected and three major pests were taken into account for the study. Peak incidence of rice stem borer and leaf folder in all the three varieties were observed at 105 days after transplanting of the crop. Jalukie special harboured the maximum number of borer population (26.67%) followed by ranjit (26.30%) and miracle rice (23.00%). Leaf folder incidence was maximum in ranjit (29.47%) followed by miracle rice (27.83%) and lowest incidence was in jalukie special (27.33%). The incidence of ear head bug was observed from 60 days after transplanting till harvest. Peak incidence was observed at 120 days after transplanting. Incidence was highest in ranjit (4.43 bugs 5 sweeps-1) followed by Miracle rice (3.57 bugs 5 sweeps-1) and Jalukie special (3.13 bugs 5 sweeps-1). Among the botanical treatments, *Litsea citrate* seed extract was found to give effective control against the three pests almost at par with

Monocrotophos. Crude stem extract of *Costus speciosus* and seed extract of *Chenopodium ambrosioides* were also found to be effective in reducing the pests.

### **2.3 Effect of staggering in date of transplanting on the incidence of insect pest complex of rice.**

Climatic factors such as temperature, relative humidity, rainfall, and mass air movements may affect the distribution, development, survival, behaviour, migration, reproduction, population dynamics and outbreaks of insect pests of rice. These factors usually act in a density-independent manner, influencing insects to a greater or lesser extent depending on the situation and the insect species. Temperate conditions set the basic limits to insect distribution, and examples are given of distribution patterns in north eastern Asia in relation to temperature extremes and accumulation. Diapause is common in insects indigenous to the temperate regions, but in the tropics, diapause does not usually occur. It is induced by short photoperiod, low temperature, and sometimes the quality of the food to enable the insect to overwinter. Population outbreaks have been related to various climatic factors, such as previous winter temperature, temperature of the current season and rainfall. High temperature and low rainfall can cause a severe stem borer infestation. Rainfall is important for population increase of the oriental armyworm and of rice green leafhoppers and rice gall midges in the tropics. The cause of migrations of *Mythimna separata* (Walker) has been traced to wind direction and population growth patterns in different climatic areas of China. It is believed that *Sogatella furcifera* (Horvath) and *Nilaparvata lugens* migrate passively each year into Japan and Korea from more southerly areas. Probably these insects spread out annually from tropical to subtropical zones where they multiply and then migrate to temperate zones. Some knowledge is available on the effects of climate on rice insects through controlled environment studies and careful observations and statistical comparisons of events in the field; however, much more conclusive evidence is required to substantiate numerous suggestions in the literature that climatic factors are related to, or cause, certain biological events.

Meagre and scanty information's are available in literature pertaining to date of planting on the incidence of insect pest of rice. Hence, under AICRIP (ICAR), some efforts have been made to generate some valuable information by conductance of experiment on effect of planting dates on pest incidence of rice and their ultimate impact on grains yield of rice under the influence of climate change and farming practices.

According to Shrivastava *et al.*, (2008) cultural control methods act as first line of defense, as modification of certain farm operations make the environment unfavorable for insect multiplication. Modification of planting, growing, cultivating, harvesting, plant spacing cropping system and fertilizer management technique prevent build up of populations of certain insect pest species infesting the crop.

Magunmder *et al.*, (2013) conducted the field experiment in the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, Bangladesh in order to investigate the effects of rice variety and planting dates on the incidence of insect pests and natural enemies. Three varieties Binasail, Binadhan-4 and TN-1 were transplanted on four different dates. Both rice variety and planting date had significant effects on pest incidence. Binasail and Binadhan-4 hosted lower populations of insect pests as compared to the other varieties. Early planted rice had lower pests and natural enemy's population than later-transplanted rice. There were interaction between varieties and transplanting date, while early transplanted BINA dhan4 hosted the lowest population of insect pests, but TN-1 variety when was cultivated at late season, showed the highest insect-pest population. In case of natural enemies the highest abundance was observed in the variety of TN1 at 1st transplanting date. The study concluded that early planting resulted in lower incidence of plant and leaf sucking pests and recommended the early planting of BINA dhan 4 and Binasail.

Prasad and Prasad (2015) studied the impact of staggering in date of planting on incidence and abundance of major insect pests of rice in wet season in the agro-climatic condition of Jharkhand. They found that earlier (1<sup>st</sup> week of July) was the date of planting, lesser was the incidence and abundance of major insect pests viz, YSB, hispa, GLH, gall midge and leaf folder infesting rice and the intensity of attack of these pest species was found to increase with delaying in the date of transplanting latest upto the 3<sup>rd</sup> week of August. Yield realization of rice grains also followed almost similar trends. On the contrary, they also found that earlier was the date of planting, higher was the incidence and abundance of ear bug infesting rice.

**Reports on impact of dates of planting on major prevailing insect pests of rice during 2012, 2014, 2015, and 2016 at difference locations regions of India as reported by Anonymous (2012, 2012, 2014, 2015, and 2016), under AICRIP rice entomological experiments.**

Anonymous 2012: In brief, across the locations, mean pest incidence in different dates of planting indicated that damage caused by the insect pests (%DH,

%WE, %LFDL, %WMDL, %SS, %CWDL & GB/hill) was relatively high in late planting as compared to early and normal plantings whereas the number of BPH/WBPH per hill were high in early planting as compared to late planting.

Under the AICRIP, the experiments were conducted at various location, during 2014; Overall the mean insect pest incidence across location was low in different dates of planting during *kharif* 2014. There was not much difference in insect pest incidence /damage in different dates of planting with respect to gall midge and leaf damaging insects such as leaf folder, whorl maggot, hispa, rice skipper and gundhi bug. However, dead hearts and white ears caused by stem borer were relatively high in late planting. BPH population was high in normal and late plantings as compared to early planting whereas white backed plant hopper was high in normal planting. Grasshopper damage and GLH population were observed high in early planting. White leafhopper (WLH) incidence was observed only at Chinsurah in early and late plantings (Anonymous, 2014, AICRIP).

Briefly, effect of planting dates on insect pest incidence (EPDP) trial was conducted at 19 locations during *kharif* 2014. Dead heart damage was low across 15 locations while white ear damage was high in early planting at Raipur alone (39.36%) and in late planting at Nawagam (35.4%), Faizabad (34.14%), Pusa (22.36%) and Raipur (20.09%). Gall midge damage was observed at 6 locations and found high at Sakoli during normal planting (14.88% SS) followed by late planting (12.79%). Leaf folder damage was low in all the plantings at 15 locations except at Nawagam in late planting (16.52%) and Ranchi in normal planting (12.38%). Incidence of whorl maggot, hispa, case worm, grasshopper, rice skipper and GLH was low in all the plantings across the locations. BPH and WBPH incidence was observed at 7 locations but was found high only at Gangavathi in normal planting (28.21 BPH/hill & 26.02 WBPH/hill). White leafhopper (WLH) incidence was observed only at Chinsurah in early and late plantings.

According to Anonymous 2015 (AICRIP), overall, the mean insect pest incidence across the locations during *kharif* 2015 was moderate to severe in different dates of planting. Incidence of stem borer, gall midge, whorl maggot, caseworm, grasshopper, skipper, BPH, WBPH, GLH and gundhi bug was significantly high in late planting as compared to early and normal plantings. However, leaf folder incidence was low in normal planting and at par in both early and late plantings whereas hispa and white leafhopper incidence was relatively high in early planting as

compared to normal and late plantings. For the first time, incidence of *Pyrrilla sp.* was reported from New Delhi in normal planting alone.

In brief, effect of planting dates on insect pest incidence (EPDP) trial was conducted at 20 locations during Kharif 2015. In general, the pest incidence was moderate to severe across locations and relatively high in late planting. Dead heart damage was low at 15 locations in all the plantings while it was high in normal planting (22.18%) at Pusa and in late planting at Titabar (26.75%). White ears were recorded at 17 locations, of which the damage was high in late planting at Karaikal (22.49%) followed by Titabar (21.64%). Gall midge damage was observed at 7 locations with highest damage in late planting at Sakoli (34.09%) followed by Titabar (16.48%). Of the 16 locations at which leaf folder incidence was observed, highest damage was recorded at Titabar in late planting (30.28%) and in all the three plantings at Brahmavar (26.80 – 26.92%). Caseworm damage was recorded at 3 locations with highest damage in late planting at Titabar (37.36%). BPH incidence was observed at 9 locations while WBPH at 5 locations. Highest population of BPH (16/ hill) and WBPH (20/ hill) was recorded in late planting at Gangavathi. White leafhopper was observed from 2 locations i.e., Chinsurah and Karaikal, grasshopper and skipper were recorded only from Khudwani. For the first time, *Pyrrilla sp.* was observed in normal planting at New Delhi.

Anonymous 2016 (AICRIP), in nutshell effect of planting dates on insect pest incidence (EPDP) trial was conducted at 18 locations during Kharif 2016. In general, the pest incidence was low to moderate in different dates of planting across locations. Stem borer damage was reported from 13 locations, of which highest damage of dead hearts was observed at Titabar in late planting (27.51%) followed by Navasari in late planting (20.75%). Similarly, white ear damage was high in late planting at Navasari (25.84%). Gall midge incidence was reported from 6 locations with highest damage of 15.84% SS at Titabar in late planting. Among the defoliators, leaf folder incidence was reported from 16 locations with highest damage at Titabar in late planting (25.26%). Low incidence of whorl maggot (<10%) was reported from 4 locations and hispa (<5%) from 2 locations. Caseworm incidence was reported from 3 locations with highest damage at Titabar in late planting (24.93%). Both, plant and leaf hoppers were reported from 5 locations. Highest population of BPH (12/hill) was observed in late planting and WBPH (13/hill) in normal planting at Gangavathi. Grasshopper incidence was observed at two locations viz., khudwani and chatha while rice skipper

incidence was also observed at Khudwani alone, Horned caterpillar incidence (<5%) was observed at Navasari alone in all the plantings.

### **2.3.1 Rice stems borer: *Scirpophaga incertulas* (Walker)**

As per finding of Garg and Vema (1994) it was observed that September sown crops suffered less damage by stem borer, while gall midge and leaf folder load was minimum during October sown crop.

Singh and Chander (2001) opined that the change of planting times create phonological asynchrony between pest and host and effect of shift in planting time is more site specific than any other cultural control methods. It was observed that early planting minimized incidences of gall midge, thrips, grasshoppers, stem borer, leaf folders, leaf hopper, and plant hopper. Late planting maximized the incidence and abundance of many of the pests, viz. gall midge, thrips, stem borer, leaf hoppers, plant hopper, seed bug, leaf miner and white grub.

Suharto and Usyati (2005) revealed that *S. incertulas* damage as on 14<sup>th</sup> day before farmer's transplanted crop had higher (average 37.90%) infestation as compared to those found at common transplanted, and 14 days after farmers planted crops (0.65 % and 0.54% ), respectively.

Sarwar (2012) conducted field experiment to determine the effects of host plant resistance in early, medium and late sown varieties of rice [2 non aromatic IR8 (P) and Sharshar, and 2 aromatic Basmati 370 (P) and Mehak] due to the incidence of rice stem borers. Treatments comprised the crop sown on 3 different dates at the fortnightly intervals starting from the last week of June till the end of July to note the rate of stem borer's infestation. The data on the incidences of insect pests and yield performances of rice varieties were studied. Rice yellow stem borer, *Scirpophaga incertulas* (Walker) (Lepidoptera: Pyralidae), was the most important insect pest of rice, attacking all stages of the crop causing substantial losses in early, medium and late sown crops, and degree of stem borer infestation depended upon the planting time. The pest incidence was the least on early sown crop as compared to medium and late sown crops. Similarly, the highest yield was obtained in early sown crop, and the crop sown after this date showed drastic reductions in yield. Among different varieties tested, Sharshar showed best results in holding least pest infestation and increased grain yield approached by, IR8 (P), Mehak and Basmati 370 (P). Hence, use of tolerant rice varieties and their early sowing under agro climatic conditions of this region is recommended to protect the crop from borer's invasion.

Sarao and Mahal (2013) evaluated four methods of rice crop establishment, viz. conventional transplantation, bed transplantation (BT), furrow transplantation (FT) and puddled direct seeding (PDS), were evaluated during two wet seasons to determine their influence on the incidence of insect pests and grain yield. Observations were recorded starting from 40 days after transplanting (DAT) and seeding (DAS) to 110 DAT and DAS. The interaction between crop establishment methods and observation days was significant in the case of folded leaves by *Cnaphalocrocis medinalis* (Guenée), dead hearts by *Scirpophaga incertulas* (Walker) and the *Sogatella furcifera* (Horvath) population. The number of folded leaves in the bed-transplanted crop (8.87%) and puddle direct seeded crop (10.62%) was significantly higher than that in crop grown using the other crop establishment methods. The incidence of deadheart damage was significantly higher in the PDS plots (5.85%), while that of white head damage was higher in the BT (5.89%) and PDS (6.54%) plots than in the plots managed by the other methods. *S. furcifera* population build-up was significantly higher in the FT (1.98 hoppers/hill) and PDS (2.24 hoppers/hill) plots than in the plots managed by the other crop establishment methods. Paddy yield was significantly higher in the conventionally transplanted crops followed by the furrow- and bed-transplanted crops.

Hugar *et al.*, (2014) assessed the effect of date of sowing on infestation by yellow stem borer (YSB) in rice. During *Kharif* season in aerobic rice, peak activity was noticed at 60 DAS in all the dates of sowing with 2.13, 3.85, 6.23, 7.97, 9.94 and 12.03 percent DH, respectively. Grain yield of 30th May and 15th June aerobic rice sowing crop was higher with 48.55 and 46.48 q/ha, respectively, whereas, in 30th July and 15th August aerobic rice sowing crop, yield was as low as 18.92 and 15.93 q/ha, respectively. During the *Rabi* season, the percent DH infestation in aerobic rice was least in 30th November sowing with 0.05, 0.20, 0.70, 1.55 and 1.45 percent at 30, 45, 60, 75 and 90 DAS, respectively and percent WH of 0.82 prior to harvest with higher yield of 49.86q/ha followed by 15th December, 30th October, 15th November and 30th September sown crop with yield of 47.89, 37.96, 22.16 and 19.81 q/ha, respectively with decreased order in incidence. Whereas, the infestation was highest in 15th October sown crop with percent DH of 0.72, 1.63, 6.75, 9.40 and 6.4 at 30, 45, 60, 75 and 90 DAS, respectively and percent of WH of 7.4 prior to harvest with lowest yield of 16.60 q/ha.

Kumar and Prasad (2017) reported overall impact of dates of transplanting was found to be descending order of: early planting >normal planting >delayed planting > very late planting.

### 2.3.2 Gall midge: *Orseolia oryzae* Wood Mason (Diptera: Cecidomyiidae)

Ogah *et al.*, (2006) conducted field experiments to evaluate the effect of dates of transplanting (July 31, August 14 and August 28), plant spacing (10 cm x 10 cm, 20 cm x 20 cm and 30 cm x 30 cm) and nitrogen levels (0 kg ha<sup>-1</sup>, 80 kg ha<sup>-1</sup> and 160 kg ha<sup>-1</sup>) on infestation of rice by African rice gall midge. The experiments were conducted at West African Rice Development Association (WARDA) research farm at Ogidiga near Abakaliki during the 2002 and 2003 farming seasons. The experiments were laid out in split-split- plot in randomized complete block design. The rice variety used for the experiments was ITA 306 a susceptible variety to African rice gall midge. Percentage infestation of rice by African rice gall midge were most severe (47. 5% and 41.32%) on earliest transplanted rice (July 31) irrespective of plant spacing and nitrogen levels for all the experimental years. Similarly rice plants on plots with the least plant spacing (10 cm x 10 cm) had the highest infestation of 40.6% and 33.40 % by African rice gall midge for 2002 and 2003 respectively. Severity of infestation was found to decline with the increasing plant spacing. Percentage infestation increased significantly (P=0.05) with the increasing levels of nitrogen with 34. 3% and 25.75 % infestation recorded in plots treated with 160 kg ha<sup>-1</sup>. Date of transplanting, plant spacing and nitrogen level significantly influenced the grain yield of rice with highest grain yield of 188.9 g, 307. 9 g and 198. 9 g for the second planting date, 30 cm x 30 cm plant spacing and 80 kg ha<sup>-1</sup> nitrogen levels respectively.

Echezona *et al.*, (2006) carried out field experiments during 2003 and 2004 to evaluate the effect of planting dates (14 July, 11 August and 8 September) and nitrogen rates (0, 80 and 160 kg N ha<sup>-1</sup>) on African rice gall midge (*Orseolia oryzivora*) infestation in rice grown on lowland, subhumid, tropical conditions of Ebonyi State, Nigeria. The results showed that pest infestations were significantly higher on rice planted in July than those planted in either August or September. Increasing the N rates significantly increased pest infestation irrespective of the planting date. Grain yields of rice were higher in August than in any other months given the same treatments. The highest grain yield was obtained from plots that received 80 kg N ha<sup>-1</sup>; further increase from 80 to 160 kg N ha<sup>-1</sup> decreased grain yield

by 7.7% in 2003 and 11.7% in 2004. Differences in planting date  $\times$  N fertilization interaction among insect counts and grain yield did not attain any level of statistical significance. Conversely, differences in date  $\times$  N fertilization interaction on tiller number, plant height and panicle number per hill were significant ( $P < 0.05$ ).

Souleymane *et al.*, (2006) conducted field experiments during the rainy seasons in 2003 and 2004 in central Burkina Faso to assess the importance of the African rice gall midge *Orseolia oryzivora* Harris & Gagné in relation to the planting date under irrigated conditions. The young midge larva feeds at the growing point of the rice tiller, which stimulates the plant to produce an oval hollow gall that prevents the plant from heading. Experiments consisted of three treatments arranged randomly within each of the four replications. Treatments were planting dates separated by 7 days. The rice cultivar planted in the experiment was FKR 14, which matures in 120 days. Nine entomological evaluations (assessment of the number of galls per hill) were performed for each planting date; starting at 25 days after transplanting (DAT) and ending at 81 DAT. Evaluations were conducted on 20 randomly selected hills and consisted of counting the total number of tillers and galls per hill. These hills were identified on one of the two diagonals of each treatment. At the rice maturation stage, 20 randomly selected hills were harvested and the grains from each hill were weighed and recorded. Yield loss was estimated for each treatment from these data. Results showed that the later the planting date, the higher the damage caused by *O. oryzivora*. The damage was low ( $< 10\%$ ) during the vegetative phase but increased dramatically ( $> 20\%$ ) during the reproductive phase of the rice plant, regardless of the planting date. Yield losses were correlated to the observed damage: In 2003, for the first planting date, 1% of galling was associated with 1% yield loss, while the same level of damage was associated with 1.3% yield loss for the second planting date.

Singh *et al.*, (2007) carried out field experiment during *kharif* 1997 and 1998 in Imphal (Manipur, India) to determine the influence of planting time on the incidence of rice gall midge (*O. oryzae*) in rice crops. Three susceptible rice cultivars, i.e. Leimaphou, Norin18 and TN1, were used for the experiment and seven transplanting dates starting from 23 June at weekly interval were maintained. In all the tested cultivars, the lowest incidence was observed in the earliest transplantation at both 30 and 50 days after transplanting (DAT). The infestation gradually increased with delay in transplanting and highest infestation at 50 DAT was recorded in 28 July transplanting. A strong positive correlation between planting date and gall midge

infestation was observed in all the three cultivars. At 50 DAT, there was 0.550, 0.392 and 0.450% increased in gall midge incidence for every week delay in transplanting in Leimaphou, Norin18 and TNI, respectively

Karim *et al.*, (2016) reported that the African Rice Gall Midge, *Orseolia oryzivora* H. & G., is an important insect pest recorded in 20 countries in Sub-Sahara Africa. In Burkina Faso, the insect pest particularly prevails in Western and South-Western of the country where both biotic and abiotic conditions favor its development. The insect pest can damage up to 60% of rice tillers in Western Burkina Faso. A study was conducted during the 2011 wet season in the Kou Valley, located 25 km North-West of Bobo-Dioulasso, Western Burkina Faso. Its objective was to evaluate the damage of this insect pest in farmers' fields in relation with rice transplanting periods. The Kou Valley rice scheme, 1200 ha, was divided into two zones within which 48 farmers' fields were randomly selected in relation with rice transplanting periods: P1: 1st period; P2: 2nd period and P3: 3rd period; that is 16 fields per period. Both agronomic and entomological evaluations were performed each week starting from the 21th day after transplanting (DAT) up to 84 DAT. Results showed that the highest average damage level (16% of galls) was recorded in the 3rd transplanting period. The highest larval and pupal parasitism was recorded in P3 at 84 DAT. Pupal parasitism due to *Aprostocetus procerae* Risbec was higher than larval parasitism due to *Platygaster diplosisae* Risbec. Lastly, the lowest yield (4.78 t/ha) was recorded in P3. These results can be used in the implementation of an integrated pest management strategy for this insect pest in the Kou Valley.

### **2.3.3 Rice hispa: *Dicladispa armigera* Oliver (Coleoptera: Chrysomelidae)**

(Singh R H 2007) studied on the effect of different dates of transplanting of rice crop *viz* 30<sup>th</sup> May, 10<sup>th</sup> June, 20<sup>th</sup> June, 30<sup>th</sup> June and 10<sup>th</sup> July on the incidence of *Dicladispa armigera* was made during the year 2005. The later sown crop of rice suffered most from the attack of *D. armigera* than the earlier transplanted crop

Chakraborty and Deb (2012) studied the effect of weather factors on the incidence of hispa infesting rice. Incidence of rice hispa (RH), *Dicladispa armigera* population in rice crop was assessed by sweep net estimation during four consecutive crop seasons (2005-2008) at Hemtabad, Uttar Dinajpur, West Bengal. It was found that hispa population was initiated at about 29 standard meteorological weeks (SMW), improved at first slowly up to 27 SMW then steadily up to 35 SMW attaining the maximum at about 36 SMW which was maintained up to about 38 SMW. The

population then subsumed at first slowly up to 40 SMW then abruptly. After 43 SMW insignificant number of RH population was detected. Abiotic conditions such as maximum temperature, temperature gradient, maximum relative humidity, humidity gradient and average relative humidity had significant positive influence on *D. armigera* population. An insignificantly positive relation was also found with the average temperature. In case of minimum temperature, minimum relative humidity, sunshine hours and heavy rainfall, a negative influence on population development was observed.

#### **2.3.4 Rice leaf folder: *Cnaphalocrocis medinalis* Guenee**

The experimental results of the field experiments conducted during Kharif 1989 and 1990 indicated that during this season, the leaf folder infestation did not differ significantly across different dates of transplanting. However, maximum infestation occurred during September transplanting. Irrespective of dates of planting the leaf folder incidence was higher during 7 to 9 weeks after planting (Mishra *et al.* 1997).

The incidence of leaf folder (*Cnaphalocrocis medinalis*) population in rice crop was assessed by Chakraborty and Deb (2011) through light trapping during four consecutive *kharif* crop seasons (2005-2008) at Hemtabad, Uttar Dinajpur, West Bengal. The pest population was initiated at about 25 standard meteorological weeks (SMW), improved at first slowly up to 27 SMW then steadily up to 32 SMW attaining the maximum at about 34 SMW which was maintained up to about 37 SMW. The population then subsumed at first slowly up to 40 SMW then abruptly. Abiotic conditions such as minimum temperature, temperature gradient, maximum relative humidity and average relative humidity had significant positive influence on *C. medinalis* population. In case of minimum relative humidity and sunshine hours a negative influence was observed. In addition, other factors such as maximum temperature, relative humidity gradient, average relative humidity, number of rainy days and rainfall imparted insignificant positive effect on population development. Based on the nature of incidence and abundance of *C. medinalis*, a package can be generated and accordingly time fitted seedling transplantation as the precautionary measure may be highlighted in the northern parts of West Bengal.

#### **2.3.5 Green leaf hopper: *Nephotettix* spp. (Hemisphere: Cicadellidae)**

Litsinger (1994) found that late planting of rice causes high infestation against early planting within a given planting period, particularly in the dry season, reduces the risk of insect-vector disease.

Chen *et al.*, (2003) also reported that the occurrence of insect pests and their natural enemies on rice is influenced by variety and date of planting. The GLH population may be due to the susceptibility of variety and weather condition. In all season there was a reduction in the incidence of GLH for early transplanting. Similar findings of reduced pests and diseases in early maturing variety and early transplanting date have been reported by Litsinger *et al.*, (1987). Low incidence of pest and diseases in early planting rice is also reported by Moniperumal (1989). In early transplanted crop when the infection stage of pest and microbes are over, the inoculums would be finding a place in a late transplanting crop (Rani and Pillai, 2012).

Shamim *et al.*, (2009) from Middle Gujarat region showed that green leaf hopper attained peak population during 43<sup>rd</sup> SMW, which support the present trial results.

In the case of late transplanting, the surrounding crop might have completed their susceptible growth stages and the entire pest inoculums would be feeding or confining to the late transplanted crop (Rani and Pillai, 2012). This might be the reason for higher insect pests' incidence for delayed transplanting. Varying the planting time of crops works as a means of cultural control by creating asynchrony between crop phenology and insect pests phenology which can retard the colonization (Ferro, 1987). The higher population was found in the later stage of the crop. It is occurred due higher canopy developed and they induce a favorable condition of insect reproduction, growth, and development.

Ali *et al.*, (2013) reported that planting date had an effect on pest incidence ( $p = 0.01$ ). Planting on 1<sup>st</sup> July resulted in lower GLH incidence than on 16 July, 1<sup>st</sup> August and 16 August. There were significant differences in the pest incidence in rice field transplanted on different dates ( $p = 0.01$ ). Likewise, the abundance of natural enemies was highest at early season and thereafter declined.

Madhukar *et al.*, (2014), found that the rice green leaf hopper seasonal incidence results during *kharif* 2012 & 2013 revealed that the population of nymphs and adults was started from first week of September (36<sup>th</sup> SMW). Thereafter, the population was found gradually increasing with maximum population was recorded

during first week of October (40<sup>th</sup> SMW). Further, the incidence showed decline infestation till harvest of the crop (43<sup>rd</sup> SMW).

### 2.3.6 Gundhi bug: *Leptocorisa acuta* Thunb. (Hemiptera: Alydidae)

Gupta, *et al.*, (1993) reported that *Leptocorisa acuta*, *L. oratorius*, *Nezara viridula*, *Dolycoris indicus*, *Gerris nitida* and *Horridipamera nietneri* were found infesting rice grains in the milky and dough stages in Orissa, India. *Leptocorisa* spp. damaged 1.72-5.23% of grains during the dry season and 2.5-6.21% during wet seasons. The pentatomids *E. ventralis* [*Eurydema ventralis*], *M. histrio* [*Menida histrio*] and *N. viridula* infested grains in rainfed upland and irrigated medium land paddy fields during both seasons only in Cuttack and Puri districts. The grain damage caused by these species was 3.24-14.98 and 3.11-11.96% during dry and wet seasons, resp. *G. nitida* only infested grains during wet seasons in lowland paddy fields in Puri district, causing 1.98-5.17% damage. *H. nietneri* infested grains in irrigated medium land and rainfed lowland fields in the Ganjam district and damaged 0.840-2.28% of grains during dry seasons and 1.60-4.65 during the wet seasons.

Sachan, *et al.*, (2006) conducted field survey during the crop seasons of 2000-02 to determine the insect fauna associated with basmati rice, along with their nature of damage, seasonal incidence and economic importance, in Tarai region of Uttar Pradesh, India. A total of 28 insect species were recorded. The yellow stem borer, *Scirpophaga incertulas* (July-October), leaf-folder, *Cnaphalocrocis medinalis* (August-September), and brown planthopper, *Nilaparvata lugens* (August-September), were found as major pests. The striped stalk borer, *Chilo suppressalis* (July-October), **gundhi bug, *Leptocorisa acuta* (September-October)**, white-backed planthopper, *Sogatella furcifera* (August- September), green leafhopper, *Nephotettix virescens* (August-September), grasshoppers, *Hieroglyphus banian* and *Atractomorpha crenulata* (August- October), and root weevil, *Echinocnemus oryzae* (July-September), were found moderate.

According to Shrivastava *et al.*, (2008) the change in planting time means to create phonological asynchrony between pest and host plant. Early plantings (June-July) result in low population of gall midge, leaf folder and army worm while late plantings (August) reduces incidence of white grub, gundhi bug, grasshopper and BPH. Preponing of transplanting to December in rabi reduce BPH damage. To reduce the load of BPH simultaneous planting should be encouraged, additionally simultaneous planting of resistant cultivars from divergent genetic pool would

minimize selection pressure and thus reduce for development of new biotypes be strategically sound.

A study was undertaken by Venkatesh *et al.*, (2009) to monitor the population of paddy earhead bugs using modified Robinson light trap during kharif 2006 (from August to October 2006) in the paddy fields at Agricultural College, Navile, Shimoga. The mercury vapour electrical bulb of 200 watt was used as the source of light and dichlorovos was used for killing the trapped insects. Number of bugs trapped were collected and counted once in two days. In kharif light trap catches were found to be in peak numbers from September first fortnight to October first fortnight. Flowering and milk stages of rice crop were synchronized with these periods. That earlier studies showed higher activity during these periods of crop growth may be the reason for higher trap catches. Similarly the lowest catches during August may be due to low population in the field and also the crop was in vegetative stage.

Chakraborty (2011) observed that the numerically least damage with minimum *L. acuta* incidence was noted from the field treated with monocrotophos 36 WSC (1.46 adult +2.01 nymphs/5 hills and 2.41 chaffy grains). This was followed by commercial formulation of Nimbecidine (5%), neem oil (2%), neem seed kernel extract (5%), neem leaf extract (5%), neem root extract (5%) and neem bark extract (5%) in descending order. The pesticide untreated plot has registered 4.73 adult +8.62 nymphs' population/5 hills and 33.81% chaffy grains. In consideration of yield increase over control, maximum efficacy was registered when monocrotophos 36 WSC was applied @ 1125 ml/ha. This was followed by commercial formulation of nimbecidine, neem oil, neem seed kernel extract, neem leaf extract, neem root extract, neem bark extract in descending order.

PS III variety of rice was grown in Rewa region of MP of India. Gundhi bug incidence was found relatively higher (7/hill) in late planting of rice. Chouhan (2013) conducted field experiment to study the effect of dates of planting on pest incidence with three date of planting i.e. early planting, normal planting and late plantings of rice to find out the suitable planting time for lesser infestation of gundhi bug. It was found that planting time of crop had the influence on gundhi bug population. The bug infestation began 50 days after transplanting in all the treatment but variation in the infestation reflected after 60, 70, 80 and 90 days of transplanting. The higher number of bug population was noted in the late planted crop (30/08/2013) with a significant

reduction in yield (14.46 q/ha) as compared to the normal and early planting crop (Anonymous, AICRIP, 2012).

Low incidence of gundhi bug (0.16 – 1.48 bugs/ hill) was observed across the plantings in PS III variety of rice was grown in Rewa region of MP. Grain yield was high in early planting (43.9 q/ha) followed by normal (37.02 q/ha) and late plantings (25.84 q/ha) (Anonymous, AICRIP, 2014).

Tinatoly Sema (2014) carried out a field trail during 2011 to investigate to determine the effects of 3 sowing dates (11 April, 26 April and 11 May) and 5 land races (Sungmang tsük, Longkhumtsük, Manen, Tangmotsük and IET 20957) or rice on ear head bug complex (*Leptocorisa* spp.) in Nagaland, India. Both nymphs and adults were influenced by the sowing dates and landraces. Their interaction at 106 days after sowing (DAS) was found highly significant. The crop sown on 11 April had higher bug population than the 11 Maysown crop. The highest mean bug population was recorded from Manen (1.92 bugs/sweep) whereas the lowest was recorded from Sungmangtsük (0.30 bugs/sweep). The sowing dates, landraces and their interaction had no significant effect on ear head bug population at 106 DAS. The maximum bug population was recorded during the milky stage of crop growth in all the cultivars, which then gradually decreased as the crop advances towards maturation stage. The awned landrace (Tangmotsük) showed the minimum grain damage at reproductive stage.

Kalita *et al.*, (2015) reported that gundhi bug population was found maximum in the first fortnight of October (14.80-16.40 gundhi bug/10 hills). The per cent of damaged grain of Gundhi bug was recorded maximum in the second fortnight of October (12.86%). This might be attributed to the coincidence of milky stage of the rice crop in this period.

Low incidence of gundhi bug alone was observed in PS III variety of rice in all the plantings (<2 bugs/ hill) in the Rewa region of MP (India). Grain yields were at par in early and normal plantings (24 & 23 q/ha) followed by late planting (15q/ha) (Anonymous, AICRIP, 2015).

Gundhi bug incidence alone was observed in all the three planting dates plantings in PS III variety of rice. Incidence of ear bug was high in late planting with maximum population at 60 and 70 DAT (17 bugs/ 5 hills). Grain yield of 32, 25 and 18 q/ ha was recorded in early, normal and late plantings, respectively (Anonymous, AICRIP, 2016).

The experimental results obtained by Kumar and Prasad (2017) showed that the treatment effects in terms of four dates of transplanting were statistically significant in respect of incidence of ear bug on rice (Var-IR- 64). As such, the incidence of ear bug was found to be in descending order of early planting (i.e. 1<sup>st</sup> July) > normal planting (15<sup>th</sup> July) > delayed planting (30<sup>th</sup> July) > very delayed planting (14<sup>th</sup> August) receiving 18.60, 14.46, 11.86 and 10.70 ear bugs/10 hills of rice in case of early and late milking stage of rice, respectively.

### **2.3.7 Yield**

A field experiment was conducted by Bashir *et al.*, (2010) in order to evaluate the effect of different sowing dates on yield and yield components of the direct sown coarse rice during the Kharif season of 2008, at Agronomic Research Area, University of Agriculture, Faisalabad. Experiment comprised of six sowing dates i.e. 31st May, 10th June, 20th June, 30th June, 10th July and 20th July. Data on agronomic parameters and economics of coarse rice were recorded. Results revealed that direct seeded rice sown on 20th June proved to be the best for obtaining maximum grain yield and net return. 20th June sowing also gave maximum number of productive (panicle bearing) tillers, number of kernels per panicle, 1000-grain weight and benefit-cost ratio.

## **2.4 Evaluation of field bio-efficacy of botanical based insecticides against insect pest complex of rice.**

Judicious use of botanical based insecticides remains the principal strategy for managing insect pests by rice growers. Within the frame work of integrated pest management (IPM) newer molecules of insecticides continue to find a proper place because of their eco-friendly value and role in addition to much needed curative action in times of impending outbreaks. That is why, every year, efforts are made even under the all India Co-ordinated Rice Improvement project (AICRIP) to thoroughly screen and evaluate newly developed formulations for their effectiveness against the major insect pest species in different rice agro-ecologies of the country. With the passage of time, older molecules of insecticides are going to be out of use and newer ones are coming under current/recent recommendations for placing them as an integral part of IPM. Hence, efforts have been made to collect information on previous work made pertaining to judicious use of insecticides for management of major insect pests of rice which are briefly described here as under in respect of different insect pests.

In India, pioneering work on the isolation and identifications of *A. indica* constituents was initiated in 1942 and has continued in various parts of the world. Leaves have been shown to contain crude fibre (11-24%), carbohydrates (48-58%), crude protein (14-18%), fat (2.3-6.9%), ash (7.7-8.5%), calcium (0.8-2.4%) and phosphorus (0.13-0.24%), as well as a number of amino acids. Recently, a two dimensional TLC method has revealed the presence of carotenoids and other constituents in the leaves of *A. indica*. Its oil is rich in fatty acids and cake (the solid residue following expulsion of the oil) has a high sulphur content relative to other oil cakes. A number of sugars and polysaccharides have been identified in the gum and bark of *A. indica*. In addition to these general types of constituents, a number of novel compounds have isolated from most parts of the trees. All parts of the *A. indica* tree possess insecticidal activity but seed karnel is the most effective. It has a multitude of pesticidal active ingredients which are together called “triterpene” more specifically “limnoids”. The azadirachtin-A (Aza A) is the most plentiful and biologically active one which has shown repellent, antifeedent and insecticidal activity against a number of insect pests and it is generally Aza. that is used for commercial insecticide.

The products of *A. indica* are cheap, easy to prepare, ecofriendly and low-cost alternatives to agro chemicals. The extracts of *A. indica* have been compared with commercial pesticides on various crop pests where they have been found to be efficacious, and equally or more cost effective. There is evidence to suggest, however, that *A. indica* is not being exploited to its full potential by farmers of south and south-east Asia. There appears to be a number of reasons for this, including a lack of knowledge surrounding *A. indica*'s role in crop protection. The demand for commercial products of *A. indica* is increasing both for local markets and export markets. The pesticides from *A. indica* are registered in the USA and, as the search for more environmentally benign pesticides continues, the demand from both the USA and Europe is likely to increase. Despite the setback to the traditional pest control uses of *A. indica* due to the advent and popularization of synthetic insecticides, new interest in the pest control potential of *A. indica* has grown worldwide since the past decade. However, if full benefits are to be achieved, then further patronage is needed from governments, policy makers, administrators, public and private organizations, national and international programs, and the donor community. Definitely, treatments of *A. indica*, comprising the use of leaves, seed/kernel powder, extracts, and even bioactive principles, cannot replace completely chemical pesticides used in crop fields

and stored products preservation, but the amounts of pesticide needed could be reduced, thereby decreasing the pesticide load in food grains. The materials of *A. indica*, in spite of possessing broad-spectrum activity against pests are generally not hazardous to beneficial organisms, such as predators and parasitoids, and, with proper timing and innovative methods of application, their use could be integrated in pest management. As such with increased interest in the biological control of pests role of botanical based insecticides for eco-friendly management of insect pests of rice in general and for aromatic rice in particular is much more demanding these days. Very meagre and scanty informations on the efficacy of botanical based insecticides against insect pest species of rice are available in the literature particularly in the context of Jharkhand so far. However, possible efforts have been made to collect the information in this regards, which are given below.

#### **2.4.1 Rice stems borer: *Scirpophaga incertulas* (Walker)**

Singh (1996) reported that neem oil could be able to provide moderate control of the yellow stem borer. The highest grain yield (51.09 q/ha) was recorded in chemical protection followed by 46.25 and 47.65 q/ha in neem oil applied @ 4.0 % and 5.0% concentration, respectively.

Dhaliwal *et al.*, (2002) reported that four high potency azadirachtin based neem formulation, 1% Rakshak and 5 % Neem Azal and 0.03 % Nimbecidine were evaluated against two major pests of rice namely , rice leaf folder (RLF), *C.medilanis* and yellow stem borer (YSB), *S.incertulas* for two kharif seasons. The incidence of RLF was minimum in case of monocrotophos, which was at par with 5% Neem Azal at 1.00 % and 2.00 ml /lit. Similarly in case of YSB it was minimum in monocrotophos and was at par with 5 % Neem Azal at 0.05ml/lit.The highest yield was obtained with monocrotophos followed by 1% Neem Azal @ 1.25ml/lit. The highest paddy yield (50.5q/ha) was recorded in monocrotophos followed by 46.4q/ha in 5% Neem Azal @ 2.00ml/lit as compared with the minimum yield of 34.30q/ha in untreated control.

Chakraborty *et al.*, (2011) reported that all treatments were significantly effective in checking stem borer infestation causing the decrease of both dead heart (DH) and white head (WH) number. Numerically, least damage was noted for monocrotophos 36 WSC. This was followed by carbofuran 3G, nimbecidine 2.5%, neem seed kernel extract (NSKE) 5%, *B. thuringiensis* 2 ml/L, neem leaf extract (NLE) 2%, neem oil 2%, karanja seed kernel extract (KSKE) 5%, mahua oil 2%,

*Vitex negundo* extract in ascending order. The control plot has registered maximum DH and WH. In consideration of yield increase over control, maximum efficacy was registered for monocrotophos respectively followed by carbofuran, nimbecidine, *B. thuringiensis*, NSKE, NLE, mahua oil, neem oil, KSKE, *V. negundo* and plant mixture in descending order. Significant differences in the number of effective tillers/m<sup>2</sup>, panicle/m<sup>2</sup> leaf area index and dry matter production/m<sup>2</sup> in consideration of different treatment formulation was noted. But plant height, panicle length, and 1000 seed grain weight differed insignificantly.

Islam *et al.*, (2013) determined the bioefficacy of treatments which included three botanical extracts viz., tobacco extracts, neem extracts, and karonja extracts at 15 ml/L concentration and two insecticides namely Acephate 75 SP @ 2 g/L and fipronil (Nema 50 SC) @ 2 ml/L of water. The botanicals and chemicals caused a significant difference in their effect against the rice pest, *S. incertulas*. Maximum number of dead hearts and white heads were recorded in control plot. A highly significant result was observed in fipronil treatment after 21 days of spraying which showed relatively higher reduction of 51.89% dead heart and 65.05% white head over control. Neem extracts reduced dead heart and white head by 38.38% and 58.08% respectively. Considering the efficacy and ecofriendly nature of Neem extract it could be considered as an effective botanical in successful management of the pest yellow rice stem borer, *S. incertulas*.

#### **2.4.2 Gall midge: *Orseolia oryzae* Wood Mason (Diptera: Cecidomyiidae)**

Mahalingam (1984) recorded that neem oil 5.0% spray significantly reduce gall midge infestation in rice.

Parija and Anonymus (1988) conducted an experiments in O.U.A.T., Bhubneshwar and revealed that neem based products either failed or provided low to moderate control of rice gall midge.

Borkar and Sarode (2008) evaluated gardi leaves (*Cleistanthus collinus*) against gall midge (*Orseolia oryzae*) and yellow stem borer (*Scirpophaga incertulas*). Gardi leaves @ 1.5t/ha were found effective against gall midge infestation and recorded 9.45% silver shoot and found at par with monocrotophos 0.05% which recorded 9.21 percentage silver shoot infestation. Similarly, gardi leaves 1.5 t/ha also recorded 7.48% dead heart infestation of stem borer being at par with the treatment of monocrotophos 0.05% which recorded 6.61% dead heart infestation caused by yellow stem borer.

Anonymous 2015 (AICRIP), the result reported from the different AICRIP center, gall midge infestation was high at Jagdalpur which ranged from 33.2 to 53.5% SS across treatments and 68.5% control at 50 DAT. At other locations, the SS damage varied between 1.2 and 24.6%. There was a significant difference in the efficacy of the treatments at 3 locations viz., Jagdalpur, Sambalpur and Titabar. However, mean infestation over 6 locations was at par in all the treatments except Neembaan (9.8 to 10.8% SS) and they were significantly superior to control (18.3%).

Anonymous 2016 (AICRIP) as they reported that the result was from the different AICRIP center, the SS damage varied between 1.03-13.03 in treatments and 6.13 to 20.10% in control. There were significant differences in the efficacy of the treatments at 5 locations. Among botanical treatments, the lowest mean infestation was recorded in Neemazal (8.4%) and the efficacy was on par with insecticides and significantly superior to control (14.70%).

#### **2.4.3 Rice hispa: *Dicladispa armigera* Oliver (Coleoptera: Chrysomelidae)**

Islam (1984) reported that the neem cake extracts has been found to be effective to control of hispa, *Dicladispa armigera* (Olive) infesting rice.

Kaul and Sharma (1999) reported that all the neem formulation viz, Nimbicidine, Neemax, Neem gold, Econeem, Neemazal and Fortune were were statistically at par with chlorpyriphos for the control of stem borer rice hispa and leaf folder infesting rice variety kasturi ,Basmati. Significantly higher yield (30-31q/ha) were obtained in treated plots as compared to 28q/ha in the untreated plants.

Bora and Hazarika (2001) conducted an experiment to investigate the effect of neem seed oil (NSO) on the fecundity and oviposition of the pest, rice hispa, *Dicladispa armigera*. It was found that the rice seedling treated with 0.8, 1.6, 2.4 and 3.2% NSO were not preferred and by *D. armigera* for feeding and oviposition. NSO exhibited as an ovicidal action against newly laid eggs of *D. armigera* at concentration of 1.6, 2.4 and 3.2%. The results suggest that NSO is effective antifeedant and anti ovipositional compound against *D. armigera*.

Prasad *et al.*, (2010) observed that among the various organic manures viz. FYM, vermi compost, green manure, neem cake and karanj cake, applied as basal use to supply nutrients to the rice plants, neem and karanj cake @ 2.5 t/ha remained significantly more effective in reducing the incidence of hispa in rice-ecosystem.

Roy *et al.*, (2017) was found that overall leaf infestation by rice hispa and infestation by adults and grubs separately were recorded at different time intervals. In

addition to these, overall effect of pest infestation on the grain yield of rice was also examined. Among the six botanicals, Neem oil was most effective in controlling rice hispa, as overall leaf infestation was 21.20% and the infestation by adults and grubs were 14.43% and 12.57%. On the other hand, among chemical insecticides, maximum efficacy was found under the treatment of Sevin 85SP where minimum leaf infestation was 9.22%, infestation by adults and grubs were 5.88% and 5.00% respectively. In case of yield, Sevin 85SP (4.62 ton/ha) showed the best efficacy in comparison to other treatments. Therefore, application of Sevin 85SP (3.46ml/L) and Neem oil (2ml/100ml) were examined as the best options in controlling rice hispa. So, it could be recommended to use Sevin 85 SP and Neem oil for the management of rice hispa.

Soren and Prasad (2018) found that neem cake applied @ 2.5 t/ha enabled the rice plants most protective against the pest having minimum incidence of 2.55 LDH/10 hills (plants) followed by karanj cake @ 2.5 t/ha (4.25LDH/10 hills). Neem cake (NC) @ 01 t/ha proved to be superior to KC (01 t/ha), NC (0.5 t/ha); however neem cake applied @ 0.5 t/ha remained at par with karanj cake @ 01 t/ha and superior to karanj cake @ 01 t/ha in terms of reducing the incidence of hispa. The leaf damage caused by hispa (LDH) ranged from minimum of 2.55 LDH/10 hills (NC @ 2.5 t/ha) to the maximum of 26.18 LDH/10 hills (N @ 80 kg/ha through urea). Thus, neem cake @ 2.5 t/ha remained most effective having minimum leaf damage (2.55 LDH/10hills) followed by karanj cake @ 2.5 t/ha (4.25 LDH /10 hills).

#### **2.4.4 Rice leaf folder: *Cnaphalocrocis medinalis* Guenee**

Nanda and Mahapatro (1998) studied the bio-efficacy of neem derivatives integrated with conventional pesticides like monocrotophos and some rice varieties namely Jaya, and Lalat so as to formulate a management strategy against the rice leaf folder *Cnaphalocrocis medinalis* (Guenee). Neem oil @ 2% (along with detergent, Teepol Ag. @ 0.1 %) applied at 20 and 70 days after transplanting (DAT) and monocrotophos @ 0.4 kga.i./ha at 40 DAT proved to be effective against this notorious pests giving rise to moderate pest suppression as such the leaf damage profiles remained in the range of 2.94- 3.9% at 30 DAT, 3.74-5.5 % at 50 DAT , In Jaya and 3.2-4.8% at 30 DAT, 3.47-4.8% at 50 DAT in Lalat variety. The result obtained could not be comparable to full chemical application of Phorate granule @ 1 kg a.i./ha, before transplanting and need based monocrotophos @ 0.5 kg a.i./ha.

Dhaliwal *et al.*, (2002) reported that four high potency azadirachtin based neem formulation, 1% and 5% Neem Azal and 0.03% Nimbecidine were evaluated against two major insects pests of rice, namely rice leaf folder (RLF), *C. medinalis* and yellow stem borer (YSB), *S. incertulas* for two kharif seasons. The incidence of RLF was minimum in case of monocrotophos, which was at par with 5% Neemazal at 1.00 and 2.00 ml/lit. Similarly in case of YSB it was minimum in monocrotophos and was at par with 5% Neemazal at 0.05ml/lit. The highest yield was obtained with monocrotophos followed by 1 % Neemazal @1.25ml/lit. The highest paddy yield (50.50q/ha) was recorded in monocrotophos followed by 46.40q/ha in 5% Neemazal @ 2.00ml/lit. compared with 34.30q/ha in untreated control.

Nigam *et al.*, (2010) evaluated comparative efficacy of some conventional and ecofriendly insecticides against rice leaf folder. All the conventional insecticides and neem oil were applied once and NSKE, biolep, dipel applied thrice. Among the synthetic insecticides, monocrotophos 36 SL @ 0.4 kg a.i./ha treated plots showed lowest leaf infestation and gave higher grain yield 37.66 q/ha (200405) and 38.58 q/ha (2005-06). The neem oil @ 5% also gave better yield (32.25 and 33.91 q/ha) than the three sprays of NSKE 5% (31.83 and 32.91 q/ha) during both years, respectively.

Ashfaq *et al.*, (2011) conducted an experiment with the objective to find out the potential of *Chrysoperla carnea* and *Trichogramma chilonis* in integration with some botanicals and one biopesticide against rice borers. The treatments included extract of *Eucalyptus camaldulensis*, *Melia azedarach*, *Azadirachta indica*, Spinosad, two bio control agents *Trichogramma chilonis* and *Chrysoperla carnea*; alone as well as in all possible combinations. The results revealed that in most of the observations maximum number of dead hearts and white heads were recorded in control plot followed by *Chrysoperla carnea*, extract of *Eucalyptus* and *Melia azedarach*, respectively. However the integration of botanicals with biocontrol agents greatly reduced, the plant damage. Maximum rice yield was obtained from plots treated with a combination of neem extract, *Trichogramma*, *Chrysoperla* and Spinosad as well as of Spinosad, *Chrysoperla* and *Trichogramma*, while minimum yield was observed from plants left untreated followed by *Chrysoperla carnea*, extract of *Eucalyptus* and *Melia azedarach*, respectively.

Girish *et al.*, (2015) conducted an experiment to determine the efficacy of newer insecticides and a botanical on rice leaf folder during kharif 2010. The variety Abhilash was used for the trial and experiment was laid out in a randomized block

design with twelve treatments and three replications. The insecticides were sprayed at 60 and 90 days after transplanting. Emamectin benzoate 5 SG @ 0.25 g/l registered its superiority over rest of the treatments by recording least per cent leaf damage and higher grain yield. The spinosad 45 SC @ 0.2 ml/l and flubendiamide 480SC @ 0.2 ml/l proved equally effective by recording at par leaf damage and grain yield with emamectin benzoate 5 SG @ 0.25 g/l. The next best treatments in the order of efficacy against the leaf folder included indoxacarb 14.5 SC @ 0.5 ml/l, profenophos 50 EC @ 2 ml/l, rynaxypyr 20 EC @ 0.3 ml/l and bifenthrin 10 EC @ 1 ml/l. Emamectin benzoate 5 SG @ 0.25 g/l recorded highest net profit of Rs. 39210 followed by spinosad 45 SC @ 0.2 ml/l (Rs. 36005) and flubendiamide 480 SC @ 0.2 ml/l (Rs. 33975).

#### **2.4.5 Green leaf hopper: *Nephotettix* spp. (Hemisphere: Cicadellidae)**

Nigam and Sen (1989) found neem oil applied at 1,2,3 & 4 % could be highly effective in reducing the incidence of green leaf hopper, *Nephotettix virescence* population.

Kaul and Sharma (1999) reported that certain neem formulations viz. Neemzal, Neemax, Neem Gold, Econeem and Fortune remained almost equally effective to that of chlorpyrifos in terms of efficacy for suppression of incidence of stem borer, hispa and leaf folder.

#### **2.4.6 Gundhi bug: *Leptocorisa acuta* Thunb. (Hemiptera: Alydidae)**

Raghuraman (1987) reported that a single spray of neem oil 3 % or neem kernel extracts (5.0%) significantly minimized the population of ear bugs (*Leptocorisa oratorius* Fabricius).

Sharmah *et al.*, (2011) evaluated the efficacy of neem (*Azadirachta indica* A.Jass), soap nut (*Sapindus trifoliatus* L.) and their formulations and Malathion as standard insecticide against the rice bug (*Leptocorisa oratorius* Fabr.) during 2000-2001 on the basis of per cent reduction under field condition. The per cent reduction in number of rice bug adults due to neem seed kernel powder, neem seed kernel powder+multani powder, multani powder, neem leaf powder, neem leaf powder + multani powder, neem leaf powder+ash, soap nut kernel powder, soap nut kernel powder+multani powder tested as dust were found to be 24.44, 14.78, 5.65, 17.06, 11.88, 6.54, 18.18 and 15.01 respectively for exposure period of ten days. The order of efficacy of the botanicals and their formulations were malathion followed by neem seed kernel powder, soap nut kernel powder, neem leaf powder, neem seed kernel

powder+multani powder, soap nut kernel powder+multani powder, neem leaf powder+multani powder, neem leaf powder+ash, multani powder for the exposure period of 3, 7 and 10 days respectively.

Surjaram *et al.*, (2014) conducted the experiment in Allahabad, Uttar Pradesh, India, during 2013 crop season to investigate the efficacy of some plant extracts (each at 20 ml/l) in controlling gundhi bug (*L. oratorius*) on rice cv. Saket4, grown on 20cm earthen pots. The treatments comprised chlorpyrifos 20 EC at 2 ml/l (T1), neem [*Azadirachta indica*] oil (T2), tobacco leaf extract (T3), custard apple leaf extract (T4), *Chrysanthemum* leaf extract (T5), neem leaf extract (T6), and control (T7). Observations on mean percentage mortality were recorded at 1, 3 and 5 days after spraying (DAS). All the treatments were significantly superior over the control, with T1 recording the highest mortality (87%), followed by T2 (83%), T6 (79%) and T3 (77%), at one DAS. At 3 DAS, the highest mortality of gundhi bug was observed in T1 (89%), followed by T2 (85%), T6 (83%) and T3 (82%). Similar results were recorded at 5 DAS. The greatest grain damage caused by the pest was observed in the control (72.6%), whereas the lowest was recorded in T1 (21.1%).

Ashokappa *et al.*, (2015) evaluated the bioefficacy of plant extract and certain insecticides. Among six plant extracts, two entomopathogenic fungi and six new molecules of insecticides against *Leptocorisa oratorius* Fabricius, the field data showed that all chemicals could bring down the population of rice earhead bug in comparison to untreated control plots where there was a minor increase of population. Insecticides, imidacloprid 17.8 SL @ 0.25 ml/l, thiamethoxam 25 WG @ 0.3 g/l and malathion D @ 20 kg/ha recorded lowest population 0.05, 0.14 and 0.18 bugs/hill with a highest yield of 7049.26, 6461.11 and 6253.33 kg/ha, respectively. Among the plant products tested azadirachtin @ 3 ml/l and *Acorus calamus* L. aqueous rhizome extract @ 10 per cent recorded 0.33 and 0.48 bugs/hill with an yield of 6057.78 and 5705.19 kg/ha, respectively. Thus, the present study has come out with such two promising botanical pesticides viz., *Azadirachtin indica* and *A. calamus* against rice earhead bug.

**Reports on efficacy of neem and other botanical pesticides against major prevailing insect pests of rice in different regions of India as reported by Anonymous (2015 & 2016), under AICRIP rice entomological experiments:**

**The experimental results of all the AICRIP locations are given below (Anonymous 2015 (AICRIP))**

**Stem borer** infestation during vegetative stage ranged from 1.2 to 22.1% DH in the treatments across 16 locations with minimum damages exceeding 5% DH in untreated control, during 30 to 76 DAT. There were significant differences in stem borer damage (DH) among the treatments at 11 locations. The insecticide and botanical treatments showed mean infestation between 5.9 and 7.3% DH across the locations compared to 11.0% DH in untreated control. Botanical insecticide treatments were significantly superior to control at 10 locations. White ears (WE) at heading stage in various treatments ranged from 1.0 to 14.5% against 5.3 to 18.6% in control across 16 centres. There was significant difference among treatments in WE damage at 9 locations. Mean WE infestation ranged from 5.4 to 7.1% in botanical insecticides treatments as compared to 10.5% in untreated control. Overall, among the botanical insecticides treatments, Neemazal and Nimbecidine along with insecticide, Dinotefuran were relatively better treatments in reducing stem borer incidence at both vegetative and reproductive phases.

**Gall midge** infestation was high at Jagdalpur which ranged from 33.2 to 53.5% SS across treatments and 68.5% control at 50 DAT. At other locations, the SS damage varied between 1.2 and 24.6%. There was significant difference in the efficacy among the treatments at 3 locations viz., Jagdalpur, Sambalpur and Titabar. However, mean infestation over 6 locations was at par in all the treatments except Neembaan (9.8 to 10.8% SS) and they were significantly superior to control (18.3%).

**Hispa** damage to foliage was recorded at two centres viz., Ranchi and Aduthurai. None of the treatments were found effective against the pest at 33 DAT and all were at par. At Ranchi after 40 DAT, both botanical and dinotefuran treatments were found effective with 20.7-30.3% leaf damage as compared to 54.0% in control.

**Leaf folder** damage was recorded across 7 locations and it was low to moderate (1.3 to 12.4%) in botanical and insecticide treatments compared to 5.7 to 28.7% in control during 30 to 90 DAT. The mean infestation ranged from 5.2 to 6.4% LFDL in the treatments compared to 11.0% in untreated control. All the botanical and insecticide treatments were significantly superior to control. Among botanicals, Neemazal recorded better efficacy against leaf folder.

**Green leafhopper** populations were high at Gangavathi followed by Ranchi centre. Dinotefuran was the most effective treatment with 23.7 hoppers /10 hills at 59 DAT (20 day's after 1<sup>st</sup> spray) as against population of 102.3 hoppers /10hills in

control at Gangavathi. All the botanical treatments were at par showing mean population range of 20.8 to 26.1 hoppers /10 hills, significantly lower than that of control (32.5). Overall, Neemazal showed better efficacy than other botanicals.

In brief, botanical insecticides trial was carried out at 24 locations to evaluate the efficacy of four commercial formulations and neem oil along with recommended insecticide, Dinotefuran against major insect pests of rice and consequent impact on natural enemies and grain yield during kharif 2015. Based on the performance of the treatments in reducing the pest incidence at various locations, the botanicals-Neemazal and Nimbecidine are found effective against stem borer. In case of gall midge, all the treatments showed efficacy in reducing the damage. Against sucking pests-BPH, WBPH and GLH, the insecticide, Dinotefuran was the most effective treatment in reducing the populations of the hoppers while botanicals were moderately effective. Regarding the efficacy of treatments against foliage feeders-leaf folder, hispa, blue beetle all botanical formulations were found effective and their efficacy was comparable with insecticide, dinotefuran. Results on effect of botanicals on natural enemies revealed that treatments were relatively safer to mirid but then spiders. Highest grain yield of 4716 kg/ha was recorded in Neem oil followed by Neemazal with 4604 Kg/ha.

**Grain Yield:** There were significant differences in grain yield among the treatments and with control at 19 locations out of total 21 locations. Based on mean yield of these locations, Neem oil recorded highest grain yield of 4719 Kg/ha with 27.7% increase over control (IOC) followed by Neemazal with 4604 kg/ha (24.7% IOC) when compared to 3692 kg/ha in control. However, the yield among the botanical and insecticide treatments was at par with range of 4465-4716 kg/ha (20.9 to 27.7% IOC)

#### **Anonymous 2016 (AICRIP)**

**Stem borer** infestation during vegetative stage ranged from 1.7 to 30.2% dead hearts (DH) in the treatments across 13 locations with minimum damages exceeding 5% DH in untreated control, during 30 to 70 DAT. There were significant differences in stem borer damage (DH) among the treatments at 12 locations. Rynaxypyr treatment recorded the lowest mean damage of 5.70% while botanical treatments showed mean DH infestation between 7.0-9.2% across the locations compared to 13.5% in untreated control. Botanical insecticide treatments were significantly superior to control at 11 locations. White ears (WE) at heading stage in various

treatments ranged from 0.49 to 20.03% against 6.92 to 38.71% in control across 13 centres. There was significant difference among treatments in white ear damage at all 13 locations. Mean WE infestation ranged from 8.57 to 10.06% in botanical treatments as compared to 5.76-7.55 in insecticide treatments and 15.63% in untreated control. Overall, Neemazal was found to be superior in reducing stem borer damage compared to other botanical treatments along with insecticide, Rynaxypyr at both vegetative and reproductive phases.

**Gall midge** occurrence was high at Pattambhi ranged from 29.98 to 39.05% SS across treatments and 40.05% control at 50 DAT. At other locations, the SS damage varied between 1.03-13.03 in treatments and 6.13 to 20.10% in control. There were significant differences in the efficacy among the treatments at 5 locations. Among botanical treatments, lowest mean infestation was recorded in Neemazal (8.4%) and the efficacy was on par with insecticides and significantly superior to control (14.70%).

**Hispa damage** was recorded at 3 centres viz., Ranchi, Malan and Karjat. Highest damage of more than 50% was observed in Ranchi, however none of the treatments were found effective against the pest at 38 DAT and all were at par. At other centres both botanical and insecticide treatments were found effective with 7.32 – 11.40% leaf damage as compared to 30.13% in control.

**Leaf folder** damage was recorded across 12 locations and highest leaf damage was recorded in Ranchi centre (13.67–75.00%) followed by Malan with 26.05 – 39.50%. Leaf damage was very low to moderate (0.52–17.05%) in botanical and insecticide treatments compared to 5.13 – 17.19% in control during 30 to 75 DAT in other centres. Rynaxypyr was the most effective treatment showing mean leaf damage of 5.49%. Among botanicals, Neemazal recorded lowest infestation (7.97%) in comparison to 16.86% in untreated control.

**Green leaf hopper** incidence was high at Ranchi (27.67-70.67 hoppers/ 10hills) at 92 DAT among the 6 centres. Dinotefuran was the most effective treatment with mean population of 13.48 hoppers/ 10 hills) and superior to control (125.69). All the botanical treatments also showed significant efficacy against the hoppers (14.16-15.13/ 10hills) when compared to control (25.69) and Rynaxypyr (18.42).

**Gundhi bug** incidence was observed in Navsari and Titabar locations. Both botanical and insecticide treatments were found effective in reducing damage by the bug at Navsari at 73 DAT and at Titabar at 70 DAT (1.00 – 7.67%) when compared to

9.33 – 13.67% in control. Among botanicals, Nimbecidine recorded the lowest mean damage (5.67%).

In brief, botanical insecticides trial was carried out at 20 locations to evaluate the efficacy of four commercial formulations and neem oil along with recommended insecticide, Dinotefuran and Rynaxypyr against major insect pests of rice and consequent impact on natural enemies and grain yield during kharif 2016. Based on the performance of the treatments in reducing the pest incidence at various locations, the insecticide – Rynaxypyr and the botanicals-Neemazal were found effective against stem borer damage. In case of gall midge, Neemazal was found effective in reducing the damage and was on par with insecticides. Against sucking pests-BPH, WBPH and GLH, the insecticide, Dinotefuran was the most effective treatment in reducing the population's efficacy of treatments against foliage feeders-leaf folder, hispa and whorl maggot-all botanical formulations were found effective and their efficacy was comparable with insecticides. Results on effect of botanicals on natural enemies revealed that all treatments were safer to both mirid bug and spiders. Highest grain yield of 5322 kg/ha was recorded in Dinotefuran while among botanical treatments, Neemazal recorded highest yield of 4866 kg/ha.

### **Grain Yield**

There was significant difference in grain yield among the treatments including control at 15 locations out of total 20 locations. Based on mean yield of these locations, Dinotefuran recorded the highest grain yield of 5322 kg/ha with 32.92% increase over control (IOC) followed by Rynaxypyr with 5234 kg/ha (30.72% IOC) when compared to 4004 kg/ha in control. Among the botanicals, Neemazal treatment recorded highest yield of 4866 kg/ha (21.523% IOC) and was at par with others with a range of 4730–4768 kg/ha (range of 18.13–19.08% IOC)

### **2.5 Evaluation of field bio- efficacy of newer molecules of insecticides against insect pests complex of rice.**

Judicious use of insecticides remains the principal strategy for managing insect pests by rice growers. Within the framework of integrated pest management (IPM) newer molecules of insecticides continue to find a proper place because of their eco-friendly value and role in addition to much needed curative action in times of impending outbreaks. That is why, every year, efforts are made even under the all India co-ordinated Rice Improvement project (AICRIP) to thoroughly screen and evaluate newly developed formulations and newer molecules of insecticides for their

effectiveness against the major insect pest species in different rice agro-ecologies of the country. With the passage of time, older molecules of insecticides are going to be out of use and newer ones are coming under current/recent recommendations for placing them as an integral part of IPM. Hence, efforts have been made to collect information on previous work made pertaining to judicious use of insecticides for management of major insect pests of rice which are briefly described here as under in respect of different insect pests.

### **2.5.1 Rice stem borer: *Scirpophaga incertulas* (Walker)**

DRR (2009) reported that the mean per cent infestation recorded in monocrotophos 36SL (5.1% DH and 7.9% WEH), buprofezin 25SC (6.2% DH and 9.6% WEH), acephate 75SP (6.6% DH and 8.7% WEH) and acephate 95SG (6.7% DH and 8.6% WEH) was significantly lower in comparison to untreated control (10.0% DH and 13.1% WEH). It was also reported that per cent yield increase over control was higher in acephate 75SP (33.3%) followed by monocrotophos 36SL (32.6%), acephate 95SG (30.1%) and buprofezin 25SC (25.6%).

Hugar *et al.*, (2009) evaluated new chemical molecules for management of *Scirpophaga incertulas* Walker in aerobic rice and found that application of fipronil 0.3G (@ 7.5 g a.i./ha), monocrotophos 36SL (@ 500 g a.i./ha), carbofuran 3G (@ 750 g a.i./ha) and lambda cyhalothrin at 50 and 70 days after sowing resulted in 3.4% and 2.43%, 4.42% and 3.92%, 5.81% and 4.03% and 8.38% and 7.13% deadheart infestation and 2.59%, 5.93%, 6.35% and 10.44% white earhead infestation, respectively against the control (15.20% and 12.31% deadheart and 12.67% white earhead infestation, respectively). Fipronil 0.3 G gave highest grain (42.97 kg/ha) and fodder (61.25 kg/ha) yields, net return (14,729 rupees/ha) and cost: benefit ratio (1: 7.86).

Hugar *et al.*, (2009/2010) showed superiority against rice yellow stem borer, of fipronil 0.3G (@ 7.5 g a.i./ha) followed by carbofuran 3G (@ 750 g a.i./ha) which were moderately effective and cartap hydrochloride 4G (@ 1000 g a.i./ha) was least effective among the granular formulations. Among the spray formulations beta-cyfluthrin 2.5EC @ 12.5 g a.i./ha was highly effective followed by monocrotophos 36SL (@ 500 g a.i./ha). Lambda cyhalothrin 2.5 EC (@ 12.5 g a.i./ha) was less effective.

Bhutto and Soomro (2010) proved that Karate (2.5EC) was the best among all the tested EC insecticides to reduced deadheart percentage, white earhead percentage and recorded more yield over the control.

Dhawan *et al.* (2010) reported that cartap hydrochloride (@ 1.0 kg a.i./ha) and fipronil (@ 45 g a.i./ha) against basmati rice stem borers at farmers' field were effective and superior over control in respect of lower deadheart and white earhead infestation.

Firake *et at.*, (2010) reported that Regent 5SC (fipronil) was found to be the most effective against yellow stem borer, *Scirpophaga incertulas* (Walker). Regent (@ 75 g a.i./ha) reduced 49.61 per cent damage followed by cartap hydrochloride (@ 750 g a.i./ha) and Lamda cyhalothrin (@ 25 g a.i./ha).

Misra (2010) reported that lambda cyhalothrin 2.5 EC (@ 12.5 g a.i./ha) registered 2.67% deadheart at 15 days after second spray with 81.05% and 55.28% reduction in deadheart and white ear-head infestation and 25.00% increment in grain yield over the control.

Prasad *et al.*, (2010) recorded that lambda cyhalothrin 5SC (@ 12.5 g a.i./ha) resulted in 3.33% average YSB infestation and 2.08 t/ha average grain yields in comparison to untreated control (6.34% average YSB infestation and 1.48 t/ha average grain yields). The insecticidal check monocrotophos 36SL (@ 500 g a.i./ha) was superior to untreated control with 4.04% average YSB infestation and 1.83 t/ha average grain yields.

Singh *et al.*, (2010) revealed that cartap hydrochloride 4G (@ 18.75 kg/ha), fipronil 0.3G (@ 18.75 kg/ha) were better than monocrotophos 36SL (@ 1.25 liter/ha) and gave effective control of stem borer as compared to control.

Prasad and Prasad (2010) conducted a field experiment during *kharif*, 2007 in rice research farm Birsa Agricultural University, Ranchi with rice (var. Jaya) to evaluate the bio efficacy of some newer molecules of insecticides applied at 30, 50 and 70 DAT against major lepidopterous insect pests a.i./ha. Cartap hydrochloride @1.0 and 0.75 kg a.i./ha proved most effective in managing the incidence of stem borers and realizing higher yield of rice grains.

Rath (2011) tested eight insecticides against the major insect pests of rice in the agro- climatic conditions of cuttack region of Jharkhand in the field conditions. Their resulted revealed that the newer combination product, flubendamide+buprofezin (4+20%)@ 875g/ha recorded lesser incidence of YSB in

terms of dead heart (7.83 and 3.46% DH) and white ear head of 4.66 and 3.46 percent of WE(%), gundhi bug(9.0 and 11.93 % grain damage) which, in turn, resulted in the higher grains yield of 3.228 and 5.830 t/ha in the rice variety, Jaya followed by monocrotophos 36 WSC applied @ 1390 ml/ha (3.01 and 5.10 t/ha) and acephate 95% SG gave rise to the grain yield of 2.990 and 4.730 t/ha, during, 2009 and 2010, respectively. Grain damage due to gundhi bug varies from 9.00 to 10.93 percent during 2009 and 11.93 to 21.00% during, 2010 in pesticide treatment. They also found that all the test insecticides were found effective against YSB and ear bug. In control, stem borer damage was high i.e., 12.80 and 8.83% DH, 7.8 and 9.03% WEH; gundhi bug damage remained to the tune of 16.16 and 32.56 percent and the grain yield was 2.470 and 3.400 t/ha during, 2009 and 2010 respectively.

Chakraborty (2011) found that carbofuran 3G (@ 30 kg/ha), fipronil 0.3G (@ 750 ml/ha), monocrotophos 36WSC (@ 1125 ml/ha) were significantly effective in checking stem borer infestation by decreasing both deadheart and white earhead number and registered higher yield against control plot (6.1% DH and 4.3% WEH).

Chakraborty (2011) recorded that monocrotophos 36WSC followed by carbofuran 3G was significantly effective in checking stem borer infestation causing the decrease of both deadheart and white earhead number and registered yield increase over control.

DRR (2011) reported that a spray of cartap hydrochloride as a need based application significantly lowered stem borer damage (12.57% DH at 30DAT, 7.54% DH at 50DAT and 6.8% WEH) over untreated control (13.2% DH at 30DAT, 12.95% DH at 50DAT and 9.6% WEH) and gave higher grain yield (4373.46 kg/ha) as compared to control (3972.22 kg/ha).

Kulagod *et al.*, (2011) found that cartap hydrochloride 50 SP (@ 1.0 g/litre) gave the lowest per cent deadheart and white earhead infestation and gave the highest grain yield. However, it was at par with fipronil 5FS (@ 2.5 ml/litre).

Prasad and Gupta (2011) revealed that during *kharif* 2006 and 2007 season, thiamethoxam + lambda cyhalothrin treatment was the most promising with 1.8 per cent YSB infestation. However, during *kharif* 2006 and 2007 season, thiamethoxam + lambda-cyhalothrin and indoxacarb + lambda-cyhalothrin recorded 1.3 and 1.5 per cent YSB infestation, respectively, were the most promising treatments and were significantly superior compared to the untreated control. The grain yield data also

revealed that all the insecticidal treatments were significantly superior to the untreated control and were comparable to the control insecticide monocrotophos.

Prasad *et al.*, (2014) tested the efficacy of certain new insecticides against stem borer. The results clearly indicated that acephate 75 SP @ 667 g/ha followed by the combination of flubendiamide (4%) + buprofezin (20%) 24 SC @ 875 ml/ha and flubendiamide 20 WDG @ 175 g/ha with 3.50, 4.15 and 4.40 average YSB infestation; and 18.00, 16.37 and 16.27 q/ha average grain yields, respectively, were effective against YSB on semi deep water rice.

Prasad *et al.*, (2014) evaluated the efficacy of certain newer molecules of insecticides against stem borer. Altogether, there were 9 treatments including 5 insecticides, viz. buprofezin 25 SC @ 700 ml ha<sup>1</sup>, acephate 95 SG @ 592 g ha<sup>1</sup>, acephate 75 SP @ 667 g ha<sup>1</sup>, dinetofuran 20 SG @ 200 g ha<sup>1</sup>, flubendiamide 20 WDG @ 175 g ha<sup>1</sup>; 2 combination of insecticides, viz. flubendiamide (4%) + buprofezin (20%) 24 SC @ 875 ml ha<sup>1</sup>, buprofezin (20%) + acephate (50%) 70 WP @ 900 g ha<sup>1</sup> besides insecticidal check monocrotophos 36 SL @ 1390 ml ha<sup>1</sup> and untreated control. The stem borer infestation, i.e. white ears varied from 2.24 to 10.90% over the *kharif* seasons. The results on stem borer infestation and yield indicated that all the insecticidal treatments were significantly superior to untreated control. The results clearly indicated that acephate 75 SP @ 667 g ha<sup>-1</sup> followed by the combination of flubendiamide (4%) + buprofezin (20%) 24 SC @ 875 ml ha<sup>-1</sup> and flubendiamide 20 WDG @ 175 g ha<sup>-1</sup> with 3.50, 4.15 and 4.40 average YSB infestation; and 18.00, 16.37 and 16.27 q ha<sup>-1</sup> average grain yields, respectively, were effective against YSB on semi deep water rice. The insecticidal check, monocrotophos 36 SL @ 1390 g ha<sup>-1</sup> was superior with 5.54% average stem borer infestation and 13.42 q ha<sup>-1</sup> average grain yield to untreated control with 9.69% average stem borer infestation and 10.87 q ha<sup>-1</sup> average grain yield.

Patro *et al.*, (2015) evaluated efficacy of the integrated pest management indices of insecticidal combination products for eco friendly and sustainable management of paddy (cv Pratikshya). Five conventional insecticides and three numbers of their combiproducs as well as two check insecticides were sprayed at 25 and 50 days after transplanting and compared with in treated check. The overall IPMI (Integrated Pest Management Index) value of Profex super (9.14) is close to Decis (12.49) indicating its safeties to nontarget organisms and at the same time this chemical was found to reduce the pest population significantly over other insecticides

with highest yield performance. The results indicated that Profex super (Profenophos 40%+Cypermethriun 4%) @ 440 ml/ha was the best combination product for ecofriendly sustainable management of major paddy pests (yellow stem borer, gall midge and brown plant hopper) with highest yield (30.23 q/ha).

### 2.5.2 Gall midge: *Orseolia oryzae* Wood Mason (Diptera: Cecidomyiidae)

Sankpal *et al.*, (1980) demonstrated the use of granular insecticides applications against rice gall midge and found that the most effective compound was phorate 10% (granule) applied at 1 kg a.i. toxicant /ha at 10 and 30 days after transplanting followed by carbofuran as 3%(granule) applied at 0.75kg a.i./ha, disulfotan as 5%(granule) at 1.0 kg a.i./ha and lindane (gamma B.H.C.) as 6% (granule) at 1.5 kg a.i./h.

Patnaik *et al.*, (1983) reported that application of granular formulation of phorate (Thimet) @2 kg a.i. per ha applied at 20 and 40 days after transplanting gave rise to good protection against *O.oryzae* as compared with other treatments (applicatoion of granular formulation of diazinon or carbofuran, alternate spraying with phosphamidon and fenitrothion or a seedling root dip in 0.02% granular phorate followed by field treatment with granular carbofuran).

Sesmal *et al.*, (1987) conducted an experiment and found that phorate (Thimet-10 G) @ 1.0 kg a.i./ha applied 10 days sowing in standing water effectively checked gall midge damage in the nursery bed of rice.

Rao (2003) conducted field experiments in Andhra Pradesh, India, for two years (Year not given) to evaluate the efficacy of isazofos, carbofuron, trizophos, itofenprox, carbaryl and chlorpyrifos against *Scirpophaga incertulas* and *Orseolia oryzae*. The result showed that 0.5 and 0.75 kg isazofos/ha was the best in controlling *S.incertulas* and *O.oryzae*.

Dash and Mukherjee (2003) conducted a field experiment to evaluate the efficacy of some granular and sprayable insecticides in their certain doses. It was found that application of either one of (0.075 kg a.i./ha fipronil, 1.0 kg a.i./ha chlorpyriphos, 1.0kg a.i./ha, carbofuran, 0.75kg a.i./ha lambda cyhalothrin, 0.3kg a.i./ha amitraz, 0.025kg a.i./ha, imidacloprid, 0.1kg a.i./ha salofflufen, 0.1kg a.i./ha methofenozide, 0.5kg a.i./ha profenophos and 0.5kg a.i./ha, chlorpyriphos 0.5 kg a.i./ha) against the major insect pests of rice against the major insect pests of rice (cv.

Jaya), i.e., stem borer and gall midge. Almost all the insecticide were found highly effective in the agro - climatic condition of Orissa.

Misra *et al.*, (2004) conducted a field experiment to evaluate the six combination insecticides *viz.*, Koranda (acephate 25%+fenvalerate 3%), Viraat (cypermethrin 3%+quinalphos 20%), Nagata (ethion 40%+cypermethrin 5%), Rocket (Profenophos 40%+cypermethrin 4%), Nurelle D (chlorpyriphos 50%+cypermethrin 5%) and Spark (deltamethrin 1%+triazophos 35%), were field screened @ 560, 230, 450, 440, 550 and 360 g a.i./ha, respectively against the rice gall midge (*Orseolia oryzae* Wood Mason) and the hoppers *viz.*, brown planthopper (*Nilaparvata lugens* Stal.), white backed planthopper (*Sogatella furcifera* Horvath) and the green leafhopper (*Nephotettix virescens* Dist.) during *Kharif*, 2003 at Bhubaneswar. The results revealed that all the combination insecticides successfully reduced the incidence of silver shoot (61.7478.65%), BPH (51.6865.63%),WBPH (64.4880.90%) and GLH (75.0085.31%). Koranda resulted in highest reduction of the hoppers. Although there was a significant reduction in the spider population initially due to application of combination insecticides, but their population builded up in two weeks.

### **2.5.3 Rice hispa: *Dicladispa armigera* Oliver (Coleoptera: Chrysomelidae)**

Balasubramanian *et al.*, (1983) studied that the effect of combined application of carbofuran and nitrogen. Observation recorded 60 days after transplanting revealed that population of the pest increased as the rate of release of nitrogen increased but there was no interaction between nitrogen and carbofuran in reducing the incidence of the pest species.

### **2.5.4 Rice leaf folder: *Cnaphalocrocis medinalis* Guenee**

Saroja and Raju (1982) reported that carbofuran at 0.4 and 0.5 kg a.i./ha gave rise to the most effective control of leaf folder (*C.medinalis*).

Bhagat (1986) reported that most effective insecticides for controlling the rice leaf folder were U.C. 54229 at 0.75 kg a.i./ha quinalphos at 1.5 kg a.i./ha and monocrotophos at 0.5 kg a.i./ha.

Nigam *et al.*, (1989) reported that an insecticidal trial was to test the efficacy of some newer insecticides against major insect pest complex of rice crop carried out at Oilseed Research Farm, Kalyanpur, Kanpur, during *Kharif* 1990, 1991 & 1992 in randomized block design having four replication in the plot size of 5x5 m experimental plots. In all, there were eleven treatments including control (no

treatment). The insecticides used were cartap 4G, Lindane 6 G @ 1.0 & 0.75 KG a.i./ha, carbofuran 3G 1.0 kg a.i./ha, cartap 50 SP @ 0.075 & 0.05 kg a.i./ha, ethofenprox 10 EC @ 0.075 & 0.05 kg a.i./ha, Phosalone 35 EC @ 0.05 kg a.i./ha. granular insecticides were applied at 40 DAT in rice fields having 5cm standing water and EC formulations were sprayed when major insect pest population reaches its peak (ETL) period. Observations were recorded 3 days, 7 days, 15 days after insecticidal spray and at harvest of the crop. Amongst the treatments, carbofuran 3G, cartap 4G @ 1.0 kg a.i./ha and Phosalone 35 EC @ 0.05 kg a.i./ha proved better than other treatments including control (no treatments) against major rice insect pest viz. rice gundhi bug, *Leptocorisa varicornis*, rice green leaf hoppers, *Nephotettix viresens*, white jassids, *Cicadella spectra*, rice leaf roller, *Cnaphalocrocis medinalis* and rice ear eating caterpillar, *Mythimna separata*.

Kalita *et al.*, (2008) conducted an experiment in the Assam, India, during the 2003 kharif season, to determine the efficacy of 8 different insecticides against certain rice pests, such as stem borer (*Scirpophaga incertulas*), gall midge (*Orseolia oryzae*), leaf folder (*Cnaphalocrocis medinalis*) and case worm (*Parapoinx stagnalis*), and using monocrotophos (Monocil 36 WSC) at 500 g a. i./ha as control. The results revealed that all the insecticidal treatments reduced the insect populations significantly over control and incurred significantly higher yield. Among the treatments, carbofuran (Furadan 3G) at 1000 g a. i./ha reduced maximum population of insect pests and gave highest yield (45.72% increase of yield over control). Besides carbofuran (Furadan 3 G), imidacloprid (Confidor 200 SL), profenofos (Carina 50 EC) and profenofos 40% + cypermethrin 5% showed better results than monocrotophos (control). Hence, these may also be applicable for rice pest management.

Prasad and Prasad (2010) conducted a field experiment during *kharif*, 2007 in rice research farm Birsa Agriculture University, Ranchi with rice (Var. Jaya) to evaluate the bio- efficacy of some newer molecules of insecticides against its major lepidopterous insect pests. It was found that the combination product (imidacloprid 40% plus ethiprole 40%) 80 WG applied in the combined form @ 125 g a.i./ha remained most effective in reducing major lepidopteran insect pest viz. *Nymphula depunctalis* (Gn.), *Canphalocrosis medinalis* (Gn.). Another combination product (flubendamide 36% plus fipronil 30% ) 66WG @ 50 g a.i./ha and imidacloprid 200

SL @ 100 ml/ha and bifenthrin 10 EC @ 500 ml/ha were also found to be very effective in suppressing the incidence of major prevailing insect pests of rice in the agro-climatic conditions of Ranchi region of Jharkhand.

Painkra and Salam (2013) conducted a field experiment to determine the efficacy of various insecticides in the management of leaf folder (*Cnaphalocrocis medinalis*) in rice cv. MTU1010. The treatment comprised farmers practice of one spray of chlorpyrifos 20 EC at 0.04% (T1) and foliar application of triazophos 40 EC at 0.08% (2 sprays at 10 day intervals; T2). Data on damaged leaves per hill, percent incidence, average yield, percent increase in yield, net returns and B: C ratio was recorded. Results showed that the performance of the new technology (T2) under various conditions for the management of leaf folder was more effective compared to the farmers practice (T1) and enhanced the productivity of rice.

Singh *et al.*, (2015) was found the spray of cartap hydrochloride 75 SG @ 375 g a.i./ha was most effective in minimizing the leaf damage up to (0.48%) and was at par with higher dose of cartap hydrochloride 75 SG @ 750 g a.i./ha (0.60% damage) and fipronil 5 SC @ 250 ml/ha (0.69% damage). The remaining treatments, cartap hydrochloride 50 SP @ 500 g a.i./ha (1.08%), lambda cyhalothrin 2.5 EC @ 12.5 ml/ha (1.29%) and cartap hydrochloride 75 SG @ 281.5 g a.i./ha (1.03%) were found effective and significantly superior over untreated control.

Chanu and Sontakke (2015) conducted a field experiment to assess the comparative efficacy of new insecticide rynaxypyr 0.4 G and 18.5SC (chlorantraniliprole), and emamectin benzoate 5SG at different doses against rice leaf folder along with recommended insecticides like fipronil, carbofuran and profenophos on rice variety 'Swarna' (MTU7029) during *kharif*, 2012 and summer, 2013 at Central Research Station Farm, Orissa University of Agriculture and Technology, Bhubaneswar. The granular formulation of rynaxypyr (0.4 G) @ 50 g a.i./ha was found to be the most effective in reducing the damage (80.27 and 86.12% reduction over control) with the highest grain yield (51 q/ha and 55 q/ha) with respect to damage reduction over control (77.03% and 84.98%) and grain yield (49 q/ha and 53 q/ha), the next best was rynaxypyr 0.4 G @ 40 g a.i./ha with second highest C:B ratio during *kharif*, 2012 (1:5.80) and highest during summer, 2013 (1:6.81). Rynaxypyr (18.5 SC) and emamectin benzoate (5 SG) were less effective. Recommended

insecticides such as fipronil 0.3 G, profenophos 50EC and carbofuran 3 G recorded comparatively higher incidences, less field efficacy, with lower grain yield.

### **2.5.5 Green leaf hopper: *Nephotettix* spp. (Hemisphere: Cicadellidae)**

Prasad (2010) found that all the insecticidal treatments remained significantly effective in reducing the incidence of the insect pest species viz. gall midge, GLH, YSB, leaf folder and hispa which in turn realized increased yields of paddy grains. Application of carbofuran 3G @ 30kg/ha at 10 DAT, followed by 3 sprays with monocrotophos 36 WSC @ 1390 ml/ha at 30, 70 & 90 DAT (date after transplanting) could be most effective in suppression of all the prevailing major insect pest species realizing the highest grains yield (34.17q/ha).

### **2.5.6 Gundhi bug: *Leptocorisa acuta* Thunb. (Hemiptera: Alydidae)**

Prasad *et al.*, (2008) reported that judicious application of the recommended insecticides viz. monocrotophos 36WSC @ 1390ml/ha alternated with (chlorpyrifos 20 EC) @ 2.5lit/ha per spray supplemented with the host plant resistance (HPR) could be a promising IPM strategy for realizing substantially higher grains yield with possible minimum environmental hazards.

Girish *et al.*, (2015) evaluated the efficacy of certain newer insecticides and botanicals against ear head bug and yellow stem borer population in rice. New insecticides viz., flubendiamide 480 SC @ 0.2 ml/l, indoxacarb 14.5 SC @ 0.5 ml/l, bifenthrin 10 EC @ 1 ml/l, spinosad 45 SC @ 0.2 ml/l, chlorfenapyr 2 SC @ 1 ml/l, novaluron 10 EC @ 1 ml/l, emamectin benzoate 5 SG @ 0.25 ml/l, ranaxypyr 20 SC @ 0.3 ml/l, thiacloprid 240 SC @ 0.25 ml/l, azadirachtin 3000 ppm @ 3 ml/l and profenophos 50 EC @ 2 ml/l (check) were evaluated in the field during *kharif* season of 2010 against the ear head bug [*Leptocorisa acuta* (Thunberg)] and yellow stem borer [*Scirpophaga incertulus* (Walker)]. The results revealed that out of eleven insecticides sprayed at 90 days after transplanting, profenophos 50 EC @ 2 ml/l recorded the lowest ear head bug population (0.33 ear head bugs/hill) followed by thiacloprid 240 SC @ 0.25 ml/l (0.37 ear head bugs/hill) and novaluron 10 EC @ 1 ml/l (0.53 ear head bugs/hill). Whereas, thiacloprid 240 SC @ 0.25 ml/l recorded significantly least infestation of yellow stem borer (0.93% white ear). In other insecticidal treatments the level of ear head bug and white ear suppression was comparatively low.

Rath *et al.*, (2015) evaluated bioefficacy of the eleven insecticides including new insecticide sulfoxaflor and check insecticide monocrotophos were in field

condition against yellow stem borer and rice gundhi bug during dry season of 2011 and 2012. Imidacloprid 17.8% @ 300 g/ha treatment recorded lowest percentage of DH (3.3%), WEH (3.33%), gundhi bug damage (7.16%) and highest grain yield of 5.28 t/ha in variety Jaya followed by the treatment Sulfoxaflor 24% @ 375 g/ha, 4.96 t/ha, Thiamethoxam 25% @ 100 g/ha, 4.9 t/ha and triazophos 40% @ 625 g/ha, 4.78t/ha during 2011 and similar result was also observed in 2012. All the tested insecticides significantly reduce damage due to yellow stem borer and gundhi bug. The grain yield of treatment imidacloprid 17.8% @ 300 g/ha was highest (5.28 and 5.21 t/ha) significantly superior to check insecticide monocrotophos 36% @ 1390 ml/ha (4.65 and 4.62 t/ha) and at par with thiamethoxam 25% @ 100 g/ha (4.9 and 4.85 t/ha), triazophos 40% @ 625 g/ha (4.78 and 4.8 t/ha) and new insecticide Sulfoxaflor 24% @ 375 g/ha (4.96 and 4.92 t/ha) during 2011 and 2012 respectively. The check insecticide was found superior to new insecticide sulfoxaflor at lower dose i.e. 311 g/ha against yellow stem borer and gundhi bug damage.

A decorative border resembling a scroll, with rounded corners and a grey shadow effect. The border is composed of a top horizontal line, a right vertical line, a bottom horizontal line, and a left vertical line. Each corner is rounded and features a grey scroll-like element.

*MATERIALS*  
*AND*  
*METHODS*

## *Materials and Methods*

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Description of the materials used and methodology adopted during the course of the present investigation “Management of insect pest complex of rice” has been presented in this chapter. For conducting any scientific experiment (s) or trials or investigation (s), required principles, methods and physical materials are required either in field or laboratory or in both conditions.

The studies were conducted at RRF (Rice Research Farm) of RAC (Ranchi Agricultural College) Kanke, Birsa Agricultural University, Ranchi, Jharkhand during *Kharif* 2016 and 2017 in order to fulfil the requirements of the objectives of different aspects of the present studies “**Management of insect pest complex of rice**” as envisaged in the plan of these work have been described here as below:

Nevertheless, the survey work on incidence of pest complex of rice were carried out in and around BAU, Kanke, Ranchi to visualize the pest scenario associated with rice crop in Ranchi.

The pest (s) found on rice crop were classified into minor, mild, major, severe and key pest according to the status of the respective pests and also on the basis of their intensity of infestation, abundance or incidence of pest. Keeping in view the frequency (mode) of occurrence of the respective pests in different observational plots (fields), the pests were categorized as stray or regular pest along with the growth stages of the crop upon which the pest incidence was found to occur.

### **3.1 Study Area:**

Kanke (Ranchi) known as rice production area of Jharkhand under agro-climatic zone seven eastern plateau and hills (plateau region of Chotanagpur and Santhal Parganas) sub zone-V. RAC Rice research farm is located at 23<sup>0</sup>17’N and 82<sup>0</sup>19’E and 625 m above sea level has a semi-arid and subtropical climate with extremes of weather conditions.

This place has a sub-tropical climate characterized with hot and dry summer, cold winter with moderate annual rainfall. This region receives rainfall from both the streams of south-west and north-east monsoon. The mean annual precipitation of this region is 1400 mm of which 80-85 percent is received during June to September. Pre monsoon showers are usually received in the month of May. Late arrival and early cessation of monsoon rains are not very uncommon. Scanty post monsoon rains are

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also experienced during winter. Temperature of this region varies as low as 2.2<sup>0</sup>C in the winter and as high as 42.4<sup>0</sup>C in summer. May and June are the hottest months with a maximum and minimum temperature of 37.7<sup>0</sup>C and 24.2<sup>0</sup>C, respectively. December and January are the coldest months of the year, when temperature falls below 10<sup>0</sup>C. Temperature generally decreases from second week of September onwards to December. Rapid decline in temperature with occasional frost is also observed during late December and early January. This temperature starts rising from middle of January and reaches to its peak in May-June. The sunshine hours also ranges from as low as 1.6 hours/day in July to 8.8 hours/day in April. The relative humidity (R.H.) rises up to 93 percent during July-August and falls down to 37 percent during April-May.

### **3.2 Experimental site and soil:**

#### **3.2.1 Experimental site**

The experimental field was located at Rice research farm of RAC Farm, Kanke during *Kharif* 2016 and 2017. Under the experiment No.01 field survey and surveillance work was conducted periodically in order to visualize and reckon the incidence of pest complex of rice in different rice growing areas of Jharkhand and the other four experiments were conducted in four different plots, Experiment No.02 was conducted with and three replication comprising of twenty rice varieties (cultivars) sub plot size of 5mX4m=20 m<sup>2</sup>, Experiment No.03 was conducted with three treatments on different dates of sowing & transplanting (early, normal and late) each at 20 days intervals and ten replication with plot size 15mX3m = 45 m<sup>2</sup>, Experiment No.04 was conducted with ten treatments in use ten botanical insecticides with three replication each having plot size 5mX4m=20 m<sup>2</sup> and Experiment No.05 was conducted with ten treatments were in use ten newer molecules of chemical insecticides with three replication each having plot size of 5mX4m=20 m<sup>2</sup>. The experimental design used was RBD (randomized block design) in all four experiments. The experimental plots were provided with assured irrigation facilities having uniform topography and proper drainage and all the required agronomical packages of practices.

#### **3.2.2 Soil**

The soil of experimental site belongs to “Red-yellow-light grey catenaric soil association group” representing the major soil group of Chotanagpur plateau. The soil was clay loam with 37.3% sand, 30.2% silt and 32.5% clay. The soil was slightly

acidic in reaction (pH 5.9), low in organic carbon (3.8 g/kg) and available nitrogen (212.7 kg/ha), medium in available phosphorus (31.35 kg/ha) and in potassium (185.06 kg/ha). The data collected on physical and chemical properties of the soil (0-15 cm) of the experimental site before the start of the experimentation is given in Appendix I.

### **3.3. Climate and Weather:**

Prevailing weather conditions during the crop season as envisaged through temperature (Max. and Min.) relative humidity (at % 7AM & 2PM) and rainfall (mm) were collected from automatic weather station the Department of Agricultural Physics and Environmental Science of RAC, Kanke, Ranchi. The weather data during the period of the investigation is given in the Appendix II and Appendix III.

#### **3.3.1 Meteorological condition during the period of investigation**

The weekly meteorological data on weather condition during the crop growth period from June to November, 2016 and 2017 have been furnished in Appendix II and Appendix III.

##### **3.3.1.1 Rainfall**

Sowing and planting work of rice coincided with sufficient rains received during *khariif* season of the years 2016 and 2017. The crop received rainfall of 1285.20 mm in 2016 and 1532.60 mm in 2017.

##### **3.3.1.2 Temperature**

During the crop period (June to November) mean maximum temperature varied between 26.90 to 37.70 °C and 24.90 to 34.40 °C whereas minimum temperature from 10.90 to 24.90 °C and 11.50 to 22.60 °C respective year 2016 and 2017, which falls within the range of optimum temperature (21- 37 °C) requirement of rice crop for various phenophases.

##### **3.3.1.3 Relative Humidity**

Mean monthly relative humidity at 7 AM and 2 PM during the crop period was 83.30/62.80% in 2016 and 85.50/68.90 in 2017, which was congenial for crop growth.

### **3.4 Materials used for experimentation**

#### **3.4.1 Seed**

Sahbhagi Dhan variety is medium duration (115 days), drought tolerance and good yield potential of 4.5-5.0 t/ ha. This is recommended for *Don III* & *Don II* medium land. This was used in experiment no. 3 in the present investigation in order

to study the impact of dates of plantings on incidence of major insect pest of rice.

IR- 64 Drt. variety is also medium duration (125), drought tolerance and yield potential of 5.0 t/ ha. This is recommended for *Don III & Don II* medium land. This was used in experiment no. 4 in the present investigation in order to evaluate the bioefficacy of botanical insecticides against major insect pest of rice.

Naveen variety is resistant to blast and bacterial sheath. The crop matures in about 120 days, and having yield potential of 5.0 t/ha. This was recommended for irrigated ecosystem, *Don III & Don II* medium land. This is used in experiment no. 5 under the present field studies for evaluation of bioefficacy of new molecules insecticide against major rice insect pests.

### **3.4.2 Fertilizer**

Urea (46% N), DAP (46% P, 18% N) and MOP (60% K<sub>2</sub>O) were used as the recommended fertilizer. The recommended dose of fertilizer for Nitrogen, phosphorous and potash were 80, 40 and 20 kg/ha respectively.

### **3.4.3 Plant Protection Chemicals**

Indofil M-45(mancozeb 75% WP) @ 2.5 kg/ha were used for crop protection from disease, which was applied as uniform and blanket spray operation against the foliage diseases *viz.* Blast brown spot.

### **3.4.4 Agronomic management**

#### **3.4.4.1 Field preparation**

A plot having uniform fertility and even topography was selected for conducting field trial. The field was ploughed twice 15 days before sowing. One ploughing was done just two days prior to sowing. Finally two planking was done to get well levelled, pulverized compact seed bed for good and uniform germination. Layout was done to meet the requirement of experimental design.

#### **3.4.4.2 Transplanted rice**

Twenty one days old 2-3 seedlings/hill were transplanted manually in the puddle field at a depth of 2-3 cm with a spacing of (20 cm × 15 cm). There were 20 rows are maintained in each conventionally transplanted plot. The entire process was done by hand and therefore, it was time consuming, laborious, caused drudgery to labours and also resulted in high cost of production, however gave uniform and adequate plant stand.

#### **3.4.4.3 Fertilizer application**

Uniform fertilization (80:40:20kg N:P<sub>2</sub>O<sub>5</sub>:K<sub>2</sub>O/ha) was done for all the rice

establishment methods. Urea, diammonium phosphate and muriate of potash were used as fertilizers for nitrogen, phosphorus and potassium. Half dose of nitrogen and full dose of phosphorus and potassium were applied at the time of sowing. Rest of the nitrogen was top dressed in two equal splits at 25 and 50 days after transplanting. Whereas the fertilizer application in the nursery bed for raising seedling of rice was 8:4:2 kg N:P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O per 1000 sq m., half dose of N and full dose of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O were applied as basal and remaining N was top dressed at 15 DAS.

#### **3.4.4.4 Irrigation**

In rice cultivation through the transplanting method irrigation water was periodically applied as and when required the field almost up to 15 days before harvesting.

#### **3.4.4.5 Manual weeding**

In the cultivation of rice through transplanting manual weeding was done at 25 DAT.

#### **3.4.4.6 Plant Protection**

Adequate measures were taken to save the crop from diseases for the successful experimentation need based and blanket application of indofil M-45 (mancozeb 75% WP) @ 2.5 kg/ha was also provided to keep the crop free from the infestation of blast and brown spot diseases caused by *Pyricularia oryzae* *Helmithosporium oryzae*, respectively.

#### **3.4.4.7 Harvesting, threshing and winnowing**

Harvesting of rice in the experimental plot was done after attainment of physiological maturity by the crops in different experimental fields. Border rows from all the sides were first harvested and then the net plots were harvested, separately, with the help of sickle from the ground level. The harvest from each plot was, separately, bundled tagged and brought to the threshing floor for complete drying in the sun for 3-4 days. After drying, threshing was done with the help of manual labours, followed by winnowing.

### **3.5. Yield of the crop**

Harvested crop of each plot of the each of four experiment of the present thesis protocol investigation were threshed manually and weight of grain yield was recorded plot wise. Treatment wise mean weight of yield was worked out. Finally, the yield weight of grains per plot was converted into quintal per hectare and percentage of yield increase over the control was calculated for proper documentation.

**3.6 Mathematical formula or procedures used for recording observations for their proper interpretations:**

Certain mathematical procedures, steps or formula were employed for interpretation of information in the form of the experimental data. These are mentioned here as under:

**(i) Gall midge (GM):**

$$SS(\%) = \frac{\text{Total no. of silver shoot (SS) in 10 hills (plants)}}{\text{Total no. of tillers (SS + healthy tillers) in 10 hills (plants)}} \times 100$$

**(ii) Yellow stem borer (YSB):**

(a)  $DH(\%) = \frac{\text{Total no. of dead hearts (DH) in 10 hills}}{\text{Total no. of tillers (DH + healthy tillers) in 10 hills}} \times 100$

(b)  $WE(\%) = \frac{\text{Total no. of white ear (WE) in 10 hills}}{\text{Total no. of panicles (WE+ healthy panicles) in 10 hills}} \times 100$

**(iii) Rice hispa :**

(a) Total no. of damaged leaves by hispa (HDL) / 10hills

(b)  $\% \text{ Leaf damage (HDL)} = \frac{\text{Total no. of damaged leaves (HDL) in 10 hills}}{\text{Total no. of leaves (damaged + healthy) in 10 hills}} \times 100$

**(iv) Leaf folder :**

(a) Total no. of damaged leaves due to leaf folder (LFDL)/10 hills.

(b)  $\% \text{ Leaf damage (LFDL)} = \frac{\text{Total no. of damaged leaves (LFDL) in 10 hills}}{\text{Total no. of leaves (damaged + healthy) in 10 hills}} \times 100$

**(V) Green leaf hopper (GLH) :**

Incidence of GLH = Total no. of GLH /10 hills  
i.e., total no. of GLH/5Net sweeping

**(vi) Gundhi bug/Ear bug (EB) :**

Incidence of EB = Total no. of EB /10 hills  
i.e., total no. of EB / 5Net sweeping

**Table 3.1: Measuring units used for determining the population /abundance/incidence of the insect pest fauna associated with rice agro-ecosystem.**

Sl. No.	Insect pest species	Measuring scale for determining abundance /incidence of the pest(s)
1	Gall midge, <i>Orseolia oryzae</i> (Wood Mason)	(i) Percentage of Silver shoot (SS) due to gall midge (SS %) (ii) Hill (plant) infestation due to gall midge (HI%)
2	Yellow stem borer, <i>Scirpophaga incertulas</i> (Walker)	(i) Dead heart, DH (%) (ii) White ear head, WEH (%)
3	Rice hispa, <i>Dicladispa armigera</i> (Olivier)	(i) No. of damaged leaves(HDL)/10hills(plants) (ii) Leaf damage (%)
4	Leaf folder, <i>Cnaphalocrocis medinalis</i> (Guenee)	(i) No. of damaged leaves(LFDL)/10hills(plants) (ii) Leaf damage (%)
5	Green leaf hopper (GLH), <i>Nephotettix virescens</i> (Distant)	(i) No. of GLH/10 hills(plants) or , No. of GLH/5 Net sweeping
6	Gundhi bug/Ear bug (EB), <i>Liptocorisa acuta</i> (Thunberg)	(i) No. of the bugs/10 hills(plants) Or, No. of the bugs/5 Net sweepings (ii) Grain damage (%)
7	Grass hopper, <i>Hieroglyphus banian</i> Fab.	(i) No. of the insects/10 hills Or, No. of the insects/5 Net sweepings
8	Case worm <i>Nymphula depunctalis</i> (Guenee)	(i) Percentage of leaf damage
9	Black hairy caterpillar, <i>Nisaga simplex</i> (Wlk).	(i) No. of larvae /meter row length(MR) Or, No. of caterpillar/Sq.m.
10	Termite (ant), <i>Odontotermes obesus</i> Ramb.	(i) Percentage of plant (hill) damaged showing dead heart or white ear head. (ii) No. of damaged plant/Sq.m.
11	Rice mealy bug, <i>Brevinnia rehi</i> (Lindinger)	(i) Percentage of leaf damaged bearing cottony growth on leaves (ii) Percentage of plant(hill)damaged due to mealy Bug
12	White grub, <i>Holotrichia spp.</i>	(i) Percentage of plant (hill) damage showing weathering
13	Thrips, <i>Stenchaetothrips biformis</i> (Bagnall)	(i) Percentage of plant (hill) damage showing narrow rolling or pinning due to thrips attack.
14	Brown plant hopper (BPH), <i>Nilaparvata lugens</i> (Stal.)	(i) No. of the BPH/10 hills
15	Yellow hairy caterpillar <i>Psalis pennatula</i> (Fabricius)	(i) No. of larvae /meter row length(MR) Or, No. of caterpillar/Sq.m.

Objective wise detailed methodology followed for the investigation is described under the following sub-headings:

1. The study on biodiversity of insect-pest species in the agro-ecosystem of rice in Jharkhand.
2. Evaluation of certain rice cultivars/varieties against major insect-pests of rice.
3. The study on the effect of staggering in date of transplanting on the incidence of insect-pest complex of rice.
4. Evaluation of field bio- efficacy of botanical based insecticides against major insect-pests of rice.
5. Evaluation of field bio- efficacy of newer molecules of insecticides against major insect-pests of rice.

### **3.7.1 Experiment No.01:**

#### **The study on the biodiversity of insect-pest species in the agro-ecosystem of rice Jharkhand.**

##### **Observational Procedures**

Method : Visit, survey and surveillance and interaction with local farmers.

Periodicity : Once in a fortnight. Usually six times in a crop season

Pest survey and surveillance work was conducted at fortnightly intervals in *kharif* during the experimental year of 2016 and 2017 in Rice Research Farm BAU to explore the information pertaining to pest problems associated with rice. As such, ranges of incidence or population across the cropping season were determined. The observational data on the incidence of all the respective pest species, recorded at different locations, viz. BAU's Rice Research farm of Kanke, ZRS, KVK and Villages were recorded and pooled together on fortnightly basis in terms of their mean of each of 2016 and 2017.

A pocket lens (10X) was used for the detection of minute insect species. The pest affected plant materials e.g. leaves, stems, panicles and roots etc. (whichever necessary) as well as the insect pests were plucked and collected as per the requirements in the polythene bags and glass vials and brought to the laboratory for their close examination for estimation in terms of qualitative and quantitative composition of the pest species prevalent in transplanted rice ecosystem in wet season.

As some pest species (i.e., stem borer, gall midge, thrips, rice hispa, green leaf hopper, leaf folder, ear head bug etc.) in their adult stages needed an insect catching

(collecting) net to detect and identify that which pest incidence is there. The information concerning location (locality/place) collection date, nature of damage were recorded and noted down for documentation in the compiled form of the whole *kharif* season, recorded during, 2016 and 2017.

Observations were taken periodically at fortnightly intervals in order to determine the succession of occurrence, intensity and their pest status of infesting rice plants at different crop stages. As such the recorded observation in terms of the population of insect pest fauna and their intensity of occurrence associated with rice agro – ecosystems were determined and recorded by employing the measuring units which are mentioned in the Table-3.1. Finally, all the data obtained from different fields recorded from various localities areas were pooled together as pest-wise which were recorded at fortnightly intervals. As such, population of pest species and the intensity of pests over the cropping season were determined. According to the quantum of abundance or incidence, the pest (s) was classified into: minor, mild, major, severe or key pest based on their status. Keeping in view the mode (frequency) of occurrence, the pests were categorized as stray or regular pest along with the growth stage (s) the crop upon which the pest incidence occurred.

### 3.7.2 Experiment No.2:

#### Evaluation of certain rice cultivars/varieties against major insect-pests of rice.

The experiment to evaluate certain rice varieties for their relative resistance against major insect pests was conducted at the rice research farm, B.A.U, Kanke Ranchi, Jharkhand during *kharif*, 2016 and *kharif*, 2017, the brief description of which is given, here, as under:

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#### Detail of the field experiment, conducted during *kharif* 2016 and 2017

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Design	:	RBD (Randomized block design)
Rice varieties	:	20
Replications	:	3
Spacing (plant to plant)	:	15 cm
Spacing (row to row)	:	20 cm
Plot size	:	5 x 4 m
N:P:K	:	80:40:20 kg/ha (As per local recommendation)
Date of Sowing	:	5 <sup>th</sup> July
Date of Transplanting	:	24 <sup>th</sup> July
Date of harvesting	:	9 <sup>th</sup> November

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**Observations recorded:**

- i. Periodical observations on major insect pest fauna and yield grains after harvest of the crop were recorded properly

**Observations recorded:**

- Observations was recorded on the incidence of YSB, gall midge, leaf folder, hispa, GLH and gundhi bug etc. following the same procedures to those of experiment no. 01.

**Treatments details:-**

**Table No. 3.2 List of rice varieties cultivars/ proposed for their field screening for their relative resistance against major insect pests of rice:**

Sl.No.	VARITIES	SL.No.	VARITIES
1	CR Dhan - 303	11	Akshay Dhan
2	IR-20	12	IR-64 Sub-1
3	MTU- 1010	13	CR Dhan -205
4	IR-64Drt.	14	DRR-44
5	Naveen	15	BVS-1
6	Sahbhagi Dhan	16	Kavya
7	Pusa- 1176	17	Lalat
8	Abhishek	18	Advanta-801 <sup>+</sup>
9	IR-36	19	Suraksha (RC)
10	CR Dhan - 304	20	TN-1 (SC)

Twenty genotypes selected rice varieties/cultivars were taken for the investigation. Each treatment was replicated thrice in the randomised block design. TN-1 and Suraksha were kept as susceptible check (SC) and Suraksha as resistant check (RC). All the recommended agronomical packages of practices were followed for raising the crop. Field preparation was done by ploughing once by tractor drawn disc plough and second ploughing was done by mould board plough. Date of sowing and transplanting were 05.07.2016 and 24.07.2016 in *kharif*, 2016 and 05.07.2017 and 24.07.2017 in *kharif*, 2017, respectively. Seedlings were transplanted in 5x4 m<sup>2</sup> plot area with 15 cm (plant to plant) x 20 cm (row to row) spacing. The recommended doses of fertilizers (N:P:K : 80:40:20 kg/ha) were applied. Nitrogen, phosphorus & potash in the form of urea, diammonium phosphate and muriate of potash were used respectively. However, the half of nitrogen was applied as basal dose and remaining

half of nitrogen was top dressed after 30 days after transplanting and balance half dose was applied at panicle initiation stage.

**Observations schedule for studies on HPR**

- a. Observations pertaining to incidence of gall midge in terms of silver shoot (SS%) and hill infestation (HI%) were recorded at 30 and 45 DAT.
- b. Observations on dead heart (DH %), caused by YSB were recorded at 30, 45 and 60 DAT (days after transplanting) and white ear head (WE %) at maturity stage of the crop.
- c. Observations on leaf damage caused by hispa (HDL%) were recorded at 20 and 35 DAT.
- d. Observations on leaf damage caused by leaf folder (LFDL %) were registered on 60 and 80 DAT.
- e. Observations on no. of GLH/10 hills were taken on 70 and 85 DAT.
- f. Observations on no. of ear bugs /10 hills (plants) were recorded on peak milking stage of the crop of rice.
- g. Grain yield was recorded at the maturity of the crop after harvest.

**3.7.3 Experiment No.3:**

**The study on the effect of staggering in date of transplanting on the incidence of insect-pest complex of rice.**

Field trials were conducted during the *kharif* seasons 2016 and 2017 at rice research farm of BAU, Kanke, Ranchi in randomized block design (RBD) with three treatments (three date of sowing and transplanting) and ten replications with the rice variety, Sahbhagi Dhan with plot size of 15x3 (45 m<sup>2</sup>). All recommended agronomical packages of practices were followed to raise the crop. Periodical variation in the incidence of major insect pest species (i.e., stem borer, gall midge, rice hispa, green leaf hopper, leaf folder and ear bug ) were recorded regularly in the experimental plot (s) on rice (Sahbhagi Dhan). Field observations were recorded periodically at fortnightly intervals in case of gall midge at 30 and 45 DAT (days after transplanting) in terms of percentage of silver shoot (SS %). The observations on yellow stem borer (YSB) were registered at 30, 45 and 60 DAT in terms of percentage of dead heart (DH%). Observation on white ear head (WE) was recorded at maturity stage of crop in terms of WE%. Observations of leaf damage, due to hispa (LDH) were registered at 25 and 40 DAT. Observations of leaf damage, due to leaf folder

(LDLF) were recorded at 60, 70 and 80 DAT. Observations were recorded pertaining to GLH (no. of GLH/10 hills) at 40, 60 and 80 DAT. Observations to incidence of ear bug were registered, at milking stage of the crop in terms no. of ear bug 10 hills (i.e. EB/10 hills).

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**Detail of the field experiment, conducted during *kharif* 2016 and 2017**

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Design	:	RBD (Randomized block design)
Treatments	:	Three (dates of sowing and transplanting of rice, each at 20 days intervals).
Replication	:	10
Spacing (plant to plant)	:	15 cm
Spacing (row to row)	:	20 cm
Plot size	:	15 x 3 m
N:P:K	:	80:40:20 kg/ha (As per local recommendation)
Crop variety	:	Sahbhagi Dhan

**Treatments details:-**

Time of planting	:	1) Early planting 2) Normal planting 3) Late planting
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Sl. No.	Dates sowing	Dates of transplanting	Date of harvesting
D <sub>1</sub>	12 <sup>th</sup> June	01 <sup>st</sup> July	14 <sup>th</sup> October
D <sub>2</sub>	02 <sup>nd</sup> July	21 <sup>th</sup> July	03 <sup>rd</sup> November
D <sub>3</sub>	22 <sup>th</sup> July	12 <sup>th</sup> August	25 <sup>th</sup> November

**Observations recorded:**

- In each sub-plot, 10 hills were marked and tagged at random and record observations were recorded on insect pests on the marked hills starting from the first appearance of the pest at fortnightly intervals.
- At each observation in the marked hills
  - ✓ count total number of tillers per hill,
  - ✓ number of dead hearts per hill,
  - ✓ number of silver shoots per hill,
  - ✓ number of damaged leaves (specify the pest) per hill,

- ✓ number of total leaves per hill,
- ✓ total number of panicle bearing tillers per hill and
- ✓ White ears per hill
- ✓ No. of GLH & GB at 10 hills or / 5 net sweeps

#### Observations on grains yield:

Observations on yield were recorded after harvesting of the crop at attainment of maturity stage. Yields were recorded on kg/plot and converted in to q/ha.

#### 3.7.4 Experiment No. 4:

#### Evaluation of field bio- efficacy of botanical insecticides against major insect-pests of rice.

The experiment to evaluate the efficacy of certain botanical based insecticides against major insect pests species of rice were conducted at Rice research farm, RAC, B.A.U, Kanke, Ranchi, Jharkhand during *kharif*, 2016 and *kharif*, 2017.

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#### Detail of the field experiment, conducted during *kharif* 2016 and 2017

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Design	:	RBD (Randomized block design)
Insecticidal treatments	:	10
Replications	:	3
Spacing (plant to plant)	:	15 cm
Spacing (row to row)	:	20 cm
Plot size	:	5 x 4 m
N:P:K	:	80:40:20 kg/ha (As per local recommendation)
Date of sowing	:	4 <sup>th</sup> July
Date of transplanting	:	23 <sup>th</sup> July
Date of insecticide application	:	25, 40, 80, & 95 DAT
Date of harvesting	:	8 <sup>th</sup> November
Crop variety	:	IR-64Drt.

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Treatment application: Periodical and need based application of respective insecticidal treatments were applied on the basis of ETL of the pest species at the different stages of the crop growth.

#### Observation:

- Observations on pest incidence was recorded at one day before & 4<sup>th</sup>, 7<sup>th</sup> and 10<sup>th</sup> days after insecticidal application (DAA)
- Grains yield after harvest was recorded.

- Observations were recorded on the incidence of YSB, gall midge, leaf folder, hispa, GLH and gundhi bug by following the similar procedures as employed in the previous experiment.

**Treatment details:-**

**Table No. 3.3 Treatment details of some selected commercial formulations of botanical insecticides used against major insect-pests of rice:**

Treatments	Trade name	(a.i. in formulations) Aza. % EC	Dose of the formulated product (ml or g /ha)	Dose ml or g/l of water
T 1	Neem Baan	1 % EC	1000 ml	2.00 ml
T 2	Neemazal	1 % EC	1000 ml	2.00 ml
T 3	Nimbecidine	0.03 % EC	2500 ml	5 ml
T 4	Multineem	0.03 % EC	2500 ml	5 ml
T 5	Neemoil	-	2500 ml	5ml
T 6	Achook	0.03 % EC	2500 ml	5 ml
T 7	Pongamia oil (karanj oil)	-	2500 ml	5ml
T 8	Dinotefuran*	20 SG	200 g	0.5 g
T 9	Rynaxypyr*	20SC	150 ml	0.3 ml
T 10	Untreated contol	-	-	-

\* Chemical insecticides

Seven treatments botanical based insecticides were taken for the investigation. Each treatment was replicated thrice in randomised block design. Different botanical based insecticides viz. Neem Baan (Aza.1%EC), Neemazal (Aza.1%EC), Nimbecidine (Aza.0.03 % EC), Multineem (Aza.0.03 % EC), Neemoil, Achook (Aza.0.03 % EC), Pongamia oil (karanj oil), and two chemical insecticides viz. dinotefuran (20SG) and rynaxypyr (20SC) were kept in the form of check of chemical insecticides for the comparisons. In addition the 10<sup>th</sup> and the last treatment were kept

as untreated check for the overall comparisons of the test treatment for estimation of bioefficacy of the insecticides. All insecticides were applied at 25 DAT and repeated at 40, 80 & 95 DAT. All the recommended agronomical packages of practices were followed for raising the crop. Field preparation was done by ploughing once by tractor drawn disc plough and second ploughing was done by MB plough. Date of sowing and transplanting were 04.07.2016 and 23.07.2016 in *kharif*, 2016 and 04.07.2017 and 23.07.2017 in *kharif*, 2017, respectively. Seedlings were transplanted in 5x4 m plot area with 15 cm (plant to plant) x 20 cm (row to row) spacing. The recommended doses of fertilizers (N:P:K : 80:40:20 kg/ha) were applied. Nitrogen, phosphorus and potash were used in the form of urea, diammonium phosphate and muriate of potash. However, the half of nitrogen was applied as basal dose and remaining half of nitrogen was used in equal and split doses was top dressed after 30 days after transplanting and at panicle initiation stage.

**Table 3.4: Details of the test botanical insecticides used to control major insect pests of rice.**

Tr. No.	Name of insecticide		Formulations Aza. % EC	Price (Rs./litre or Kg)	Sources/manufacturer
	Common name	Trade name			
T1	Neem Baan	Neem Baan	1.00	1020	M/S Pest Control India Ltd,Mumbai.
T2	Neemazal	Neemazal	1.00	950	M/S EID Parry India Ltd,Chennai.
T3	Nimbecidine	Nimbecidine	0.03	650	M/S T.Stanes & Company Ltd,Coimbatore.
T4	Multineem	Multineem	0.03	450	M/S Multiplex Agricare Pvt. Ltd.Bangalore.
T5	Neemoil	Local	-	350	Local market
T6	Achook	Achook	0.03	600	M/S PI Industries Ltd.
T7	Pongamia oil (karanj oil)	Local	-	250	Local market
T8	Dinotefuran	Osheeen	20 SG	1350	M/S PI Industries Ltd.
T9	Rynaxypyr	Coragen	20SC	8500	M/s Dupont India Ltd.

### 3.7.5 Experiment No. 5:

#### Evaluation of field bio-efficacy of newer molecules of insecticides against major insect-pests of rice.

In order to evaluate field bio-efficacy of newer molecules of different insecticides against major insect-pests of rice, a field trial was conducted at Rice research farm, RAC, B.A.U, Kanke, Ranchi, Jharkhand during *kharif*, 2016 and 2017. Treatment application: Periodical and need based application of the respective test insecticidal treatments were applied based on the ETL of the pest species at the different stages of the crop.

#### Observation:

- Observations on pest incidence were be recorded at one day before & 4<sup>th</sup>, 7<sup>th</sup>, & 10<sup>th</sup> days after insecticidal application (DAA)
- Grains yield after harvest was recorded.

#### Observations recorded:

- Observations were recorded on the incidence of YSB, gall midge, leaf folder, hispa, GLH and gundhi bug by following the procedures similar to previous experiments.

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#### Detail of the field experiment, conducted during *kharif*, 2016 and 2017

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Design	:	RBD (Randomized block design)
Insecticidal treatments	:	10
Replications	:	3
Spacing (plant to plant)	:	15 cm
Spacing (row to row)	:	20 cm
Plot size	:	5 x 4 m
N:P:K	:	80:40:20 ka/ha (As per local recommendation)
Date of sowing	:	3 <sup>rd</sup> July
Date of transplanting	:	22 <sup>th</sup> July
Date of insecticide application	:	25, 40, 80, & 95 DAT
Date of harvesting	:	7 <sup>th</sup> November
Crop variety	:	Naveen

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Ten treatments comprising of newer molecules of chemical insecticides were taken for the investigation. Each treatment was replicated thrice in randomised block design. Different chemical insecticides viz. Spinetoram 6SC plus methoxyfenozide 30SC, spinetoram 6SC plus methoxyfenozide 30SC, triflumezopyrim 106SC, flubendiamide 48SC, rynaxypyr 20SC, acephate 95SG, dinotefuran 20SG, triazophos

40EC and carbofuran 3G alternated with triazophos 40EC and one untreated control plot were kept for their relative comparison of bioefficacy of the test treatments. All insecticides were applied at 25DAT and repeated at 40, 80 & 95 DAT. All the recommended agronomical packages of agronomical practices were followed. Field preparation was done by ploughing once by tractor drawn disc plough and second ploughing was done by MB plough. Date of sowing and transplanting were 03.07.2016 and 22.07.2016 in *kharif*, 2016 and 03.07.2017 and 22.07.2017 in *kharif*, 2017, respectively. Seedlings were transplanted in 5x4 m plot area with 15 cm (plant to plant) x 20 cm (row to row) spacing. The recommended doses of fertilizers (N:P:K : 80:40:20 kg/ha) were applied. Nitrogen, phosphorus & potash in the form of urea, diammonium phosphate and muriate of potash were used respectively. However, the half of nitrogen was applied as basal dose and remaining half of nitrogen was top dressed in two splits after 30 days after transplanting and at panicle initiation stage.

**Table 3.5: Details of the test chemical insecticides used to control major insect pests of rice.**

Tr. No.	Name of insecticide		Formulations (a.i)	Price (Rs./lit. or Kg)	Sources/manufacturer
	Common name	Trade name			
T1	Spinetoram 6SC plus methoxyfenozide 30SC	Spinetoram 6SC plus methoxyfenozide 30SC	36SC	NMAY**	M/s Dow Agrosciences Ltd
T2	Spinetoram 6SC plus methoxyfenozide 30SC	Spinetoram 6SC plus methoxyfenozide 30SC	36SC	NMAY**	M/s Dow Agrosciences Ltd
T3	Triflumezopyrim	DPX-RAB55	106SC	NMAY**	M/s Dupont India Ltd..
T4	Flubendiamide 48SC	Fame	48SC	14000	M/S Bayer India Ltd.
T5	Rynaxypyr	Coragen	20SC	8500	M/s Dupont India Ltd.
T6	Acephate	Hunk	95SG	900	M/s Rallis India Ltd. Mumbai
T7	Dinotefurain	Osheen	20 SG	1350	M/S PI Industries Ltd.
T8	Triazophos	Hostathion	36SL	450	M/s Rallis India Ltd. Mumbai
T9	Carbofuran* + triazophos (in form of alternate use)	Furadan* + Hostathion (in form of alternate use)	3G+40 EC	65 /450	M/s Rallis India Ltd. Mumbai

\* Refers to the granular formulations of insecticide which is applied by broadcasting method and not by foliar spray. \*\*NMAY – The product is not marketed as yet.

**Treatment details:-****Table No. 3.6 Treatment details of field bio-efficacy of some selected commercial formulations of newer molecules of chemical insecticide against major insect-pests of rice:**

Treatments	Trade name	Common Name	% a.i. in formulations	Dose of the formulated product (ml or g /ha)	Dose ml or g/l of water
T 1	Spinetoram 6SC plus methoxyfenozide 30SC	Spinetoram 6SC plus methoxyfenozide 30SC	36SC	375 ml	0.75 ml
T 2	Spinetoram 6SC plus methoxyfenozide 30SC	Spinetoram 6SC plus methoxyfenozide 30SC	36SC	400 ml	0.80ml
T 3	DPX-RAB55	Triflumezopyrim	106SC	238 ml	0.475 ml
T 4	Fame	Flubendiamide 480 SC	48SC	50 ml	0.10 ml
T 5	Coragen	Rynaxypyr	20SC	150 ml	0.30 ml
T 6	Hunk	Acephate	95SG	526 g	1.053
T 7	Osheen	Dinotefurain	20 SG	200g	0.40 g
T 8	Hostathion	Triazophos	36SL	1500 ml	3 ml
T 9	Furadan + Hostathion (in form of alternate use)	Carbofuran + triazophos (in form of alternate use)	3G+40EC	30kg+1500 ml	30kg+ 3 ml
T 10	Untreated control	-	--	-	-

### **3.8. Calculation of economics of bio-efficacy evaluation of botanical and chemical insecticidal experiments**

#### **Factors affecting/regulating quantum of net benefit (net income) and benefit cost ratio (B:C ratio)**

There are certain factor(s) which regulate the quantum of net profit and cost benefit ratio (C:B ratio) resulting from the employment of the pest management operations/practices through application of botanical/chemical insecticide. The factors are given below:

- i) Yield of crop produce
- ii) Additional (extra) yield obtained over the untreated control, resulting out from the insecticidal protection operation
- iii) Price/money value of the crop produce/extra yield obtained through the insecticidal operations
- iv) Dose of the insecticide used (i.e. quantity of the insecticide/ha) and total quantity of the insecticide used for managing the insect pest complex.
- v) Price of the insecticide used for the pest management operation
- vi) Cost of labourer involving in the pest management operation

As such, economics of insect pest management operation through judicious and need based application of botanical/chemical insecticides, is regulated by additional gain in yield resulting into gross monetary return (gross benefit), money value of the extra yield generated through the employment of the pest control operation comprising of cost of insecticides used and the involved operational cost incurred on agricultural labourer. When the insecticides used have higher price, it would result in to relatively higher quantum protection cost, which, in turn, may realize relatively lesser net profit and benefit cost ratio (B:C ratio) and vice versa.

If the dose of the insecticide is relatively lower, it would lower down the cost of protection up to considerable extent. In the present studies, the price of rynaxypyr 20SC is as high as Rs 8500/lit. Hence, the cost of protection provided through application of this insecticide could be the highest among all the test insecticides which, in turn, significantly lowered down the extent of net profit generated out from its application, resulting in also the lower benefit cost ratio (B:C ratio).

- (a)** The increase (gain) in yield, treatment-wise, over untreated (control) plot was calculated by applying the formula mentioned as below: -

$$\text{Percent increase in (gain) yield} = \frac{T - C}{C} \times 100$$

Where,

T = yield obtained from treated (protected) plot

C = yield obtained from untreated (control) plot

(b) Net monetary returns (net profit) and benefit cost ratio (BCR) were calculated by following mathematical steps and formulae:

(i) **Computation of additional gain in yield over control (Ya)**

Additional gain in the yield over control is the difference between the yield in the respective treatment (s) and yield obtained from control plot (Yc).

i.e.,  $Y_a = Y_t - Y_c$  whereas  $Y_t$  = Yield obtained from the respective treatment (s);  $Y_c$  = yield obtained from unprotected (control) crop.

$Y_t$  = Yield obtained from treated plot.

(ii) **Computation of Net monetary returns (net profit Rs./ha)**

**Net profit** = monetary value of  $Y_a$  – cost of pest control,  
CPC  
= Rs. /ha

Where, cost of pest management (control) comprises of cost of insecticides and labourers

(iii) **Computation of benefit cost ratio (BCR)**

Benefit cost ratio (BCR) =  $\frac{\text{Net profit (Rs. /ha)}}{\text{Cost of pest control (Rs. /ha)}}$

### **3.9. Statistical analysis of the experimental results:**

The data of results obtained from aforesaid experiments in terms of pest incidence were compiled and tabulated in the form of mean values of three replications and their suitable transformations were made for appropriate statistical analysis for their proper interpretation and documentation for drawing the conclusions.

Data recorded on yields obtained from different plots, replication/entry wise in terms of Kg were converted into q/ha to calculate their mean values for appropriate statistical analysis for drawing the inferences.

The data recorded for different characteristics were subjected to statistical analysis by adopting the method of analysis of variance (ANOVA) as described by Gomez and Gomez (1984). The significance of comparison was tested. The significant difference values were computed for 5 percent probability of error. Wherever the variance ratio (F value) was found significant, critical difference (CD) values were computed for the comparison among the treatment means.

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*RESULT  
AND  
DISCUSSION*

## *Results and Discussion*

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The present investigations on “**Management of insect pest complex of rice**” carried out through field studies were performed to find out the various insect fauna associated with rice for their proper management. Some of them are pest species and some of them are natural enemies of insect pest fauna. The methodologies of observations recorded are mentioned in the previous chapter. The data of the experimental results were subjected to the appropriate statistical analysis and have been presented in this chapter.

Accordingly, the thesis protocol was undertaken with the five sets of field experiments to meet the requirements of five objectives of the present field investigations. An attempt has also been made to have critical appraisal of the experimental data in the context of the objectives of the present investigations by comparing with previous related results obtained by earlier workers and thus objective-wise results and their scientific analysis and discussions are presented and explained which are given below.

- i) Study on biodiversity of insect-pest species in the agro-ecosystem of rice in Jharkhand.
- ii) Evaluation certain rice varieties and genotypes against major insect-pests of rice.
- iii) Study the effect of staggering in date of transplanting on the incidence of insect-pest complex of rice.
- iv) Evaluation field bio- efficacy of botanical based insecticides against major insect-pests of rice.
- v) Evaluation field bio- efficacy of newer molecules of insecticides against major insect-pests of rice.

### **4.1 Biodiversity of insect-pest species in the agro-ecosystem of rice in Jharkhand**

The status of important insect pests in different rice growing districts and ecologies in Jharkhand is presented in Tables 4.1.1, 4.1.2 & 4.1.3. Table 4.1.1 contains information recorded on insect pest fauna in different district in the state of Jharkhand. The results revealed that as many as two dozen of insect pests were found to prevail in the rice ecologies but out of them only eighteen are more prominent which were found to attack rice crop in the field conditions. Among them nine insect pest species viz. yellow stem borer, gall midge (except five district), leaf folder,

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gundhi bug, green leafhopper, BPH (except two district), hispa, termite and grass hoppers were found to attack rice crop almost in the whole state in the field condition in the form of low to severe form. Out of eighteen, six insects viz. yellow stem borer, gall midge (except five district), leaf folder, gundhi bug, BPH (except two district), and termite were found to occupy as major pest status in 24 districts in Jharkhand, rests eight insect species i.e. green leafhopper, rice hispa, grass hoppers, rice mealy bug, root/white grubs, whorl maggot, yellow hairy caterpillar and thrips appeared as minor pest and four of them i.e. case worm, swarming caterpillar, hairy caterpillar and cut worm exhibited as sporadic pests species in Jharkhand state in the present studies (Table 4.1.2).

Krishhaiah *et al.* (2008) obtained more or less similar observations pertaining to insect pests' species situation in India. The results of the field studies of Prasad *et al.* (2006) indicated that of 19 insect pests belonging to 7 order and 13 families were found to occur in different rice ecologies in the state of Jharkhand. They were found to attack rice crop in the field condition. Out of total 19 insect pest species occurring in the state, 11 belong to major, 8 minor and 4 sporadic categories of pests in rice growing areas in Jharkhand. Based on mode of injuries caused and the extent of damage caused by the insect species, to the crops, they could be categorized in groups such as major pest of rice which were yellow stem borer, leaf folder, gundhi bug, gall midge, rice hispa, grass hopper, case worm, swarming caterpillar, black hairy caterpillar, army worm, termite, whorl maggot and root grub. Brown plant hopper, green leaf hopper, rice thrips, rice mealy bug, rice skipper and white grub were found to be pests of minor economic importance in general. However, rice hispa, army worm, black hairy caterpillar and swarming caterpillar were found to occur in sporadic pests in terms of mode of occurrence and caused considerable extent of damage to rice crop in the Jharkhand region, whenever they occasionally occurred on the scare in severe form when the agro-climatic conditions remained congenial for the pest species.

In the Jharkhand state water holding capacity of soil is very low due to porous nature of the soil and undulating topography. Depending upon topography, lands of the state are broadly classified into six groups. The upland is further divided in to three groups *Tanr I*, *Tanr II* and *Tanr III* and low lands are divided in to three groups *Don I*, *Don II* and *Don III*, *Don I*- low land, *Don II*- shallow land and *Don III* drought

prone shallow land and *Don III & Tanr III* are together called medium land (Singh, B.N. 2008) (Table 4.1.3).

*Don I* (low land) is one of the best and most suitable major rice growing areas which are about 6.3 lakh ha. *Don I* (low land), that area having most dominant pest which was yellow stem borer. The pest was found to attack the rice crop from nursery to maturity stage and more damage at tillering and panicle stages almost throughout the state. Asian rice gall midge (bio-type-3) was found to infest rice crop during early stage and rice hispa was also found to infest rice crop during early stage, case worm remained a major pest problem in low land and rice grass hoppers appeared almost in all the rice ecologies but they were more pronounced in low and medium land situations in the rice in the state of Jharkhand. The experimental findings of Prasad *et al.* (2006) were almost in agreement with the results of present experimental findings.

*Don II* (shallow land) is the major rice growing areas having about 6.7 lakh ha in Jharkhand. Insect pests were major biotic stress of this fragile ecology of *Don II*. The findings of field survey and surveillance on the major insect pests of shallow rainfed lowland revealed that yellow stem borer (*Scirpophaga incertulas*), rice leaf folder (*Cnaphalocrocis medinalis*), case worm (*Nymphula depunctalis*), rice gall midge (*Orseolia oryzae*) and rice hispa (*Dicladispa armigera*) were found to infest the crop during early stage of rice crop. BPH could be found as the regular pests during early crop stage when water stagnation was found for longer period. Hybrid rice varieties grown in this ecology were prone to attack of rice leaf folder. Rice ear head bug (*Leptocorisa* sp.) was also observed to infest at milking stage of the crop in present studies. Findings of Prasad *et al.* (2006) are almost in agreement with the results of present results.

*Don III* land and *Tanr III* land together called medium land which is about 3.7 lakh ha in the state of Jharkhand. The lands in this group are used for rice growing in shallow lowland and upland drought prone ecologies. Yellow stem borer, gall midge, swarming caterpillar, mealy bug, leaf folder, gundhi bug, green leaf hopper, BPH, rice grass hopper, rice hispa, black hairy caterpillar, yellow hairy caterpillar, thrips and termite were major problems in this medium class of land situation in the state in the present studies. Prasad *et al.* (2006) and Prasad & Prasad (2011) also expressed more or less had almost similar opinion in this regards.

*Tanr I & Tanr II* land are loam soil and the land is immediately adjacent to the houses. The land is used for raising rice seedlings and very less area come under

direct seeded rice. In this region there were major problem of termite in the vegetative stage of the crop; yellow stem borer was major problem in the vegetative and reproductive of the crop and gundhi bug remained the major problem at milking stage of the crop. Stray and very low occurrence of this insect pest was found in the rice agro-ecosystem through out the state during *kharif* 2016 and 2017. Prakash *et al.*, 2004 had almost similar opinion for upland rice hill areas. Prasad *et al.* (2006) and Prasad and Prasad (2011) expressed more or less similar views.

Recently, Soren and Prasad (2013) also obtained more or less similar results to that of the present studies, wherein 14 insect pest species were found to attack rice in its different stages of crop growth almost in succession as well as in overlapping fashion. Out of them about half of a dozen of insect pest species were noticed as major insect pests and rest eight species as minor pests. The major pests of the crop included viz. YSB, gall midge, hispa, leaf folder, GLH, case worm and gundhi bug.

Hembrom and Prasad (2014) obtained more or less similar information to the tune of the present studies and found that 17 insect pest species prevailed in the various stages of crop growth, more or less, in succession and also in over lapping manner. Out of them six insect pest species were observed as major prevailing insect pests and remaining insects were rated as pests of minor and negligible economic significance in rice ecosystem . As such, the major insect pests of rice were: gall midge (*Orseolia oryzae* WM), yellow stem borer (*Scirpophaga incertulas* Wlk), hispa (*Dicladisa armigera* Oliv), leaf folder (*Cnaphalocrosis medinalis* Guen) and ear bug (*Leptocorisa* spp).

More recently, Kumar and Prasad (2017) obtained more or less similar information to that of the present studies and found that out of 17 insect pest species, prevailing in rice ecologies in the state of Jharkhand, gall midge, yellow stem borer, leaf folder, green leaf hopper and case worm appeared as mild to severe pest species, hispa and gundhi bug as moderate (mild ) pest; whereas other insect pest species viz. grass hopper (*H.Baanian*; *Oxya chinesis*), black hairy caterpillar (*N.simplex*), termite (*O.obesus*), mealy bug (*B.rehi*), thrips (*S.biformis*), white grub (*H.sp.*), BPH (*N.lugens*) remained the pest of negligible and minor economic importance in medium and low land transplanted rice ecologies in Jharkhand region of India.

## **4.2. Evaluation of certain rice varieties against major insect-pests of rice.**

Twenty cultivars/varieties were evaluated in Rice Research Farm of Birsa Agricultural University, Ranchi during *Kharif* in 2016 and 2017 for their reaction against five major insect pests' viz., Y.S.B, gall midge, hispa, leaf folder, green leaf hopper (GLH) and gundhi/ear bug (GB or EB). Results are shown in respective tables in the subsequent pages in Tables 4.2.1 to 4.2.7.

### **4.2.1. Relative incidence of hispa (*Discladispa armigera* Olivier) in some rice genotypes/varieties**

Twenty common rice genotypes/varieties were tested for two consecutive years', 2016 and 2017 in *Kharif* against hispa (*D. armigera*). Adults of hispa feed as externally and grubs of the same insect feed on the chlorophyll content of leaves internally living between the two epidermal layers by scrapping the leaf-tissues almost parallel to the mid rib of the leaf lamina resulting in parallel white strips on the leaf blade of rice. As such, the leaf damage, caused by hispa could easily be identified and counted for taking observations for calculating per centage of leaf damage caused by hispa (LDH).

The observations on the percentage of leaf damage caused by hispa, (LDH %) were recorded at 20 and 35 DAT (days after transplanting) during both the years' of experimentation, viz 2016 and 2017 for calculating the mean of the two observational dates of 25 and 35 DAT for both of the years', separately. Ultimately, mean of per centage of leaf damage of the respective years' was also calculated for computation of the overall mean of per centage of leaf damage of two years' of experimentations. The results on the observations on leaf damage caused by hispa in respct of varietal reponse are presented in Table 4.2.1.

#### **Observations on per centage of leaf damage caused by hispa (LDH %)**

It was a general observation that relatively higher incidence of hispa was noticed during 2017 as compared to that of 2016, recorded at 20 and 35 DAT in almost all the test varieties. The leaf damage due to hispa (% LDH) ranged from 1.61 to 18.73 per cent and that of 2.83 to 22.55 per cent during 2016 and 2017, respectively at 20 DAT. The leaf damage due to the same pest species varied from 2.38 to 21.15 per cent and that of 3.18 to 23.55 per cent during 2016 and 2017, respectively at 35 DAT; minimum being in case of Kavya and maximum in TN-I. It was found that there were significant differences among the test rice genotypes in terms of extent of incidence of leaf damage (LDH), recorded at 20 and 35 DAT during both of the years'

of experimentation. The mean incidence of the insect pest of the two years' in terms of leaf damage (LDH %) in the test rice genotypes also differed significantly and the overall mean values of the pest followed almost similar trends (Table-4.2.1). The experimental results revealed that the lowest leaf damage was found in case of Kavya amounting to the tune of 1.61, 2.83 and 2.38, 3.18 per cent at 20 and 35 DAT, recorded during 2016 and 2017, respectively and DRR-44, IR-20, Naveen and CR-Dhan 205 remained almost at par followed by Advanta-801<sup>+</sup>, Lalat, BVS-I, IR-64 Sub-I, CR-Dhan 304 and Sahbhagi-Dhan, as against the highest of leaf damage in case of TN-I ranging from 18.73 to 23.55 per cent in the present investigation. Based on the overall mean of leaf damage of two years' investigation, Kavya received the minimum leaf damage (2.50% LDH) followed by CR. Dhan – 205 (4.58% LDH), DRR-44 (4.93 % LDH), IR-64 Sub-1 (5.44 % LDH), Naveen (5.57 % LDH), IR – 20 (5.83 % LDH), Sahbhagi-Dhan (5.91 % LDH), CR-Dhan – 304 (6.11 % LDH), Suraksha (9.27 % LDH) and Akshay Dhan (9.59% LDH). The significantly highest leaf damage (21.50% LDH) was registered in case of the susceptible rice variety, TN-I in the present studies.

Bentur *et al.*, (2011) reported that Sahyadri, Suraksha, Bidhan Dhan-2, Sabita, IR-64 and PTB-33 proved to be resistant against rice hispa. Soren and Prasad (2013) found that Kavya remained least affected by hispa and TN-I, IR-64 and Pusa Basmati-I received the highest leaf damage due to hispa, Hembrom and Prasad (2014) reported that Kavya, Suraksha and BG-380-2 were found to be least affected by hispa as against the highest incidence of the pest was noticed in case of TN-I, IR-64, MTU-7029 and Pusa Basmati-I. All these findings are almost in the conformity with the result of the present studies.

As such, based on the overall findings of the present studies it may concluded that Kavya, CR Dhan-205, DRR-44, IR-64 Sub-I, Naveen, IR-20, Sahbhagi-Dhan, CR Dhan-304, Suraksha and Akshay Dhan proved to be promising against hispa (*D.armigera*).

#### **4.2.2. Relative incidence of yellow stem borer (*Scirpophaga incertulas* Walker) in some rice varieties:**

Twenty common rice genotypes/varieties were tested for two consecutive years', 2016 and 2017 in *Kharif* against yellow stem borer (YSB) in the vegetative and reproductive stage of the crop. At the vegetative stage the larvae of the pest

caused dead heart (DH) and at the reproductive stage of the crop, the same could be able to cause white ear (WE).

The observation on the dead heart (%) were recorded at 30 and 45 DAT (days after transplanting) during both of the years' of experimentation for calculating the mean of the two observational dates for both of the years'. Ultimately, mean of per centage of dead hearts of the respective years' was also calculated for computation of the overall mean per centage of dead hearts of the two years' experimentations.

Similarly, the observation on the white ears were recorded at dough stage and pre-harvest stage of the crop for the ultimate computation of overall mean of the white ears of the two years'' experimentation. The results on the relative incidence of dead heart (DH %) and white ear (WE %) are presented in Tables 4.2.2 and 4.2.3.

#### **Observation on dead hearts (DH).**

It was general observation that relatively lesser quantum of the incidence of the pest, in terms of dead hearts, was noticed during 2<sup>nd</sup> year as compared to that of 1<sup>st</sup> year of the experimentation, recorded at 30 and 45 DAT.

It was noteworthy to mention that the dead heart, ranged from 1.82 to 20.72 per cent and that of 1.67 to 18.18 per cent during 2016 and 2017, respectively at 30 DAT. The dead heart incidence ranged from 2.32 to 22.35 per cent and 1.67 to 17.55 per cent during 2016 and 2017, respectively at 45 DAT. As such, the intensity of the pest was founded to be increased with the advancement of growth stage and age of the crop from 30 to 45 DAT. It was found that there were significant differences among the test rice genotypes in terms of extent of incidence of dead hearts, recorded at 30 and 45 DAT during both of the years' of the experimentations. The mean incidence of the pest of the two years' recorded in the test rice genotypes also differed significantly and overall mean incidence of the pest followed almost similar trends (Table 4.2.2).

The experimental results (Table 4.2.2) revealed the lowest intensity of dead heart was found in case of Suraksha, amounting to the tune of 1.82, 1.67 and 2.32, 1.67 per cent at 30 and 45 DAT recorded during 2016 and 2017, respectively. The next best rice genotype was Kavya which also received significantly lower incidence of dead heart to the tune of 4.58, 3.57 and 5.67, 4.23 per cent at 30 and 45 DAT recorded during 2016 and 2017 respectively. The rice genotypes viz CR Dhan -303, CR Dhan- 304, Naveen, Lalat, CR Dhan – 205 and Sahbhagi-Dhan remained almost at par with Kavya in terms of lower incidence of dead heart at 30 and 45 DAT, during both of the years' of experimentations. The mean values of dead hearts computed

from two years' data, recorded at 30 and 45 DAT and that of the overall mean values of the two years' of all the observations followed almost similar trends. The highest incidence of dead heart to the tune of 20.72, 18.18 and 22.35, 17.55 per cent was registered in case of the susceptible variety, TN-1 at 30 and 45 DAT recorded during, 2016 and 2017, respectively.

As such, based on the overall mean values of two years' of investigations, the least per centage of dead heart (1.87%) was recorded in case of Suraksha, followed by Kavya (4.50%), Lalat (5.59%), CR Dhan – 303 (5.94%), CR Dhan – 205 (6.77%), Sahbhagi-Dhan (6.88%), CR Dhan – 304 (7.02%) and Naveen (7.27%). These rice cultures were rated as promising and resistant against dead heart incidence, caused by YSB. The susceptible rice variety, TN-1 received the highest dead heart amounting to 19.70 per cent in the present studies based overall mean of two years' results.

Earlier, Prasad *et al.*, (2012) also found that rice varieties Suraksha, Lalat and BG- 380-2 remained moderately resistant to YSB and Pusa Basmati-1 and Jaya were susceptible to the same pest spp. in terms of dead heart incidence. As such, the findings of Prasad *et al.*, (2012) are in consonance with the results of the present investigations.

#### **Observation on white ear**

The results (Table 4.2.3) indicated that relatively higher incidence of white ear, caused by YSB, was observed during 2017 as compared to those of 2016 both at dough and pre-harvest stages of the crop almost in all the test rice genotypes, just in reverse of dead heart incidence. Almost similar trends of incidence of white ear were registered in case of mean of the two observations obtained at dough and the maturity stage of the crop, recorded during 2016 and 2017.

It was noteworthy to mention here that the white ear ranged from 2.34 to 19.45 per cent and that of 2.80 to 22.59 per cent during 2016 and 2017, respectively at dough stage of the crop. The white ear incidence varied from 3.44 to 23.45 per cent and 4.07 to 25.37 per cent during, 2016 and 2017, respectively at the pre-harvest stage of the crop. As such, the intensity of the pest incidence was found to be enhanced with advancement of the age of the crop, i.e. from dough to the maturity stage of the crop. It was found that there were significant differences among the test rice cultivars in terms of extent of incidence of white ear, recorded at dough and pre-harvest stages of the crop during both the years' of field investigations. The mean incidence of the pest species, in terms of white ear, of the two years', recorded in the test rice genotypes

also differed significantly and overall mean incidence of the pest followed almost similar trends (Table 4.2.3).

The experimental findings (Table 4.2.3) revealed that the significantly lowest intensity of white ear was found in case of Suraksha amounting to the tune of 2.34, 2.80 and 3.44, 4.07 per cent at dough and pre-harvest stages of the crop during 2016 and 2017, respectively. Akshay Dhan, IR-36, CR Dhan – 304, Kavya, CR Dhan-303, IR 64 sub-1 and IR 20 remained almost at par with Suraksha in terms of incidence of white ear, recorded at dough and pre-harvest stages of the crop during, 2016 and 2017 (Table 4.2.3). The mean values of white ear of 2016 and 2017 recorded at the both stages and that of the overall mean of two years' followed almost similar trends. The rice varieties viz. Lalat, DRR-44, PUSA-1176 and Sahbhagi-Dhan also received almost considerably lower incidence of white year, below 10 per cent. The highest incidence of white ear was recorded in case of the susceptible variety, TN-1 during both of the years' of the present field investigations at dough and pre-harvest stages of crop. The mean values of WE of 2016 and 2017, separately and that of overall mean of the both years', recorded in, TN-1 followed almost similar trends.

As such, based on the overall mean values of WE recorded during two years' investigations, the least per centage of white ear (3.16%) was noticed in case of Suraksha which remained at par with Kavya(4.34%), Akshay Dhan(3.46%), IR-20 (4.36%), IR-36 (4.50%), IR 64 sub-1 (4.64%) and followed by CR-Dhan- 304 (5.27% WE) CR Dhan – 303 (5.78% WE), Lalat (6.66% WE) and Sahbhagi-Dhan (9.63%) and all these rice genotypes received below 10 per cent white ear, caused by the stem borer, as against the highest incidence of WE was observed in the susceptible variety, TN-1 (22.71% WE) in the present studies. Prasad and Prasad (2011) reported that rice entries viz. SKL-7-61-9-10-12 and BG-380-2 suffered from the lowest incidence of YSB whereas JGL-3855, DJP-1998-11-1-1 and Birsa Mati harboured higher incidence of YSB. Findings of Prasad *et al.*, (2012) and Prasad *et al.*, (2016) also endorsed the results of the present investigation referring Suraksha, Kavya, Akshay Dhan, IR-20 and IR-36, IR-64 sub-1 emerged as promising and resistant (ie. <5% WE) against WE and those of CR-Dhan-304, CR Dhan- 303, Lalat and Sahbhagi-Dhan were rated as promising and moderately resistant (<10% WE) to WE, caused by YSB.

Prasad *et al.* (2018) also reported that the pest tolerant/resistant varieties viz. Lalat, IR-36 and Naveen received significantly lower incidence of dead heart as

compared to those of the pest susceptible varieties viz. IR-64, Brisa Mati, PAC-801, PAC-807 and TN-1.

As such, based on the overall mean findings of the present investigations, it may be concluded that rice genotypes viz. Suraksha, Kavya, Lalat, CR Dhan-303, CR Dhan-205, Sahbhagi-Dhan, CR Dhan-304, and Naveen could be considered as promising and resistant against dead heart incidence, due to YSB and Surakha, Kavya, IR-20, IR-36, IR-Sub-1, CR-Dhan- 303, CR Dhan-304, Lalat and Sahbhagi-Dhan proved to be promising and resistant against incidence of white ear caused YSB.

#### **4.2.3. Relative incidence of gall midge (*Orseolia oryzae* Wood Mason) in some common rice genotypes/varieties**

Twenty common rice genotypes/varieties were tested for two consecutive years', 2016 and 2017 in *kharif* against gall midge (*O.oryzae*). The feeding by maggots of Insect pest (i.e. gall midge) on the growing point of the newly emerged tiller results in the malformation in the form of gall (ie. silver/ onion shoot) which are nothing but it is modified form of central leaf sheath. The gall formation due to attack gall midge could be able to debar the affected rice tiller from initiation and formation of panicle resulting in direct reduction in grains yields.

The observations on the incidence of per centage of silver (onion) shoots were recorded at 30 and 45 DAT (days after transplanting) during 2016 and 2017 in wet season for calculation of mean of the two observational dates for both of the years'. Ultimately, mean of per centage of silver shoot (SS%) of the respective years' was also calculated for computation of the overall mean per centage of silver shoot of the two years' experimentation. The results on the relative incidence of silver shoot (SS%) are presented Table 4.2.4.

#### **Observation on the incidence of silvershoot (SS%)**

A perusal of results indicated that none of the rice genotypes/varieties remained free from the attack of the pest (*O.ryzae*). It was general observation that relatively higher quantum of the incidence of silver shoot (SS%) was observed during 2017 as compared to that of 2016 at both the observational dated (ie. 30 and 45 DAT).

It was found that silver shoot ranged from 1.61 to 12.42 per cent and that of 2.83 to 18.62 per cent during 2016 and 2017, respectively at 30 DAT and 2.38 to 15.02 and 3.08 to 21.62 per cent at 45 DAT during 2016 and 2017, respectively, the lowest being in case of Kavya and the highest in case of TN-I. As such, the intensity

of the pest attack was found to be increased with the advancement of growth and age of the crop from 30 to 45 DAT.

It was found that there were significant differences among the test rice genotypes in terms of extent of incidence of silver shoot, recorded at 30 and 45 DAT during both of the years' of the experimentations. The mean incidence of the pest, in terms of SS (%) of the two year's recorded in the test rice genotypes also differed significantly and the overall mean incidence of the pest of 2016 and 2017 followed almost similar trends (Table 4.2.4)

The experimental results revealed that the lowest intensity of silver shoot (SS%) was found in case of Kavya, amounting to the tune of 1.61, 2.83 and 2.38, 3.08 per cent at 30 and 45 DAT (day after transplanting), recorded during 2016 and 2017, respectively. The rice varieties, viz, Suraksha, BVS-1, CR Dhan-303, IR-20, IR-36 and Akshay Dhan almost remained at par with Kavya in terms of significantly lower incidence of silver shoot (SS%) at 30 and 45 DAT, during both the years' of experimentations. The mean values of silver shoot computed from the two years' results, recorded at 30 and 45 DAT and that of the overall mean values of the two years' in respect of the test rice genotypes, followed almost similar trends. The next group of rice varieties receiving silver shoot (SS%) incidence below 5 per cent encompassed Naveen and Lalat based on the overall mean of silver shoot of 2016 and 2017 and, as such, all these nine rice varieties were rated as promising and resistant against gall midge biotype-3 in the agro-climatic conditions of Ranchi Jharkhand in the present studies. The highest incidence of silver shoot (SS%) to the tune of 12.42, 18.62 and 15.02, 21.62 per cent was registered in case of the susceptible variety, TN-I at 30 and 45 DAT, recorded during 2016 and 2017, respectively in the present studies.

As such based on the overall mean values of silver shoot of the two years' of investigations, the least per centages of silver shoot (2.48% SS) was recorded in case of Kavya, which remained at par with those of BVS-I (2.94% SS), Suraksha (3.08% SS), and IR-36 (3.55% SS) followed by Akshay Dhan (3.89% SS), Lalat (3.99%SS), Naveen (4.88%SS), CR Dhan-303 (4.15%SS) and IR-20 (4.28%SS) all receiving below 5 per cent silver shoot as against the highest incidence of 16.92 per cent of SS in case of the susceptible variety, TN-I in the present studies.

Prasad and Prasad (2011) conducted field experiment during wet season of 2009 and 2010 in the farmer's field in the gall midge endemic areas (District Simdega, Jharkhand) to screen out certain popular rice varieties against gall midge.

They found that five rice varieties viz Naveen, Lalat, BVD-203, BG-380-2 and, IR-36 exhibited as resistant to gall midge bio-type -3 which, in turn, gave rise to the higher grains yields to the tune of 43.59, 38.29, 33.58, 34.56 and 32.07 q/ha. The susceptible varieties viz IR-64 and Birsa Mati registered the highest pest incidence of SS (%) to the extent of 23.63 and 39.86 per cent which resulted to the considerably lower yields of 16.94 and 18.60 q/ha, respectively in the gall midge endemic areas (ie Simdega) of the agroclimatic conditions of Jharkhand. Later on, Prasad *et al* (2012) found that BG-380-2, Lalat and Suraksha proved to be resistant against gall midge and Pusa Basmati-I and Jaya received significantly higher incidence of gall midge resulting in grains yield-loss ranging from 34.5 to 36.23 per cent.

More recently, findings of Prasad *et al* (2018), based on the overall mean results of two years' experiments, conducted in the gall midge endemic area (Simdega) in Jharkhand which indicated that five rice varieties viz. Kavya (2.91% SS), Lalat (3.91 %SS), IR-36 (4.66%SS), and RD-202 (4.60%SS) emerged as highly resistant to gall midge bio-type – 3. Suraksha (5.99%ss) and BG-380-2 (6.48%SS) remained moderately resistant to the pest. MTU-7029 (54.39%SS) and TN-I (52.05%SS) receiving silver shoot above 50 per cent were rated as the highly susceptible to the pest. The maximum grains yield of 42.40 q/ha was realized from Lalat which remained at par with that of BG-380-2 (42.15 q/ha), Abhishek (41.65 q/ha), RD-202 (40.60 q/ha) and IR-36 (37.60 q/ha). The lowest yield of 25.65 q/ha was obtained in case of the susceptible variety, TN-I which remained at par with that of IR-64 (28.09 q/ha) and MTU-7029 (29.15 q/ha). As such, findings of Prasad and Prasad (2011), Prasad *et al.*, (2012) and that of Prasad *et al.*, (2018) were in corroboration with the results of the present investigation.

As such, based on the findings of the present investigations, the rice genotypes viz. Kavya, Suraksha, IR-36, and BVS-I could be considered as promising and resistant against gall midge biotype-3 and those of Akshay Dhan, Lalat, Naveen, and CR-Dhan-303 could be rated as promising and moderately resistant against gall midge (*O. oryzae*) bio-type-3 in the agro-climatic conditions of Jharkhand.

#### **4.2.4. Relative incidence of leaf folder (*Cnaphalocrosis medinalis* Guenee) in some rice genotypes/varieties**

As many as twenty common rice genotypes/varieties were evaluated for their relative resistance/susceptibility for two consecutive years', 2016 and 2017 in *Kharif* against leaf folder (*C. medinalis*). Larvae of the insect pest folds rice leaf mostly

longitudinally and inward direction and feeds on the green tissues/chlorophyll contents by living within the leaf folds, resulting in reduction in photosynthetic process, which in turn, could be responsible for reduction in grains yield of the crop. As such, the damaged leaf, caused by the insect pest, could easily be identified and counted for taking the observation for calculating per centage of leaf damage, caused by, leaf folder (LDLF).

The observations on the per centage of leaf damage, caused by leaf folder (LDLF%) were recorded at 60 and 80 DAT (days after transplanting) during both the years' of experimentation of 2016 and 2017 for calculating mean of the two observational dates of 60 and 80 DAT for both of the years', separately, and that of mean of 2016 and 2017, separately, recorded at 60 and 80 DAT. Ultimately overall mean values of the two years' were also calculated. The results recorded on the incidence of leaf folder (LDLF%), in respect of response of the test rice genotypes are presented in Table 4.2.5.

#### **Observations on the per centage of leaf damage caused by leaf folder (LDLF%)**

In general the intensity of leaf damage caused by the pest in the 1<sup>st</sup> year (2016) remained relatively at lower level as compared to those of the 2<sup>nd</sup> year (2017) of experimentation, recorded at 60 and 80 DAT in almost all the test entries. The leaf damage, caused by leaf folder (LDLF%) ranged from 2.33 to 19.20 and that of 4.47 to 29.73 per cent recorded at 60 DAT during, 2016 and 2017, respectively. The leaf damage resulting from the same species varied from 3.44 to 24.35 and that of 6.58 to 33.95 per cent recorded at 80 DAT during 2016 and 2017 respectively, minimum being in Kavya and maximum leaf damage in case of the susceptible rice variety, TN-I at both of the observational dates during the two years' of experimentation. It was found that there were significant differences among the test rice genotypes in terms of extent of leaf damage (LDLF%) recorded at 60 and 80 DAT, during both of the years' of investigations. The mean incidence of the pest species of the two years', in terms of leaf damage (LDLF%), in the test rice varieties/genotypes also different significantly.

It was found that the minimum incidence of the pest, in terms of leaf damage due to the pest (LDLF%) was found in case of Kavya amounting to the tune of 2.33, 4.47 and 3.41, 6.58 per cent recorded at 60 and 80 DAT during 2016 and 2017, respectively, which remained at par with that of Suraksha receiving leaf damage of 2.42, 5.49 and 3.69, 7.33 per cent during the respective years' at 60 and 80 DAT, accordingly. Similarly, the rice varieties, DRR-44, CR-Dhan-205 and CR Dhan-304

also remained statistically at par with that of Kavya in respect of leaf damage caused by leaf folder, recorded at 60 and 80 DAT during 2016 and 2017. The mean values of leaf damage due to leaf folder (LDLF%) recorded at 60 and 80 DAT during the both of the years' of experimentations, separately, and that of the overall mean of the two years' followed almost similar trends.

Based on the overall mean of the two years' results, the test rice varieties/entries could be arranged in order of Kavya (4.20%) < Suraksha (4.73%) < Sahbhagi-Dhan (8.44%) < IR-64 Sub-I (8.93) < Advanta 801+ (8.96%) in terms of leaf damage, caused by leaf folder, below 10 per cent. These entries could be considered resistant/ tolerant to leaf folder.

Significantly highest extent of leaf damage was found in case of the susceptible variety, TN-I (26.81% LDLF) followed by Lalat (21.20% LDLF), IR-64 (18.42% LDLF) and BVS-I (17.44% LDLF) which could be rated as susceptible to attack of leaf folder in the present studies. Gupta *et al.* (2002) screened 45 rice cultivars against leaf folder and found that four of them, namely, NDR-1058-1-4, IET-13310, NDR – 2025-2 and Mahsuri were free from attack of leaf folder. Hembrom and Prasad (2014) reported that Kavya, BG-380-2 and Suraksha emerged as resistant against leaf folder (*C. madinalis*) and the highest incidence of the pest was noticed in case of TN-I followed by Lalat, IR-64 and MTU-7029. Kumar and Prasad (2017) revealed that the minimum, extent of leaf damage due to leaf folder, was noticed in case of Kavya, BG-380-2 and IR-36. These findings are almost in agreement with that of results of the present studies. BVS-I is a scented rice variety which received relatively higher leaf damage upto 17.44 per cent due to attack of leaf folder in the present studies. Kumar and Prasad (2017) reported that the scented rice varieties viz. Birsa Mati, Pusa Basmati-I and BVS-I remained moderately susceptible to leaf folder with leaf damage to the extent of 14.25, 17.55 and 16.45 per cent, respectively. As such findings of Kumar and Prasad (2017) are also in the consonance with the results of the present investigation. Hence, based on the overall results of the present studies, it may be concluded that Kavya, Suraksha, CR Dhan-304, Naveen, Sahbhai, IR-64 Sub-I and Advanta 801+ could be considered as promising and resistant against leaf folder.

**4.2.5. Relative incidence of green leaf hopper (*Nephotettix nigropictus* Stal.; *Nephotettix virescens* Distant) in some rice genotypes/varieties:**

Two species of green leaf hopper (GLH) viz. *Nephotettix nigropictus* (Stal.) and *Nephotettix virescence* Dist were found in the rice-agro-ecosystem in the state of Jharkhand in the form of their mixed population. Nymph and adult stages of the green leaf hopper infest the rice crop at all the stages of the plant's growth. They insert their stylets into the leaf tissues and suck the sap from phloem cells resulting in weakening of leaves that leads to decrease in the vigour of plants which in turn, could be able to cause reduction in the grain's yield of rice. The observations on the incidence of *Nephotettix* species were recorded in terms of number of GLH/10 hills at 70 and 85 DAT during *Kharif* 2016 and 2017 on the 10 randomly selected plants through net sweep methods. The mean values of two years', recorded at 70 and 85 DAT were calculated, separately, for computing the mean of population of GLH/10 hills of for the entire period of 2016 and 2017, individually. Ultimately, overall mean of population of GLH of the two years' were calculated for drawing the final conclusion in respect of relative incidence of GLH in the test rice genotypes. The results are presented in Table 4.2.6.

**Incidence of *Nephotettix* species infesting rice varieties (genotypes):**

Significantly the least numbers of GLH/10 hills were recorded in case of rice genotype, DRR-44 amounting to, 7.85, 12.88 and 9.35, 15.45 GLH/10 hills at 70 and 85 DAT during, 2016 and 2017, respectively as against the highest population of the pest to the tune of 40.33, 51.04 and 42.33, 52.10 no. of GLH/10 hills at 70 and 85 DAT, recorded during the respective years', harboured by the susceptible rice variety, TN-I followed by IR-64 and MTU-1010, recorded almost throughout the crop growth. Rice entry, DRR-44 received the lowest incidence of GLH throughout the observational periods, and CR Dhan-205, Suraksha Kavya, Lalat, CR Dhan-303, IR-36 and CR Dhan-205 remained at par throughout the observational period in terms of lower incidence of green leaf hopper. Based on the lower degree of pest intensity, the test entries in terms of GLH/10 hills, could be arranged in the order of : DRR-44 (11.38) < CR Dhan-304 (11.62) < CR Dhan-304 (11.76) < Suraksha (11.84) < IR-36 (11.86) < CR Dhan-205 (12.16) < Lalat (13.53) < Kavya (13.95) < Naveen (15.30) < Akshay Dhan (16.36) < Sahbhagi-Dhan (16.57) which could be considered as resistant against green leaf hopper in the present studies. Because, the susceptible test rice variety, TN-I received much more and substantially higher incidence of the pest (i.e. 46.45/10 hills) in the present investigation. Earlier, Pasalu *et al.*, (2004) found that the rice cultivars viz. PTB-2, W-1263, Lalat, Vikramarya and Khaira remained resistant to

green leaf hopper Soren and Prasad (2013) found that Kavya, IR-36, Lalat and Naveen proved to be highly promising against GLH. On the other hand, TN-I was found to be highly prone to the attack of GLH, which was followed by Pusa Basmati-I. Hembrom and Prasad (2014) reported that the rice varieties viz. RD-202, MTU-1010, BVS-I and Lalat harboured substantially lesser incidence of the insect pest to extent of 19.48 to 25.60 GLH/10 hills as against the significantly highest population of 56.51 to 60.38 GLH/10 hills. More recently, Kumar and Prasad (2017) revealed that BG-380-2, IR-36 and Naveen exhibited as moderately resistant to green leaf hopper where as TN-I, Badshah Bhog, BVS-I Arize-6444 and BR-9 appeared as susceptible to green leaf hopper. As such these findings of the earlier workers are more or less in the conformity with the results of the present studies. Based on the over mean findings of the present investigation, it may be concluded that the rice genotypes viz, DRR-44, CR Dhan-304, CR Dhan – 303, Suraksha, IR-36, CR Dhan – 205, lalat and Kavya exhibited as promising and resistant to green leaf hopper.

#### **4.2.6. Relative incidence of gundhi bug in some common rice varieties:**

There are mainly two species of ear bugs viz. *Leptocorisa acuta* Thunberg and *Leptocorisa oratorius* Fabricious which are usually prevailing in the rice ecologies in the reproductive stage of the crop. Nymph as well as adult of the insect species emits a characteristic offensive odour in the pest infested fields indicating the signal of their presence in the rice fields. On account of their feeding upon the developing milky grains which result in formation of brown spots on around the puncture points made by the pest on the surface of infested grain. Prakash and Rao (1995 & 2000) reported that the grains viability is also reduced by the infestation of ear bug. They also reported that the affected grains remain chaffy, unfilled, partly filled and secondarily contaminated by various pathogenic fungi resulting in grains discoloration. As such, the pest is responsible for both qualitative and quantitative deterioration of grains of rice as well.

In the present investigation, a mixed population of *L. acuta* and *L. oratorius* was found to prevail in the rice ecologies in the state of Jharkhand. As such the observations on the incidence of ear bug were recorded in terms of the mixed population of the two species of gundhi bug in the present studies. Adults and nymphal stages of gundhi bug suck cell sap (i.e. milk) from developing and milky grains of rice. The grains infested with gundhi bug (GB) are either partially filled or unfilled depending on the extent of milk of the grains sucked by the insect pest (GB).

Gundhi bug is also called ear bug (EB). The observations on the incidence of gundhi bugs infesting rice were recorded by net sweep method in terms of number of EB/10 hills (plants) of rice at the milking stage of rice grains, during, 2016 and 2017. Mean population of ear bugs recorded in 2016 and 2017 were also calculated for drawing overall conclusions. The results are presented in Table - 4.2.7.

A perusal of results indicated that population of ear bugs ranged from 2.38 to 18.37 EB/10 hills during, 2016 and from 1.79 to 16.61EB/10 hills in 2017, minimum being in Suraksha and maximum being in the susceptible variety of rice, TN-I with the overall mean population of the insect pest varying from 2.09 to 17.49 EB/10 hills of the crop. There were significant differences among the test rice genotypes/varieties in respect of the relative population of the insect pest harboured by the rice entries. The rice varieties viz. Suraksha and Kavya received almost the least incidence of ear bug during both of the years' of experimentations and pooled mean of population of the pest of two years' also followed the same trends. The next best rice genotypes, in terms of gundhi bug incidence, were CR Dhan – 303, IR-36, CR Dhan – 205, Sahbhagi-Dhan, Abhishek, BVS-I and Lalat having the pest incidence below 10 EB/10 hills as against the highest population of the pest ranging from 16.61 to 18.37 EB/10 hills in 2016 and 2017, respectively in case of TN-I. Based on the overall mean population of ear bug (*Leptocorisa spp.*) recorded in 2016 and 2017, the test rice genotypes could be arranged in the descending order of: Suraksha < Kavya < CR Dhan -303 < CR Dhan-205 < IR-36 < Sahbhagi-Dhan < Lalat < BVS-I < Abhishek < DRR-44 < IR-64 Sub-I < Advanta 801+ < IR-20 < Naveen < CR Dhan-304 < MTU-1010 < Akshay Dhan < Pusa-1176 < TN-I in terms no of EB/10 hills in the present studies.

On the contrary gundhi bug preferred the rice varieties, IR-50 and IR-36 in the agro climatic condition of Sriniketan region of West Bengal as reported by Shivkumar *et al.*, (2003). A field study was conducted by Shitiri *et al* (2014) during wet season of 2011 in the agro-climatic condition of Nagaland (India). They found that the ear head bug (EB) was found to infest rice and genotypes, Miracle-rice, Jolukie rice special and Ranjit from 60 DAT and up to almost till the harvest. The incidence was highest in Ranjit. As such, information on rice varietal reaction in respect of ear bug (*L. spp*) is very scarce and scanty.

**Overall reaction of some common rice genotypes varieties against the prevailing major insect pest species:**

As many as, six major insect pests species were found to prevail in the rice agro-ecosystem in the state of Jharkhand; those insect pests are: yellow stem borer, gall midge, hispa, leaf folder, green leaf hopper and ear bug. The foregoing results discussion and deliberations, pertaining to the varietal reaction studies in the present studies, against major insect pests species, revealed that the rice genotypes *viz.* Suraksha, Kavya, Lalat, CR Dhan-205, CR Dhan-303, CR Dhan-304, IR-36 and Naveen harboured almost significantly and substantially lower incidence of YSB, gall midge, hispa, green leaf hopper, leaf folder and gundhi bug. Hence they were considered as promising and resistant against the pest species. However, the rice variety, Lalat also received significantly lower incidence of all the five major insect pests *viz* YSB, gall midge, GLH, hispa and gundhi bug with relatively and substantially higher incidence of leaf folder in the present studies. Prasad and Prasad (2006) also reported that the higher incidence of leaf folder could be harbored by rice variety Lalat.

#### **4.2.7. Yield of rice grains of some rice genotypes varieties:**

The results on grains' yields were recorded during *kharif* 2016 and 2017, after harvest of the crop at attainment of maturity of the crop, in terms of kg per plot and then it was converted into q/ha. The mean yields of grains' of two years' were also calculated for drawing the overall conclusion. The result is presented Table 4.2.8.

A perusal of results revealed that the significantly highest grains yields of 60.47 and 61.83 q/ha with the mean yield of two years' (61.15q/ha) was realized from the rice variety, Akshay Dhan which, in turn, remained at par with Advanta 801<sup>+</sup> yielding 58.57 and 60.03 q/ha during, 2016 and 2017, respectively with the higher mean yield of 59.30 q/ha followed by CR Dhan-205, CR Dhan – 303, Lalat, IR-36, Abhishek and MTU-1010, as against the lowest yield of 21.03 and 22.43 q/ha recorded during 2016 and 2017 with minimum mean yield of 21.73 q/ha in the present studies in case of the susceptible rice variety, TN-1.

It is an established fact that the yield realizing capacity of any genotype or variety of any crop is regulated not only by its own genetic yield potentiality as well as their resistance and tolerance ability against the prevailing biotic and abiotic factors of the environment but also by the optimal inputs supplied to the plants by the growers under the given set of congenial agro-ecological situations. It is not always possible and feasible that the pest resistant variety will always be higher yielder because the yield potentiality may also be relatively lower despite the desirable

quantum of tolerance or resistance ability against the given set of biotic and abiotic factors. If any variety could be able to realize higher grains-yield in spite of higher degree of attack of the pest then in that case, the variety will be said to be tolerant to that variety pest species. In the present studies, Akshay Dhan, Advanta 801<sup>+</sup>, Abhishek, CR-Dhan-205 and MTU-1010 could be able to realize relatively higher grains yield to the tune of 61.15, 59.30, 49.78, 52.58 and 48.24 q/ha in spite of suffering from relatively higher incidence of major prevailing insect pest species viz YSB, gall midge, hispa, leaf folder, GLH and ear bug. As such the results showed that these varieties remained tolerant to these pest species in the present studies.

However, the rice varieties *viz.* Suraksha, Kavya, CR Dhan-303, CR Dhan-304, IR-36 and Naveen exhibited as promising and resistant to the five major prevailing pest species, except Lalat which remained susceptible to leaf folder and resistant to the other prevailing pest species in the present studies. The test varieties, based on their overall mean higher yield of grains could be arranged in descending order of: Akshay Dhan (61.15 q/ha) > Advanta 801<sup>+</sup> (59.30 q/ha) > CR-Dhan – 205 (52.58 q/ha) > CR-Dhan-303 (51.16 q/ha) > Lalat (50.96 q/ha) > IR-36 (50.34 q/ha) > Abhishek (49.78 q/ha) in terms of grains yield.

### **4.3. Effect of staggering in date of transplanting on the incidence of insect-pest complex of rice**

The experiment on effect of staggering in date of transplanting was conducted in the field in 2016 and 2017 *kharif* in order to study the effect of shifting in dates of sowing and transplanting operations on the incidence and abundance of major prevailing insect pest fauna of rice. On account of shifting pattern of rainfall and other weather factors resulting in shifting in time of planting, farmers are forced to raise rice seedling in different dates for their transplanting work which usually takes place for a longer period right from July to August. The findings of the experiment are described in the subsequent Tables.

#### **4.3.1: Effect of date of transplanting on the incidence of rice hispa (*Dicladispa armigera* Olivier) in terms of leaf damage caused by the hispa (LDH %).**

Hispa (*Dicladispa armigera* Olivier) is a leaf feeding insect which feed on the chlorophyll content of leaf by scrapping (lacerating) them almost parallel to the mid rib of the leaf blade of rice (Table-4.3.4). As such, parallel white stripe to the mid rib of rice leaf resulted in devoid of the chlorophyll content from the affected part of the leaf. Observations on leaf damage caused by hispa (LDH) were recorded at 25 and 40 days after transplanting (DAT) and mean of two observations (25 & 40 DAT) during *kharif* 2016 and 2017 were calculated. The experimental results are presented in Table-4.3.1.

#### **a) Incidence of leaf damage (LDH) recorded at 25 days after transplanting (25 DAT)**

##### **i) Incidence of LDH recorded at 25 DAT, during 2016**

During, *kharif* 2016 at 25 DAT, there was significant performance was observed in respect of impact of different dates of transplanting against rice hispa (Table-4.3.1). It was interesting to note that earlier were dates of transplanting, lesser was the incidence of hispa in terms of extent of leaf damage caused by the hispa (LDH). It was also observed that there was significant impact of date of transplanting on the incidence of hispa, while considering the incidence of the pest at 25 DAT, the minimum incidence of leaf damage caused by hispa (LDH) to the tune of 3.03 per cent was recorded when the transplanting was made on the early date (i.e. at 1<sup>st</sup> date of transplanting). This date was followed by normal transplanting (i.e 2<sup>nd</sup> date of transplanting) with 5.20 per cent leaf damage due to hispa, as against the highest

incidence of the pest (7.29% LDH) registered in case of delayed date of transplanting of the crop made on 12<sup>th</sup> August, 2017.

**ii) Incidence of LDH recorded at 25 DAT, during 2017**

During *kharif* 2017, the data on leaf damage at 25 DAT caused by hispa recorded significant results among different dates of transplanting (Table-4.3.1). The significantly minimum leaf damaged (3.27% LDH) was noticed in case of 1<sup>st</sup> date of transplanting. This date was followed by 2<sup>nd</sup> date of transplanting with 5.44 per cent leaf damaged which remained significantly lower in leaf infestation than that of the 1<sup>st</sup> (early) date of transplanting infestation, but the maximum leaf damage (7.65% LDH) was observed in 3<sup>rd</sup> date of transplanting of rice (var. Sahbhagi Dhan).

**iii) Pooled mean incidence of LDH recorded at 25 DAT, during 2016 and 2017**

A perusal of mean values of leaf damage due to hispa (LDH) of 2016 and 2017 recorded at 25DAT showed significant effect among the performances of different dates of transplanting in respect of LDF (Table-4.3.1). The significantly minimum leaf damage was recorded in early (1<sup>st</sup>) date of transplanting (3.15% LDH) which was followed by 2<sup>nd</sup> date of (normal) transplanting with 5.32 per cent leaf infestation, leaf due to the pest where as the maximum leaf damage (7.47% LDH) was observed in 3<sup>rd</sup> date of (delayed) transplanting.

**b) Incidence of leaf damage (LDH) recorded at 40 days after transplanting (40 DAT)**

**i) Incidence of LDH recorded at 40 DAT, during 2016**

The leaf damage caused due to hispa at 40 DAT (Table-4.3.1) revealed significant results among different dates of transplanting and in case of 1<sup>st</sup> date of transplanting the crop suffered from the minimum incidence of leaf damage (4.58%) which, in turn, was found superior among the other two dates of transplanting. The next best time of transplanting was 2<sup>nd</sup> date of transplanting, which recorded relatively higher pest infestation (7.80% LDH) and the highest leaf damage (10.91%) due to rice hispa was observed in case of delayed transplanted crop.

**ii) Incidence of LDH recorded at 40 DAT, during 2017**

The result on leaf damage due to rice hispa recorded at 40 DAT (Table-4.3.1) revealed significant results in respect of impact of different dates of transplanting of rice. The 1<sup>st</sup> date of transplanting enabled the rice plants to suffer minimum of 4.72 per cent leaf damage which, in turn, was found to be superior among the rest of the other two dates of transplanting. The next best time of transplanting was 2<sup>nd</sup> date of

(normal) transplanting, which recorded 7.88 per cent leaf damage and the significantly highest leaf damage of 11.08 per cent was registered in case of the delayed transplanted crop of rice.

**iii) Pooled mean incidence of LDH recorded at 40 DAT, during 2016 and 2017**

The leaf damage due to hispa registered at 40 DAT reflected the significant effects among different dates of transplanting on incidence of the pest (Table-4.3.1). The 1<sup>st</sup> (early) date of transplanting enabled the rice plants to suffer the lowest leaf damage (4.65% LDH) that was found superior to the other two dates of transplanting. The next best time of transplanting was 2<sup>nd</sup> (normal) date of transplanting, where in moderate level of leaf damage (7.84% LDH) was registered and the highest leaf damage (11.00% LDH) was observed due to hispa infestation in delayed transplanting of rice which was made on 12<sup>th</sup> August.

**c) Overall mean of leaf damage (LDH) recorded at 25 and 40 days after transplanting (DAT)**

**i) Mean of LDH recorded at 25 and 40 DAT, during 2016**

If the all mean of leaf damage of obtained from 25 and 40 DAT is considered, the similar type of trend against rice hispa was observed to that of the results recorded at 25 and 40 DAT (Table-4.3.1). The minimum leaf damage of 3.81 per cent was recorded in case of early transplanting. The next best date of transplanting was found normal transplanting resulting in higher quantum of (6.50% LDH) as compared to that of early planted crop (3.81% LDH). However, the crop planted on 2<sup>nd</sup> date of transplanting received significantly lower damage than the delayed transplanting (9.10% LDH).

**ii) Mean of LDH recorded at 25 and 40 DAT, during 2017**

The mean of leaf damage of the observations recorded at 25DAT and 40DAT, also followed almost similar type of trend against hispa and gave rise to the statistically significant results (Table-4.3.1). The minimum leaf damage (i.e. 3.99% LDH) was noticed in early date of transplanting. The next best date of transplanting in terms of significantly lower leaf damage (LDH) was normal transplanting (6.66% LDH) which, in turn, showed significantly lower leaf damage than that of the delayed transplanting (9.36% LDH).

**iii) Pooled mean incidence of LDH recorded at 25 and 40 DAT, during 2016 and 2017**

The overall mean results of pooled data of leaf damage caused by hispa showed the similar type of trend against rice hispa, which was found statistically different among the three dates of transplanting of rice (Table-4.3.1). The minimum leaf damage (i.e. 3.90% LDH) was observed in early transplanting. The next best date of transplanting was normal date of transplanting (6.58% LDH) which, in turn, showed significantly lower leaf damage than that of delayed transplanting (9.23% LDH). A close observation on the overall results of 2016 and 2017 indicated the consistent performance of date of transplanting during the period of both of the years in respect of suppression in the incidence of hispa. It was interesting to note that extent of leaf damage (LDH) was found to increase with the advancement of age of the crop up to 40 DAT in case of all the three dates of transplanting. In nut shell, earlier were the dates of transplanting, lesser were the leaf damage due to hispa in the present studies.

Earlier, some scientists also obtained the similar effects of different dates of transplanting on the incidence of hispa in rice at different locations of the country. Accordingly, the results of leaf damage caused by the hispa was found to be in descending order i.e. delayed planting > normal planting > early planting in terms of leaf damage caused by hispa.

The present finding suggests that delaying in transplanting should be avoided in order to reduce the damage to the crop caused by hispa infestation. As such, early date of transplanting i.e. 1<sup>st</sup> July and normal date of transplanting (21<sup>th</sup> July) of the rice crop possessed significantly lesser damaged by hispa occurrence which was responsible for lesser loss of chlorophyll content from leaves of the crop. This type of findings was earlier reported by Prasad and Prasad (2015) and that of Anonymous (2012 & 2016) which were in close conformity with results of the present studies.

#### **4.3.2 Effect of date of transplanting on the incidence of yellow stem borer (*Scirpophaga incertulas* Walker) in terms of dead heart (DH %).**

Observations of incidence of yellow stem borer (YSB) in terms of dead heart (DH) were recorded at 30, 45 and 60 DAT (days after transplanting) and over all mean of three different observations (30, 45, & 60 DAT) recorded during *kharif* 2016 and 2017 were pooled. The results are shown in Table-4.3.2.

##### **a) Incidence of dead heart (DH) recorded at 30 days after transplanting (30 DAT)**

##### **i) Incidence of DH recorded at 30 DAT, during 2016**

During *kharif* 2016 at 30 DAT, there was significant effect of different date of transplanting on the incidence of yellow stem borer (Table-4.3.2). The significantly minimum incidence of dead heart (1.57% DH) caused by YSB was found in early transplanting made on 1<sup>st</sup> July. The result of 1<sup>st</sup> date was followed by normal transplanting i.e. 2<sup>nd</sup> date of transplanting (made on 21<sup>st</sup> July) with 4.99 per cent dead hearts, but the maximum damage (8.09% DH) was observed in case of the delayed transplanting which was made on 12<sup>th</sup> August during both of the years of experimentation.

**ii) Incidence of DH recorded at 30 DAT during 2017**

During *kharif* 2017, the effect of dates transplanting on the incidence of on yellow stem borer (DH %) observed at 30 DAT remained significant (Table-4.3.2). The significantly minimum dead heart (1.6% DH) was recorded in 1<sup>st</sup> date of transplanting. This date was followed by 2<sup>nd</sup> date of transplanting with 5.44 per cent DH infestation, but the maximum damage (8.50% DH) was noticed in 3<sup>rd</sup> date of transplanting i.e delayed transplanting made on 12 August, 2017.

**iii) Pooled mean incidence of DH recorded at 30 DAT during 2016 and 2017**

The pooled data recorded at 30 DAT from 2016 and 2017 on the incidence of yellow stem borer in terms of dead heart showed significant results pertaining to the performance of different date of transplanting in suppressing the incidence of DH per cent (Table-4.3.2). The significantly minimum dead heart (1.59% DH) was recorded in 1<sup>st</sup> date of transplanting (i.e. in case of early planted crop). This date was followed by 2<sup>nd</sup> date of transplanting with 5.21 per cent dead heart infestation, but the maximum damage (8.29% DH) was observed in case of 3<sup>rd</sup> date of transplanting.

**b) Incidence of dead heart (DH) recorded at 45 days after transplanting (45 DAT)**

**i) Incidence of DH recorded at 45 DAT, during 2016**

The experimental results (Table-4.3.2) on the incidence of dead hearts due to yellow stem borer at 45 DAT revealed that 1<sup>st</sup> date of transplanting (i.e. early planting) of rice suffered from the minimum incidence of dead heart to the tune of 3.96 per cent which was found statistically superior to the results of 2<sup>nd</sup> and 3<sup>rd</sup> date of transplanting. The next best time of transplanting was 2<sup>nd</sup> date of transplanting, which recorded significantly lower incidence of dead heart (7.16% DH) and the highest dead heart (9.54% DH) due to yellow stem borer was observed in case of the delayed transplanting of the crop made on 12<sup>th</sup> August, 2016.

**ii) Incidence of DH recorded at 45 DAT, during 2017**

The results on dead hearts caused by yellow stem borer at 45 DAT (Table-4.3.2) revealed significant results among different dates of transplanting and in 1<sup>st</sup> date of transplanting (i.e early transplanting) receiving the lowest 4.51 per cent dead heart which was found superior among all dates of transplanting. The next best time of transplanting was 2<sup>nd</sup> date (normal) of transplanting, which recorded 7.41 per cent dead hearts and the highest dead heart (10.06%) due to yellow stem borer was noticed in delayed transplanting which was made on 12<sup>th</sup> August, 2017.

**iii) Pooled mean incidence of DH recorded at 45 DAT, during 2016 and 2017**

The results on the incidence of dead hearts due to yellow stem borer recorded at 45 DAT revealed significant results with respect to impact of the different dates of transplanting on incidence of DH (Table-4.3.2). Earlier was the date of transplanting, lower was the incidence of dead heart (4.24%) caused by yellow stem borer. As such, the incidence of dead heart was found to be in order of: early transplanting < normal transplanting < delayed transplanting. The next best time of transplanting was 2<sup>nd</sup> date of transplanting, which recorded 7.28 per cent dead hearts and the highest dead heart (9.80%) was observed in delayed transplanting made on 12<sup>th</sup> August.

**c) Incidence of dead heart (DH) recorded at 60 days after transplanting (60 DAT)**

**i) Incidence of DH recorded at 60 DAT, during 2016**

The similar type of trend on performance of effect of three dates of transplanting was recorded also at 60 DAT (Table-4.3.2) which also showed significant results. The significantly lowest dead heart (2.02% DH) was found in the early date of transplanting which was made on 1<sup>st</sup> July. The next effective date of transplanting was 2<sup>nd</sup> date of transplanting (i.e normal date) with 3.64 per cent and the highest dead heart i.e. 5.58 per cent was observed in 3<sup>rd</sup> date of transplanting i.e delayed transplanting.

**ii) Incidence of DH recorded at 60 DAT, during 2017**

The similar type of trend on performance of effect of three dates of transplanting against yellow stem borer was recorded also at 60 DAT (Table-4.3.2). As such, they were effects of date planting showed significant results. The significantly lowest dead heart (2.25% DH) was found in 1<sup>st</sup> date of transplanting of rice. The next effective date of transplanting was 2<sup>nd</sup> date of transplanting (3.96%

DH) and the highest dead heart of 5.77 per cent was observed in case of 3<sup>rd</sup> date of transplanting which was made on 12<sup>th</sup> August.

**iii) Pooled mean incidence of DH recorded at 60 DAT, during 2016 and 2017**

The similar type of trend on performance of three date of transplanting against yellow stem borer was recorded at 60 DAT (Table-4.3.2). The significantly lowest dead heart (2.14%) was found in 1<sup>st</sup> date of transplanting. The next effective date of transplanting was 2<sup>nd</sup> date of transplanting (3.80% DH) and the highest dead heart (5.68%) was observed in 3<sup>rd</sup> date of transplanting.

**d) Overall mean of dead heart (DH) recorded at 30, 45 and 60 days after transplanting (DAT)**

**i) Mean of DH recorded at 30, 45 and 60 DAT, during 2016**

So far as the effect of date of transplanting on over all mean incidence of dead heart is concerned, the similar type of trend against yellow stem borer was recorded with significant results to that of DH recorded at 30, 45 and 60 DAT (Table-4.3.2). Accordingly, significantly minimum dead heart i.e. 2.52 per cent DH was recorded in early transplanting. The next best date of transplanting was normal transplanting which received intermediate quantum of DH (5.26%), which, in turn, also suffered from significantly lower damage than that of delayed transplanting (7.73% DH).

**ii) Mean of DH recorded at 30, 45 and 60 DAT, during 2017**

So far as the effect of dates of planting in terms of overall mean incidence of dead heart; is concerned, almost the similar type of trend against yellow stem borer was recorded with significant results (Table-4.3.2). The minimum dead heart i.e. 2.79% DH was observed in early transplanting. The next best date of transplanting was normal transplanting (5.60% DH) which, in turn, remained significantly superior to that of the delayed transplanting (8.11% DH) receiving significantly higher damage.

**iii) Pooled mean incidence of DH recorded at 30, 45 and 60 DAT, during 2016 and 2017**

The pooled results of overall mean of three dates of observation of dead heart, the similar type of trend against yellow stem borer was recorded with significant results (Table-4.3.2). The minimum dead heart (2.65%) was recorded in early transplanting made on 1<sup>st</sup> July. The next best date of transplanting was observed in case of normal transplanting performed on 21<sup>st</sup> July (5.43% DH) and also showed significantly lower damage than that delayed transplanting (7.92% DH).

As such, almost similar impact of dates of transplanting was registered in all the other three dates of observations i.e. at 30, 45 and 60 days after transplanting in respect of dead heart caused due to YSB. It was interesting to note that extent of dead heart incidence was found to increase with the advancement of age of the crop up to 45 DAT and thereafter the intensity of the pest attack began to decline in case of all the three dates of transplanting.

Earlier, some scientists also evaluated the impact of dates of transplanting against the incidence of yellow stem borer in rice at different locations of the country. Among them, the results of Prasad and Prasad (2015) recorded almost similar impact of dates of transplanting on incidence of dead heart, caused by yellow stem borer. Findings of Anonymous (2016) and Kumar & Prasad (2018) also endorsed the results of the present studies.

An overall impact of dates of transplanting on the incidence of dead heart was found to be increasing with delaying of transplanting referring to in the order of: i.e. early planting < normal planting < delayed planting.

#### **4.3.3 Effect of date of transplanting on the incidence of yellow stem borer (*Scirpophaga incertulas* Walker) in terms of white ear (WE %)**

The observations on the white ear, caused by yellow stem borer recorded at pre-maturity stage of the crop during *kharif* 2016 and 2017 (Table-4.3.3).

##### **a) Incidence of white ear (WE) recorded at pre-maturity stage, during 2016**

During *kharif* 2016 at pre-maturity stage of the crop, there was significant impact of dates of transplanting on incidence of white ear (WE) caused by yellow stem borer (Table-4.3.3). The significantly minimum white ear caused by yellow stem borer was noticed in early transplanting of rice made on 1<sup>st</sup> July i.e. 1<sup>st</sup> date of transplanting (3.21% WE). This date was followed by normal transplanting i.e. 2<sup>nd</sup> date of transplanting with 6.52 per cent white ear, but the maximum damage (10.17% WE) was observed in delayed transplanting of rice made on 12<sup>th</sup> August 2016.

##### **b) Incidence of white ear (WE) recorded at pre-maturity stage, during 2017**

During *kharif* 2017, the data on the incidence of yellow stem borer in terms of WE at pre-maturity stage of the crop, recorded the significant results in respect of impact of the different dates of transplanting (Table-4.3.3). The significantly minimum white ear was observed in 1<sup>st</sup> date of transplanting (1<sup>st</sup> July) (3.40% WE). This date was followed by 2<sup>nd</sup> date of transplanting with 7.07 per cent of white ear

infestation, but the maximum damage (10.70% WE) was found in 3<sup>rd</sup> date of transplanting of rice made on 12<sup>th</sup> August 2017.

**c) Pooled mean incidence of white ear (WE) recorded at pre-maturity stage, during 2016 and 2017**

The pooled mean of WE recorded during 2016 and 2017 at pre-maturity stage of the crop caused by yellow stem borer showed significant results in respect of impact of dates of three different dates of transplanting of rice (Table-4.3.3). The significantly minimum white ear (3.31% WE) was recorded in 1<sup>st</sup> date of transplanting made on 1<sup>st</sup> July during, 2016 and 2017, that date was followed by 2<sup>nd</sup> date of (normal) transplanting with 6.79 per cent white ear infestation but the maximum damage (10.44% WE) was observed in 3<sup>rd</sup> date of (late) transplanting.

There was significant impact of dates of transplanting on the incidence of white ear (WE) due to attack of yellow stem borer in the present studies. The findings of Prasad and Prasad (2015), Anonymous (2012 & 2016) and Kumar & Prasad (2018) are almost in conformity to the results of the present studies.

As such, based on the overall mean results of years studies made under the present investigation, it may be concluded that earlier was the date of planting, lesser was the extent of incidence of dead heart and white ear, caused by the yellow stem borer in case of rice (var. Sahbhagi-Dhan). Hence, it may be suggested that early planting of rice (up to 1st July) should be encouraged and normal (21<sup>st</sup> July) and delayed (12<sup>th</sup> August) planting of rice should be discouraged in order to minimize the attack of stem borer for protecting the crop against the pest (i.e. yellow stem borer).

**4.3.4: Effect of date of transplanting on the incidence of gall midge (*Orseolia oryzae* Wood mason) in terms of silver shoot (SS %).**

The observations on incidence of gall midge in terms of silver shoot (SS) were recorded at 30 and 45 days after transplanting (DAT) and over all mean of two different observations (30 & 45 DAT) recorded during *kharif* 2016 and 2017 were calculated, which are shown in Table-4.3.4.

**a) Incidence of silver shoot (SS) recorded at 30 days after transplanting (30 DAT)**

**i) Incidence of SS recorded at 30 DAT, during 2016**

During, *kharif* 2016 at 30 DAT, there was significant impact of different dates of transplanting against gall midge (Table-4.3.4). The significantly minimum incidence of silver shoot per cent (1.63% SS) was recorded in early transplanting crop

i.e. 1<sup>st</sup> date of transplanting. The early date was followed by normal transplanting i.e. 2<sup>nd</sup> date of transplanting with significantly higher incidence of the pest (8.20% SS), but the maximum damage (13.61 % SS) was observed in case of delayed transplanting made on 12<sup>th</sup> August 2016.

**ii) Incidence of SS recorded at 30 DAT, during 2017**

During *kharif* 2017, the data of gall midge damage recorded at 30 DAT showed significant results in respect of impact of different dates of transplanting (Table-4.3.4). The significantly minimum occurrence of silver shoots was recorded in 1<sup>st</sup> date of transplanting (2.16% SS). That date was also followed by 2<sup>nd</sup> date of transplanting with 9.95 per cent silver shoots infestation, but the maximum incidence of silver shoots i.e. 15.31% SS was observed in 3<sup>rd</sup> date of transplanting of rice made on 12<sup>th</sup> July, 2017.

**iii) Pooled mean incidence of SS recorded at 30 DAT, during 2016 and 2017**

The data on the mean values of silver shoots recorded at 30 DAT on the gall midge occurrence showed significant results in respect of impact of different date of transplanting (Table-4.3.4). The significantly minimum incidence of silver shoots was observed in 1<sup>st</sup> date of transplanting (1.90% SS). This date was followed by 2<sup>nd</sup> date of transplanting with significantly higher incidence of the pest (9.07% SS), but the maximum damage (14.46% SS) was found in 3<sup>rd</sup> date of transplanting due to gall midge.

**b) Incidence of silver shoot (SS) recorded at 45 days after transplanting (45 DAT)**

**i) Incidence of SS recorded at 45 DAT, during 2016**

The silver shoots (SS) caused by gall midge recorded at 45 DAT revealed significant results in respect of impact of different dates of transplanting and 1<sup>st</sup> date of transplanting received the minimum SS (3.48%) which remained superior among all dates of transplanting (Table-4.3.4). The next best time of transplanting was 2<sup>nd</sup> date of transplanting, which recorded 10.18 per cent silver shoots and the highest silver shoots (17.03%) was found due to gall midge incidence in case of delayed transplanting made on 12<sup>th</sup> August 2016.

**ii) Incidence of SS recorded at 45 DAT, during 2017**

The results on the incidence of silver shoots (SS) revealed significant results in respect of impact of different dates of transplanting due to gall midge infestation at 45 DAT and 1<sup>st</sup> date of transplanting received the minimum pest incidence (5.07% SS)

which remained among the other two dates of transplanting (Table-4.3.4). The next best time of transplanting was 2<sup>nd</sup> date of (normal) transplanting, which could allowed the plants to suffer higher incidence of silver shoots of 11.47 per cent and the highest silver shoots (18.51% SS) due to gall midge infestation was found in case of the delayed transplanting of the crop.

**iii) Pooled mean incidence of SS recorded at 45 DAT, during 2016 and 2017**

The results on silver shoot incidence due to gall midge infestation recorded at 45 DAT gave the significant results in respect of impact of different dates of transplanting and the crop of 1<sup>st</sup> date of transplanting received minimum 4.28 per cent of silver shoots (Table-4.3.4). The next best time of transplanting was 2<sup>nd</sup> date of transplanting, which recorded significantly more incidence of SS (10.82% SS) as compared to that of early transplanted crop. The highest silver shoots of 17.77 per cent due to gall midge were observed in case of delayed transplanted crop.

**c) Overall mean of silver shoot (SS) recorded at 30 and 45 days after transplanting (DAT)**

**i) Mean of SS recorded at 30 and 45 DAT, during 2016**

The similar type of trend of incidence of SS was observed in case of the mean data of silver shoots recorded at 30 DAT and 45 DAT, during 2016 (Table-4.3.4). The minimum incidence of silver shoots (2.55%) was noticed in case of early transplanting. The next best suitable date of transplanting for reducing the pest incidence was normal transplanting (9.19% SS) which in tern also received significantly lower incidence of silver shoots than that of the delayed transplanting that gained the highest crop damage (15.32% SS) due silver shoots caused by gall midge.

**ii) Mean of SS recorded at 30 and 45 DAT, during 2017**

The mean incidence of silver shoots showed almost similar trend against gall midge in respect of the impact of different dates of transplanting (Table-4.3.4). The minimum silver shoots damage of 3.62 per cent was noticed in early transplanting. The next best date of transplanting remained the normal date of transplanting (10.71% SS) which in turn, showed significantly lower damage than the delayed transplanting receiving the highest silver shoot (16.91% SS).

**iii) Pooled mean incidence of SS recorded at 30 and 45 DAT, during 2016 and 2017**

The overall mean of incidence of silver shoot showed the similar type of trend against gall midge in respect of impact of dates of transplanting (Table-4.3.4). The minimum silver shoot (i.e. 3.09% SS) was observed in early transplanting. The next best date of transplanting remained the normal transplanting (9.95% SS) which, in turn received significantly lower silver shoot than that of the delayed transplanting (16.11% SS). As such, there was consistent impact of dates of transplanting on the incidence of gall midge during both of the years. Almost similar impact of dates of transplanting was registered on the incidence of gall midge in terms of silver shoot at all the other two dates of observations i.e. 30 and 45 days after transplanting in respect of silver shoot caused due to gall midge infestation. It was interesting to note that extent of silver shoot incidence was found to increase with the advancement of age of the crop up to 45 DAT in case of all the three dates of transplanting.

Earlier, few scientists also studied the impact of different dates of transplanting on the incidence gall midge in rice. Singh *et al.*, (2007) found almost similar results of the minimum infestation in the earliest transplantation at both 30 and 50 days after transplanting (DAT). The pest infestation gradually increased with delay in transplanting and highest infestation at 50 DAT was recorded in 28<sup>th</sup> July transplanted rice crop of rice (var. IR-64) according to their findings. There was significant impact of dates of transplanting on the incidence of silver shoot (SS) due to attack of gall midge in the present studies. The findings obtained by Anonymous (2012 & 2016) are almost in conformity with the results of the present studies.

As per the above results and discussion, it may be concluded that an overall impact of dates of transplanting on the intensity of gall midge incidence was found to be decreasing order i.e. delayed planting > normal planting > early planting, referring later was the date of transplanting, higher was intensity of gall midge infestation based on the overall mean results of two years' field studies.

#### **4.3.5: Effect of date of transplanting on the incidence of leaf folder (*Cnephalocrosis medinalis*) in terms of leaf damage caused by the pest (LDLF%).**

Larvae of leaf folder fold the leaves mostly longitudinally with their saliva by spinning threads and live within the leaf folds. They feed on the chlorophyll content of leaf tissues by living within the leaf folds. The observations on the leaf damage caused by the leaf folder (LDLF) were recorded at 60, 70, 80 DAT (days after transplanting) and mean of the three observations (60, 70 & 80 DAT) in terms of percentage of leaf damage (LDLF %) recorded during *kharif* 2016 and 2017, and results

in terms of mean of 2016 and 2017 were also calculated to draw the conclusion. The results are presented in Table-4.3.5.

**a) Incidence of leaf damage (LDLF) recorded at 60 days after transplanting (60 DAT)**

**i) Incidence of LDLF recorded at 60 DAT, during 2016**

The impact of dates of transplanting was found to be significant on the intensity of incidence of the pest species (Table-4.3.5). The minimum incidence of the pest, in terms of per centage of leaf damage due to leaf folder (LDLF%), was found to the tune of 3.30 per cent in case of early transplanted (1<sup>st</sup> July) crop and this date was followed by normal transplanting (i.e. 2<sup>nd</sup> date of transplanting) with significantly higher leaf damage to the tune of 5.33 per cent of leaf damage caused by the leaf folder (LDLF), whereas the statistically maximum incidence (i.e. 8.18% LDLF) was recorded in case of delayed transplanting time (12<sup>th</sup> August) of rice.

**ii) Incidence of LDLF recorded at 60 DAT, during 2017**

The impact of dates of transplanting on the incidence of leaf folder remained statistically significant (Table-4.3.5). The significantly minimum leaf damaged was recorded in 1<sup>st</sup> date of transplanting (3.70% LDLF). This date was followed by 2<sup>nd</sup> date of transplanting with 5.73 per cent leaf infestation with the pest, but the maximum damage (8.90% LDLF) was observed in 3<sup>rd</sup> date of transplanting.

**iii) Pooled mean incidence of LDLF recorded at 60 DAT, during 2016 and 2017**

The significantly minimum leaf damage was observed in 1<sup>st</sup> date of transplanting (3.50% LDLF) (Table-4.3.5). This date was followed by 2<sup>nd</sup> date of transplanting (5.53% LDLF) where as the maximum leaf damage (8.54%) was found in 3<sup>rd</sup> date of transplanting made on 12<sup>th</sup> August.

**b) Incidence of leaf damage (LDLF) recorded at 70 days after transplanting (70 DAT)**

**i) Incidence of LDLF recorded at 70 DAT, during 2016**

The leaf damage caused due to leaf folder at 70 DAT realized the significant results among different dates of transplanting and the crop of 1<sup>st</sup> date of transplanting received the lowest leaf damage (5.30%) which remained superior among the other two later dates of transplanting (Table-4.3.5). The next best time of transplanting was found 2<sup>nd</sup> date of transplanting (21<sup>st</sup> July), which received 8.48 per cent leaf damage and the highest leaf damage (i.e 10.59%) was observed due to leaf folder was registered in delayed transplanting (12<sup>th</sup> August).

**ii) Incidence of LDLF recorded at 70 DAT during 2017**

The results recorded at 70 DAT during the 2<sup>nd</sup> year of experimentation (i.e 2017) showed almost similar trends to those of 2016 (Table-4.3.4). As such, the rice crop of 1<sup>st</sup> date of transplanting received the lowest leaf damage (5.57%). The results also showed that the next best time of transplanting was 2<sup>nd</sup> date of (normal) transplanting, which received 9.23 per cent leaf damage and the highest leaf damage (11.29%) was observed due to leaf folder in delayed transplanting made on 12<sup>th</sup> August.

**iii) Pooled mean incidence of LDLF recorded at 70 DAT during, 2016 and 2017**

The rice crop of 1<sup>st</sup> date of transplanting suffered with the minimum leaf damage (5.44%) which was found superior among the other two dates of transplanting (Table-4.3.5). The next best time was 2<sup>nd</sup> date of transplanting, which suffered from significantly lower damage (8.86% LDLF) as compared to that of 3<sup>rd</sup> date of transplanting. The highest leaf damage (10.94%) was observed in delayed transplanting.

**c) Incidence of leaf damage (LDLF) recorded at 80 days after transplanting (80 DAT)**

**i) Incidence of LDLF recorded at 80 DAT, during 2016**

The leaf damage caused due to leaf folder recorded at 80 DAT showed significant results among different dates of transplanting and 1<sup>st</sup> date of transplanting received the lowest leaf damage (9.24%), which remained superior to the other two later date of transplanting (Table-4.3.5). The next best time of transplanting was 2<sup>nd</sup> date of transplanting; in which 11.88 per cent leaf damage was noticed and the highest leaf damage (i.e. 13.57%) was found in case of delayed transplanting of rice.

**ii) Incidence of LDLF recorded at 80 DAT during 2017**

The experimental findings revealed that the crop of 1<sup>st</sup> date of transplanting received statistically minimum leaf damage (9.79%) which remained superior over the other two dates of transplanting (Table-4.3.5). The next best time of transplanting was 2<sup>nd</sup> date of transplanting, where in 12.44 per cent leaf damage was noticed and the highest leaf damage (14.42%) due to leaf folder was observed in case of delayed transplanting of rice.

**iii) Pooled mean incidence of LDLF recorded at 80 DAT, during 2016 and 2017**

The rice crop of 1<sup>st</sup> date of transplanting suffered with the significantly lowest leaf damage (9.52%) which was found superior among the other two dates of

transplanting (i.e normal and delayed transplanting) (Table-4.3.5). The next best time was 2<sup>nd</sup> date of transplanting, which recorded 12.16 per cent leaf damage and the highest leaf damage (13.99%) was observed in case of delayed transplanting. In brief, earlier was the date of transplanting; higher was the quantum of leaf damage caused by leaf folder.

**d) Overall mean of leaf damage (LDLF) recorded at 60, 70 and 80 days after transplanting (DAT)**

**i) Mean LDLF recorded at 60, 70 and 80 DAT, during 2016**

The experimental data on percentage of mean leaf damage of the three observational dates (i.e 60, 70 & 80 DAT) as influenced by three dates of transplanting remained significant (Table-4.3.5). The minimum leaf damage (i.e. 5.95%) was observed in case of early transplanting. The next best date of transplanting was normal transplanting (8.56% LDLF) which was significantly lower extent of leaf damage than that of delayed transplanting (10.78% LDLF).

**ii) Mean LDLF recorded at 60, 70 and 80 DAT, during 2017**

Over all mean of leaf damage caused by leaf folder during 2017 showed almost similar trend to that of 2016 (Table-4.3.5). As such, the minimum leaf damage of 6.35 per cent was recorded in early transplanted crop. The next best date of transplanting was normal transplanting (9.13% LDLF) which showed significantly lower leaf damage than than that of the delayed transplanting (11.54% LDLF).

**iii) Pooled mean incidence of LDLF recorded at 60, 70 and 80 DAT, during 2016 and 2017**

The analysis of overall mean data of leaf damage reflected that there was significant impact of date of transplanting on the incidence of leaf folder. Accordingly, earlier was the date of transplanting; lower was the incidence of leaf folder. As such, the minimum leaf damage (i.e 6.15%) was recorded in early transplanting (Table-4.3.5). The next best date of transplanting was normal transplanting (8.85% LDLF) which also showed significantly lower damage than the delayed transplanting (11.16% LDLF).

There were three dates of transplanting of rice made at 20 days intervals starting 1<sup>st</sup> July followed by 21<sup>st</sup> July and 12<sup>th</sup> August during both the year of experimentations of 2016 and 2017 in kharif with rice (var. Sahbhagi Dhan). In general, it was found that earlier was date of transplanting, lesser was the intensity of incidence of the leaf folder in terms of per centage of leaf damage caused by the pest

(LDLF %), which were noticed almost throughout the observational periods during the cropping season in both of the experimental years, 2016 and 2017. It was also evident that intensity of attack of leaf folder was found to increase gradually from 60 DAT to 80 DAT, but still the similar trends of impact of date of planting was followed indicating earlier was the date of planting, lesser was the intensity of leaf folder attack almost in throughout the crop growth. Accordingly, the intensity of leaf folder attack remained to be in descending order i.e. delayed planting > normal planting > early planting, having overall mean of leaf damage to the tune of 11.16, 8.85 and 6.15 per cent, respectively in the present studies.

Various workers studied the impact of date of transplanting on the incidence of leaf folder infesting rice at different locations of the country. On considering the three different dates of transplanting made at 20 days intervals, it was found that there was significant treatment difference in respect of pest reduction, almost throughout the observational periods of crop growth. The findings of the present field investigations suggested that delayed planting of rice should be avoided in order to reduce the incidence of leaf folder infesting rice. Conversely, early and normal dates of planting of rice crop should be preferred in order to have significantly lesser incidence of leaf folder in rice agro-ecosystem. Findings of Prasad and Prasad (2015) and that of Anonymous (2012 & 2016) are almost in the agreement with the results of the present field investigations.

**4.3.6: Effect of date of transplanting on the incidence of green leaf hopper (GLH), *Nephotettix virescens* Distant and *Nephotettix nigropictus* Stal.**

Green leaf hoppers (*Nephotettix nigropictus* and *N. virescence*) usually suck cell sap from rice leaves resulting in weakening of leaves. Prevalence of incidence of green leaf hopper on *kharif* rice was observed almost throughout the crop growth right from vegetative stage to reproductive stage of the crop (Table-4.3.6). Observations on incidence of leaf hopper were recorded at 40, 60 and 80 DAT (day after transplanting) and mean of three observations (40, 60 & 80 DAT) pertaining to GLH (no. of GLH/10 hills) recorded during *kharif* 2016 and 2017 were calculated for their proper interpretation, documentation and drawing the final conclusion. The results are shown in Table-4.3.6.

**a) Incidence of GLH recorded at 40 days after transplanting (40 DAT)**

**i) Incidence of GLH recorded at 40 DAT, during 2016**

The results are shown in Table-4.3.6. The findings indicated that earlier was the dates of planting, lesser was the incidence of GLH at 40 DAT. There was statistically significant impact of date of transplanting on the incidence of GLH. As such, the minimum incidence of the green leaf hopper to the tune of 8.70 GLH/10 hills was registered in case of early planted crop and this date was followed by normal transplanting i.e. 2<sup>nd</sup> date of transplanting with 10.40 GLH/10 hills, as against the maximum incidence of 16.40 GLH/10 hills recorded in case of delayed transplanting time of rice.

**ii) Incidence of GLH recorded at 40 DAT, during 2017**

The incidence of green leaf hopper (GLH) in respect of different date of transplanting recorded during, 2017 followed almost similar trend to that of the pest incidence, recorded during, 2016 (Table-4.3.6). The minimum incidence of the green leaf hopper, to the tune of 9.60 GLH/10 hills was registered in case of early planted crop and this date was followed by normal transplanting i.e. 2<sup>nd</sup> date of transplanting with 12.00 GLH/10 hills, as against the maximum incidence of 17.80 GLH/10 hills recorded in case of delayed transplanting time of rice.

**iii) Pooled mean incidence of GLH recorded at 40 DAT during 2016 and 2017**

The significantly minimum no. of GLH/10 hills was recorded in 1<sup>st</sup> date of transplanting (9.15 GLH/10 hills) (Table-4.3.6). This date was followed by 2<sup>nd</sup> date of transplanting with 11.20 no. of GLH/10 hills, but the maximum no. of GLH/10 hills (17.10) was observed in 3<sup>rd</sup> date of transplanting.

**b) Incidence of GLH recorded at 60 days after transplanting (60 DAT)**

**i) Incidence of GLH recorded at 60 DAT, during 2016**

The incidence of green leaf hopper on rice recorded at 60 DAT followed similar trend to that of 40 DAT (Table-4.3.6). As such, the minimum incidence of the pest (18.80 GLH/10 hills) was found in case of early planting (1<sup>st</sup> July) which was superior among the other two dates of transplanting in terms of pest reduction. The next best time of transplanting was 2<sup>nd</sup> date of transplanting, which received higher pest incidence (20.90 GLH/10 hills) and the highest pest population (29.30 GLH/10 hills) was observed in delayed transplanting of rice.

**ii) Incidence of GLH recorded at 60 DAT, during 2017**

The observation on the population of green leaf hopper recorded showed revealed significant results among different dates of transplanting (Table-4.3.6). As such, the minimum incidence of the pest (19.40 GLH/10 hills) was found in the early

planted crop. The next best time of transplanting was 2<sup>nd</sup> date of transplanting, which recorded 21.90 GLH/10 hills and the highest GLH/10 hills (29.90) was observed in case of delayed transplanting of rice.

**iii) Pooled mean incidence of GLH recorded at 60 DAT, during 2016 and 2017**

The result on no. of GLH/10 hills at 60 DAT (Table-4.3.6) reflected the significant results among different dates of transplanting and the crop of 1<sup>st</sup> date of transplanting received the lowest incidence of the pest with 19.10 no. of GLH/10 hills which was found superior to the other two dates of transplanting. The next best time of transplanting was 2<sup>nd</sup> date of transplanting, which recorded 21.40 no. of GLH/10 hills and the highest no. of GLH/10 hills (29.60) were noticed in delayed transplanting of rice.

**c) Incidence of GLH recorded at 80 days after transplanting (80 DAT)**

**i) Incidence of GLH recorded at 80 DAT during 2016**

The impact dates of planting were found to be significant at 80 DAT, also. It found that earlier was the date of planting lower, was incidence of GLH at 80 DAT (Table-4.3.6). The early planted crop harboured the minimum number of GLH, followed by normal and delayed planted crop resulting in 30.00, 36.80 and 49.7 GLH/10 hills, respectively.

**ii) Incidence of GLH recorded at 80 DAT, during 2017**

The significantly lowest incidence of green leaf hopper (30.70 GLH/10 hills) was recorded in case of early planted crop, followed by normal planted crop (37.60 GLH/10 hills) as against the highest incidence of 51.00 GLH/10 hills in the delayed planted crop (Table-4.3.6).

**iii) Pooled mean incidence of GLH recorded at 80 DAT, during 2016 and 2017**

The results on the incidence of GLH recorded at 80 DAT showed significant results among different dates of transplanting and 1<sup>st</sup> date of transplanting received the minimum pest occurrence (30.35 GLH/10 hills) which was found superior to the other two dates of transplanting. The next best time of transplanting was 2<sup>nd</sup> date of transplanting, which recorded 37.20 no. of GLH/10 hills and the highest no. of GLH/10 hills (50.35) were observed in delayed transplanting.

**c) Overall mean of GLH recorded at 40, 60 and 80 days after transplanting (DAT)**

**i) Mean of GLH recorded at 40, 60 and 80 DAT, during 2016**

The similar trends on the incidence of GLH were found and the impact of dates of transplanting on the incidence of GLH remained significant. The minimum no. of the pest (19.17 GLH/10 hills) was recorded in early transplanting (Table-4.3.6). The next best date of transplanting was normal transplanting (22.70 GLH/10 hills) which showed significantly lower GLH/10 hills than the delayed transplanting (31.80 GLH/10 hills).

**ii) Mean of GLH recorded at 40, 60 and 80 DAT during 2016**

Significantly minimum incidence of the pest (19.90 GLH/10 hills) was recorded in case of the early planted crop, followed by the crop planted at normal planting date (23.83 GLH/10 hills) and the maximum incidence (32.90 GLH/10 hills) was registered in case of the delayed planted crop of rice (Table-4.3.6).

**iii) Overall pooled mean incidence of GLH recorded at 40, 60 and 80 DAT during 2016 and 2017**

The pooled results of overall mean analysis of incidence of GLH of three observations recorded at 40, 60 & 80 DAT showed almost similar type of trend (Table-4.3.6). The minimum no. of GLH (i.e 19.53 GLH/10 hills) was recorded in early transplanting. The next best date of transplanting was normal transplanting (23.27 GLH/10 hills) which remained significantly lower than that of the delayed transplanting (32.35 GLH/10 hills).

Incidence of green leaf hopper on *kharif* rice was observed almost throughout the crop growth right from vegetative stage to reproductive stage of the crop (Table – 4.3.6). As such, the intensity of the pest attack was observed to be in ascending order of early planting (1<sup>st</sup> July) < normal planting (21<sup>st</sup> July) < delayed planting (12<sup>th</sup> August) during almost throughout the crop growth stage.

The findings of the present field studies were found to be in accordance with the results of Prasad and Prasad (2015), Kumar and Prasad (2018) and anonymous (2012, 2014 & 2016).

Madhukar *et al.* (2014), found almost similar trend of pest incidence indicating that the seasonal incidence of GLH recorded during *kharif* 2012 and 2013 revealed that the population of nymphs and adults was started from first week of September (36<sup>th</sup> SMW). Thereafter, the population found gradually increasing with maximum population was recorded during first week of October (40<sup>th</sup> SMW). Further, the incidence showed decline trend till harvest of the crop (43<sup>rd</sup> SMW).

Shamim *et al.* (2009) from Middle Gujarat region showed that green leaf hopper attained peak population during 43<sup>rd</sup> SMW, which support the results of present field studies. Litsinger (1994) found similar result indicating late planting causes high infestation against early planting within a given planting period, particularly in the dry season, reduces the risk of insect-vector disease. Ali *et al.*, (2013) reported that planting date had significant effect on pest incidence ( $p = 0.01$ ). Planting on 1<sup>st</sup> July resulted in lower GLH incidence than on 16 July, 1<sup>st</sup> August and 16 August. There were significant differences in the pest incidence in rice transplanted on different dates ( $p = 0.01$ ). Likewise, the abundance of natural enemies was highest at early season and thereafter declined.

Chen *et al.*, (2003), also reported that the occurrence of insect pests and their natural enemies on rice is influenced by variety and date of planting. The GLH may be due to the susceptibility of variety and weather condition. In all season there was a reduction in the incidence of GLH for early transplanting. Similar findings of reduced pests and diseases in early maturing variety and early transplanting date have been reported by Litsinger *et al.* (1987). Low incidence of pest and diseases in early planting rice is also reported by Moniperumal (1989). In early transplanted crop when the infection stage of pest and microbes are over, the inoculums would be finding a place in a late transplanting crop (Rani and Pillai, 2012). In the case of late transplanting, the surrounding crop might have completed their susceptible growth stages and the entire pest inoculums would be feeding or confining to the late transplanted crop (Rani and Pillai, 2012). This might be the reason for higher insect pests' incidence for delayed transplanting. Varying the planting time of crops works as a means of cultural control by creating asynchrony between crop phenology and insect pests phenology which can retard the colonization (Ferro, 1987). The higher population was found in the later stage of the crop. It is occurred due higher canopy developed and they induce a favorable condition of insect reproduction, growth, and development. The present investigation revealed that the appropriate transplanting dates may influence green leaf hoppers, it may be concluded that the 1<sup>st</sup> transplanting date (1<sup>st</sup> July) can minimize green leaf hopper attack.

#### **4.3.7: Effect of date of transplanting on the incidence of ear bug (gundhi bug) *Leptocorsa oratorious* and *Leptocorsa acuta*, infesting rice**

Ear bugs (*Leptocorisa oratorius* and *Leptocorsa acuta*) suck the milky juice of developing and milky grains. The insects (both adults and nymph) puncture the husk

of milky grains and suck out the milky juice of grains, making them empty, which in turn affect the yield adversely. The observations of the mixed population of pest were recorded. The number of ear bug was collected from ten randomly selected hills (rice plants) in all the three treatments and ten replications and as such the observations were recorded at the milking stage of the crop (Table-4.3.7). Observations on incidence of gundhi bug were recorded at milking stage pertaining to GB (no. of GB/10 hills) during *kharif* 2016, 2017 and finally they were pooled.

**a) Incidence of gundhi bug recorded at milking stage, during (*Kharif* 2016):**

During *kharif*, 2016 at milking stage, there was significant difference among three dates of transplanting in terms of incidence of gundhi bug (Table-4.3.7). It was general observation that earlier was the date of transplanting, higher was the number of gundhi bugs/10hills harboured by rice plants indicating maximum incidence of 20.78 bugs/10 plants which was recorded in case of the first date of transplanting (1<sup>st</sup> July) and this date was followed by normal transplanting i.e. 2<sup>nd</sup> date (21<sup>st</sup> July) of transplanting with 16.61 bugs/10 hills, as against the minimum of 9.56 ear bugs/10 hills recorded at delayed transplanting of rice on 12<sup>th</sup> August in milking stage of the crop.

**b) Incidence of gundhi bug recorded at milking stage, during (*Kharif* 2017):**

During, *kharif*, 2017 at milking stage, there was significant difference among three dates of transplanting in terms of incidence of gundhi bug (Table-4.3.7). The maximum incidence of the gundhi bug, to the tune of 23.84 GB/10 hills was registered in case of early planted (i.e.1<sup>st</sup> date of transplanted) crop and this date was followed by normal transplanting i.e. 2<sup>nd</sup> date of transplanting with 19.61 GB/10 hills, as against the minimum incidence of 12.62 GB/10 hills recorded in case of delayed planting time of rice.

**c) Overall pooled mean incidence of gundhi bug recorded at milking stge, during 2016 and 2017**

The pooled mean values of gundhi bug of 2016 and 2017 reflected the significant results pertaining to the effect of different date of transplanting (Table-4.3.7). The significantly maximum incidence of GB was recorded in 1<sup>st</sup> date of transplanting (22.31 GB/hills). This date was followed by 2<sup>nd</sup> date of transplanting with 18.01 GB/10 hills, but the minimum incidence of the pest (11.09 GB/10 hills) was observed in 3<sup>rd</sup> date of transplanting.

It was interesting to note that the least incidence of ear bug was registered in early planted crop of rice as compared to those of the crop planted at normal and early planted crop of rice at the milking stage of the crop. A close perusal of results showed that the treatment effects in terms of three dates of transplanting were statistically significant in respect of incidence of ear bug on rice (Var-Sahbhagi Dhan). As such, the incidence of ear bug was found to be in descending order of : early planting (i.e. 1<sup>st</sup> July) > normal planting (21<sup>st</sup> July) > delayed planting (12<sup>th</sup> August) in the present studies.

Very little and scanty informations are available in the literatures pertaining to the effect of dates of planting of rice on the incidence of prevailing insect pest species infesting the crop so far. However, findings of Prasad (2015) and Anonymous (2012, 2016) are more or less similar to that of results of the present field studies. Accordingly, the present findings suggest that early planting of rice are more prone to attack of ear bugs as compared to those of late planting of the crop.

#### **4.3.8: Effect of dates of planting on grain yield of rice**

##### **a) Yield of rice grain recorded during first year (*Kharif* 2016):**

A perusal of results (Table-4.3.8) indicated that the effect of shifting in dates of transplanting of rice remained significant in realizing the yields of grains of rice showing earlier was the dates of planting, higher was the yields of grains of rice. Accordingly yields of grains of rice were found to be in descending order of early planting (1<sup>st</sup> July) > normal planting (21<sup>st</sup> July) > delayed planting (12<sup>th</sup> August) in terms of realization of yields of grains to the tune of 47.06, 44.12 and 38.17 q/ha the respectively, in the respective order of planting dates of planting of rice.

##### **b) Yield of rice grain recorded during first year (*Kharif* 2017):**

A perusal of results (Table-4.3.8) indicated that the effect of shifting in dates of transplanting of rice remained significant showing earlier was the dates of planting, higher was the yields of grains of rice. Accordingly yields of grains of rice were found to be in descending order of: early planting (1<sup>st</sup> July) > normal planting (21<sup>st</sup> July) > delayed planting (12<sup>th</sup> August) in terms of realization of yields of grains to the tune of 49.70, 44.95 and 39.87 q/ha the respectively, in the respective order of dates of transplanting of rice (var. Sahbhagi Dhan).

##### **c) Two years pooled mean yield of rice grain recorded during (*Kharif* 2016 and 2017):**

A perusal of results (Table-4.3.8) indicated that the effect of shifting of dates of transplanting in rice remained significant indicating earlier date of transplanting of the crop produced higher yields of grains. Accordingly yields of grains of rice obtained from the crop planted at three dates were found to be in descending order of: early transplanting (1<sup>st</sup> July) > normal transplanting (21<sup>st</sup> July) > delayed transplanting (12<sup>th</sup> August) in terms of realization of yields of grains to the tune of 48.38, 44.53 and 39.02 q/ha respectively, in the respective order in the present studies.

Very little and scanty information are available in the literatures pertaining to the effect of dates of planting on grains yield of rice. However, the experimental results of Prasad and Prasad (2015) and Anonymous (2016) remained more or less similar to the findings of the present studies.

#### **4.4 Evaluation field bio-efficacy of botanical insecticides against major insect-pests of rice**

Out of more than two dozen of prevailing insect pest fauna, about half of a dozen of them are considered as major insect pests infesting rice in the agro-climatic conditions of the state of Jharkhand. The major insect pests are yellow stem borer, gall midge, hispa, leaf folder, green leaf hopper and ear bug (gundhi bug). Over dependence on use of chemical insecticides for pest management are well known for causing several ill effects viz., pest resurgence, development of insecticide resistance in pest species, environmental hazards like soil, air and water pollution, residue in crop produce and eradication of natural enemies resulting in ecological imbalance etc. Use of some botanicals might be of immense value in pest management without any side effects. There are several commercial formulations of botanical insecticides, available in the market. These botanical insecticides could be highly effective and useful in minimizing the crop loss and step up agricultural production. As such, it is need of the hour to evaluate bio-efficacy of various plant based insecticides as well as that of different formulation of neem based formulations available in the market in order to explore the relevant information in this regards, which could be recommended for ecofriendly management of insect pests in rice.

In the present field experiment, there were ten treatments comprising of seven botanical insecticides and two commonly used chemical insecticide (dinotefuran and rynaxypyr) and one untreated control for comparison of their relative bio-efficacy against major insect pests of rice.

Altogether 4 rounds of foliar spray of aqueous solution of these insecticides starting at 1<sup>st</sup> spray 25 DAT, followed by three sprays at 40, 80 and 95 DAT on need based basis were applied against prevailing major insect pest species. Yellow stem borer (*Scirpophaga incertulas*), gall midge (*Orseolia oryzae*), hispa (*Dicladispa armigera*), leaf folder (*Cnaphalocrosis medinalis*), green leaf hopper (*Nephotettix* spp.) and ear bug (*Leptocorisa oratorius*; *L. acuta*) were found to occur in succession and also in overlapping manner in the rice agro-ecosystem. The observations pertaining to the bio-efficacy of the test insecticides were recorded for the respective pest species.

##### **4.4.1: Effect of botanical insecticides on the incidence of rice hispa (*Dicladispa armigera*) in terms of leaf damage (LDH %)**

The results are presented in (Table -4.4.1). The observations of the leaf damage, caused by hispa, (LDH) were noticed in the middle vegetative stage of the crop. As such, observations on the percentage of leaf damage, due to hispa (LDH %) was recorded at 4, 7 & 10 DAA (days after application) during *kharif* 2016 and 2017. Peak duration of occurrence of hispa was observed almost from 25 DAT and onward period during both of years of the experimentations.

**a) Incidence of leaf damage (LDH) recorded at 4 days after application (4 DAA)**

**i) Incidence of LDH recorded at 4 DAA, during 2016**

At 4 DAA, the experimental data of botanical insecticides used against rice hispa in terms of leaf damage were found to be statistically significant (Table 4.4.1). The minimum leaf damage (0.95% LDH) were found in terms of leaf damage in the treatment comprising of the neem based product Achook (Aza.0.03% EC), which was found superior overall the test insecticides, but it was found to be at par with rynaxypyr 20 SC (1.44% LDH), dinotefuran 20 SG (1.55% LDH) and Neem Baan (Aza.1% EC) (1.80% LDH). The highest leaf damage of 8.26 per cent was observed in case of the unprotected crop of rice (var. IR-64Drt.). However, all the botanical insecticides remained significantly superior over the untreated crop of rice.

**ii) Incidence of LDH recorded at 4 DAA, during 2017**

At 4 DAA, the experimental data of botanical insecticides used against rice hispa in terms of leaf damage (LDH) were found to be statistically significant (Table 4.4.1). The minimum damage of the crop was found in terms of leaf damage (1.57% LDH) in the treatment of Achook (Aza.0.03% EC), which was statistically superior among all the test insecticides, but it was at par with rynaxypyr 20 SC (2.08% LDH), dinotefuran 20 SG (2.20% LDH), Neem Baan (Aza.1% EC) (2.45% LDH) and Neemazal (Aza.1% EC) (2.75% LDH). The highest leaf damage of 9.16 per cent was observed in case of the unprotected crop of rice.

**iii) Pooled mean incidence of LDH recorded at 4DAA, during 2016 and 2017**

The pooled data of insecticides used against rice hispa in terms of leaf damage could be able to realize significant results (Table 4.4.1). The minimum damage was found in terms of leaf damage (1.26%) in the treatment of Achook (Aza.0.03% EC), which in turn remained superior among all the test insecticides, but it was at par with rynaxypyr 20 SC (1.76% LDH) and dinotefuran 20 SG (1.87% LDH) and was followed by Neem Baan (Aza.1% EC) (2.13% LDH), Neemazal (Aza.1% EC) (2.42% LDH) and pongamia oil (2.83% LDH). The highest leaf damage of 8.71 per cent was

observed in the untreated crop of rice. However, all the botanical insecticides remained significantly superior over the untreated crop of rice.

**b) Incidence of leaf damage (LDH) recorded at 7 days after application (7DAA)**

**i) Incidence of LDH recorded at 7DAA, during 2016**

At 7 DAA, the data of insecticides used against rice hispa in terms of leaf damage (LDF) was found to be statistically significant (Table 4.4.1). The minimum leaf damage was found in terms of leaf damage in the treatment consisting of Achook (Aza.0.03% EC) recorded the lowest incidence of leaf damage caused by hispa (1.34% LDH), which remained superior among all the test insecticides, but it was found to be at par with rynaxypyr 20 SC (1.76% LDH) and dinotefuran 20 SG (2.03% LDH), which was followed by Neem Baan (Aza.1% EC) (2.31% LDH), Neemazal (Aza.1% EC) (2.75% LDH) and pongamia oil (3.24% LDH). The highest leaf damage of 9.35 per cent was observed in case of untreated crop of rice.

**ii) Incidence of LDH recorded at 7DAA, during 2017**

At 7 DAA, the experimental data of insecticides used against rice hispa in terms of leaf damage due to hispa (LDH) were found to be significant (Table 4.4.1). The minimum damage was found in terms of leaf damage (1.97% LDH) in the treatment of Achook (Aza.0.03% EC), which was statistically superior among all the test insecticides, but it was at par with rynaxypyr 20 SC (2.78% LDH) and dinotefuran 20 SG (3.02% LDH). The highest leaf damage of 10.12 per cent was observed in case of the unprotected crop of rice.

**iii) Pooled mean incidence of LDH recorded at 7DAA, during 2016 and 2017**

The pooled experimental data of insecticides used against rice hispa in terms of leaf damage (LDH) gave rise to the significant results (Table 4.4.1). The minimum damage of the crop was found in terms of leaf damage (1.66% LDH) in the treatment of Achook (Aza.0.03% EC), which, in turn remained superior over all the test insecticides, but it was at par with rynaxypyr 20 SC (2.27% LDH), dinotefuran 20 SG (2.52% LDH) and Neem Baan (Aza.1% EC) (2.80% LDH). The highest leaf damage of 9.73 per cent was observed in unprotected rice crop. However, all the botanical insecticides remained significantly superior over the untreated crop of rice.

**c) Incidence of leaf damage (LDH) recorded at 10 days after application (10DAA)**

**i) Incidence of LDH recorded at 10DAA, during 2016**

At 10 DAA, the data of insecticides used against rice hispa in terms of leaf damage (LDH) were found to be statistically significant (Table 4.4.1). The minimum damage of the crop was found in terms of leaf damage (1.77% LDH) in the treatment of Achook (Aza.0.03% EC), which remained superior among all the test insecticides, but it was found to be at par with rynaxypyr 20 SC (2.20% LDH), dinotefuran 20 SG (2.47% LDH) and Neem Baan (Aza.1% EC) (2.75% LDH). The highest leaf damage of 10.34 per cent was observed in unprotected crop of rice (var. IR-64Drt.).

**ii) Incidence of LDH recorded at 10DAA, during 2017**

At 10 DAA, the experimental data of insecticides used against rice hispa in terms of leaf damage (LDH) were found to be significant (Table 4.4.1). The minimum leaf damage 2.26 per cent was found in terms of leaf damage in the treatment consisting of Achook (Aza.0.03% EC), which was significantly superior among all the test insecticides, but it was at par with rynaxypyr 20 SC (3.08% LDH) and dinotefuran 20 SG (3.32% LDH). The highest leaf damage of 10.47 per cent was observed in untreated crop of rice.

**iii) Pooled mean incidence of LDH recorded at 10DAA, during 2016 and 2017**

The pooled data of the test insecticides used against rice hispa in terms of leaf damage (LDH) were found to be significant (Table 4.4.1). The minimum damage of rice was found in terms of leaf damage 2.01% LDH in the treatment of Achook (Aza.0.03% EC), which was superior over all the test insecticides, but it was at par with rynaxypyr 20 SC (2.64% LDH) and was followed by dinotefuran 20 SG (2.89% LDH) and Neem Baan (Aza.1% EC) (3.17% LDH). The highest leaf damage of 10.41 per cent was observed in untreated crop. However, all the botanical insecticides remained significantly superior over the untreated crop of rice.

**d) Overall mean of leaf damage (LDH) recorded at 4, 7 and 10 days after application (DAA)**

**i) Mean LDH recorded at 4, 7 and 10 DAA, during 2016**

The overall mean values of three dates of observations (4, 7 & 10 DAA) in terms of the data of insecticides used against rice hispa in the form of leaf damage (LDH) was found to be significant (Table 4.4.1). The minimum damage of rice was found in terms of leaf damage (1.35% LDH) in the treatment comprising of Achook (Aza.0.03% EC), remained superior among all the test insecticides, but it was found to be almost at par with rynaxypyr 20 SC (1.80% LDH) and dinotefuran 20 SG

(2.02% LDH). The highest leaf damage of 9.32 per cent was observed in case of the unprotected crop of rice.

**ii) Mean LDH recorded at 4, 7 and 10 DAA, during 2017**

The overall mean values of three dates of observations (4, 7 & 10 DAA), in the form of the data of insecticides used against rice hispa in terms of leaf damage was found to be significant. The minimum damage of the crop was found in terms of leaf damage (1.93%) in the treatment of Achook (Aza.0.03% EC), which was statistically superior among all the test insecticides, but it was at par with rynaxypyr 20 SC (2.65% LDH) and dinotefuran 20 SG (2.84% LDH). The highest leaf damage of 9.92 per cent was observed in unprotected crop of rice.

**iii) Overall pooled mean LDH recorded at 4, 7 and 10 DAA, during 2016 and 2017**

The overall mean values of three dates of observations (4, 7 & 10 DAA), pooled data of insecticides used against rice hispa in terms of leaf damage was gave rise to the significant results (Table 4.4.1). The minimum damage of the crop was found in terms of leaf damage (1.64%) in the treatment comprising of Achook (Aza.0.03% EC), which, in turn, was superior among all the test insecticides, but it was at par with rynaxypyr 20 SC (2.22% LDH) and was followed by dinotefuran 20 SG (2.43% LDH) and Neem Baan (Aza.1% EC) (2.70% LDH). The highest leaf damage of 9.62 per cent was observed in case of the untreated crop. However, all the botanical insecticides remained significantly superior over the untreated crop of rice. Earlier, very few scientists evaluated the bioefficacy of different botanical insecticide against hispa in rice at different locations of the country. The present findings are in close agreement with Kaul and Sharma (1999) who reported that all the test neem formulations viz. Neemazal, Neemaz, Neemgold, Econeem and Fortune were statistically at par with a chemical insecticide, chlorpyrifos in reducing the incidence of major pests viz. stem borer, hispa and leaf folder. Roy *et al.*, (2017) also similar results almost in the line of the finding of the present studies indicating overall leaf infestation by rice hispa and infestation by adults and grubs separately were recorded at different time intervals. In addition to these, the overall effect of pest infestation on the grain yield of rice was also examined. Among the six botanicals, Neem oil was most effective in controlling rice hispa, as overall leaf infestation was 21.20% and the infestation by adults and grubs were 14.43% and 12.57%. On the other hand, among chemical insecticides, maximum efficacy was found under the treatment of Sevin 85SP where minimum leaf infestation was 9.22 per cent, infestation by adults and

grubs were 5.88% and 5.00% respectively. In the case of yield, Sevin 85SP (4.62 ton/ha) showed the best efficacy in comparison to other treatments. Therefore, application of Sevin 85SP (3.46ml/L) and Neem oil (2ml/100ml) were found as the best options in controlling rice hispa. So, it could be recommended to use Sevin 85 SP and Neem oil for the management of rice hispa. This finding also endorsed the results of the present studies.

**4.4.2: Effect of botanical insecticides on the incidence of yellow stem borer (*Scirpophaga incertulas* Walker) in terms of dead heart (DH %)**

Results are shown in (Table-4.4.2). The observations on the incidence of dead heart (DH), due to attack of YSB on rice (var. IR-64) were recorded in the vegetative stage of the crop at 4, 7 & 10 days after application (DAA) of the test insecticides during, 2016 and 2017. Peak duration of occurrence of yellow stem borer (DH) was observed almost from 40 DAT and onward period during both of years of the experimentations.

**a) Incidence of dead heart (DH) recorded at 4 days after application (4 DAA)**

**i) Incidence of DH recorded at 4 DAA, during 2016**

The observation on the incidence of dead heart (DH) caused by yellow stem borer was recorded at 4 DAA (days after application), results are shown in Table 4.4.2. The bio-efficacy of seven botanical and two chemical insecticides, almost the lowest incidence of dead heart (DH) was registered in case of Achook (Aza.0.03% EC) with 0.97 per cent DH, which was superior among all the other test botanical insecticides, and followed by rynaxypyr 20 SC with 1.50 per cent DH, dinotefuran 20 SG (1.62% DH) and Neem Baan (Aza.1% EC) (1.83% DH). However, all the test botanical insecticides remained significantly superior over the untreated control, which received the highest incidence of dead hearts amounting to the tune of 8.14 per cent recorded at 4 DAA in untreated crop of rice (var. IR-64Drt.).

**ii) Incidence of DH recorded at 4 DAA, during 2017**

In the second year experiment, the observation on the incidence of dead heart (DH) caused by yellow stem borer was noticed at 4 DAA. Results are shown in Table 4.4.2. So far the bio-efficacy of the seven botanical insecticides and two chemical insecticide is considered, almost the lowest incidence of dead heart (DH) was registered in Achook (Aza.0.03% EC) with 1.59 per cent DH, which appeared to be superior among almost all the test insecticides, but it was at par with rynaxypyr 20 SC (2.13% DH) and dinotefuran 20 SG (2.20% DH) and followed by Neem Baan

(Aza.1% EC) (2.43% DH), Neemazal (Aza.1% EC) (2.75% DH), pongamia oil (2.99% DH) and Nimbecidine (Aza.0.03% EC) (3.27% DH). However, all the botanical insecticides remained significantly superior over the untreated control, which received the highest incidence of dead hearts amounting to the tune of 8.42 per cent recorded at 4 DAA in unprotected crop.

**iii) Pooled mean incidence of DH recorded at 4 DAA, during 2016 and 2017**

The mean of two years observation on the incidence of dead heart (DH) caused by yellow stem borer was registered at 4 DAA. Results are shown in Table 4.4.2. The bio-efficacy of the seven botanical insecticides and two chemical insecticides, almost the lowest incidence of dead heart (DH) was recorded in Achook (Aza.0.03% EC) with 1.28 per cent DH, which was superior among almost all the test botanical insecticides, and followed by rynaxypyr 20 SC with 1.82 per cent DH, dinotefuran 20 SG (1.91% DH) and Neem Baan (Aza.1% EC) (2.13% DH). However, all the botanical insecticides remained significantly superior over the unprotected crop, which received the highest incidence of dead hearts amounting to the tune of 8.28 per cent recorded at 4 DAA in untreated crop.

**b) Incidence of dead heart (DH) recorded at 7 days after application (7 DAA)**

**i) Incidence of DH recorded at 7 DAA, during 2016**

The impact of botanical insecticides after spray on incidence of dead heart due to yellow stem borer at 7 DAA indicated that the results remained significant and as such, rice plats treated with Achook (Aza.0.03 % EC) recorded the lowest dead heart 1.91 per cent, which was superior among almost all the test insecticides, but it was at par with rynaxypyr 20 SC (2.51 % DH) and dinotefuran 20 SG (2.68% DH) and followed by Neem Baan (Aza.1% EC), Neemazal (Aza.1% EC), pongamia oil and Nimbecidine (Aza.0.03% EC) which recorded 2.88, 3.13, 3.25 and 3.37 per cent dead hearts respectively. The highest dead heart damage of 9.44 per cent was observed in case of the unprotected crop. However, all the botanical insecticides remained significantly superior over the untreated control.

**ii) Incidence of DH recorded at 7 DAA, during 2017**

The impact of botanical insecticides after spray on dead heart due to yellow stem borer at 7 DAA indicated that the result remained significant and as such, Achook (Aza.0.03% EC) recorded the lowest dead heart (2.48%), which was superior among almost all the test insecticides, but it was at par with rynaxypyr 20 SC (3.08 % DH) and dinotefuran 20 SG (3.25% DH) and Neem Baan (Aza.1% EC) (3.45% DH).

The highest dead heart incidence of 9.67 per cent was observed in case of the unprotected crop. However, all the test botanical insecticides remained significantly superior over the untreated control.

**iii) Pooled mean incidence of DH recorded at 7 DAA, during 2016 and 2017**

The two years mean outcome of botanical insecticides after spray on dead heart due to yellow stem borer at 7 DAA indicated that the results remained significant and as such, Achook (Aza.0.03% EC) recorded the lowest dead heart 2.20 , which was superior among almost all the test insecticides, and followed by rynaxypyr 20 SC (2.80 % DH), dinotefuran 20 SG (2.97% DH) and Neem Baan (Aza.1% EC) (3.17% DH) The highest dead heart damage of 9.56% was observed in case of the unprotected crop. However, all the botanical insecticides remained significantly superior over the untreated control.

**c) Incidence of dead heart (DH) recorded at 10 days after application (10 DAA)**

**i) Incidence of DH recorded at 10 DAA, during 2016**

The results on impact of the botanical insecticides after spray on dead heart due to yellow stem borer at 10DAA (Table 4.4.2) indicated that the result remained significant and as such, Achook (Aza.0.03% EC) recorded the lowest dead heart (2.86%), which was superior among all the test insecticides, but it was at par with the chemical insecticide i.e. rynaxypyr 20 SC (3.46 % DH) and dinotefuran 20 SG (3.74% DH) and followed by Neem Baan (Aza.1% EC), Neemazal (Aza.1% EC), pongamia oil and Nimbecidine (Aza.0.03% EC) which recorded 4.06, 4.40, 4.72 and 5.11per cent dead hearts, respectively. The highest dead heart damage of 10.99 per cent was observed in unprotected crop. However, all the test botanical insecticides remained significantly superior over the unprotected crop of rice in respect of reducing the incidence of dead heart caused by YSB.

**ii) Incidence of DH recorded at 10 DAA, during 2017**

The effect of the test botanical insecticides on the incidence of dead heart due to yellow stem borer at 10DAA (Table 4.4.2) remained statistically significant and as such, rice plants treated with Achook (Aza.0.03% EC) recorded the lowest dead heart (3.43%), which was superior among all the test insecticides, but it was at par with rynaxypyr 20 SC (4.03 % DH), dinotefuran 20 SG (4.31% DH) and Neem Baan (Aza.1% EC) (4.63% DH). The highest dead heart damage of 11.56 per cent was observed in case of the unprotected crop. However, all the test botanical insecticides remained significantly superior over the untreated control.

**iii) Pooled mean incidence of DH recorded at 10 DAA, during 2016 and 2017**

The two year mean outcome of botanical insecticides after spray on dead heart due to yellow stem borer at 10DAA (Table 4.4.2) indicated that the result remained significant and as such, Achook (Aza.0.03% EC) recorded the lowest dead heart (3.14%), which was superior among all the test insecticides, but it was at par with rynaxypyr 20 SC (3.75% DH) and followed by dinotefuran 20 SG (4.02% DH), Neem Baan (Aza.1% EC) (4.34% DH) and Neemazal (Aza.1% EC) (4.68% DH). The highest dead heart damage of 11.27 per cent was observed in case of the unprotected crop. However, all the test botanical insecticides remained significantly superior over the untreated control.

**d) Overall mean of dead heart (DH) recorded at 4, 7 and 10 days after application (DAA)**

**i) Mean of DH recorded at 4, 7 and 10 DAA, during 2016**

Based on the dead heart incidence in terms of mean of three (4, 7 & 10 DAA) observational dates, the treatment effect was found to be significant. As such, Achook (Aza.0.03% EC) recorded the lowest dead heart (1.91%), which was superior among all the test insecticides, but it was at par with rynaxypyr 20 SC (2.49% DH) and followed by dinotefuran 20 SG (2.68% DH), Neem Baan (Aza.1% EC) (2.92% DH) and Neemazal (Aza.1% EC) (3.22% DH). The highest dead heart damage of 9.52 per cent was observed in case of the unprotected crop. However, all the botanical insecticides remained significantly superior over the untreated control.

**ii) Mean of DH recorded at 4, 7 and 10 DAA, during 2017**

In the second year, dead heart incidence in terms of mean of three (4, 7 & 10 DAA) observational dates, the treatment effect was found to be significant. As such, Achook (Aza.0.03% EC) recorded the lowest dead heart 2.50 per cent, which was superior among all the test insecticides, but it was at par with rynaxypyr 20 SC (3.08% DH) and dinotefuran 20 SG (3.26% DH) and followed by Neem Baan (Aza.1% EC) (3.51% DH), Neemazal (Aza.1% EC) (3.83% DH), pongamia oil (4.04% DH) and Nimbecidine (Aza.0.03% EC) (4.29% DH). The highest dead heart damage of 9.88 per cent was observed in case of the unprotected crop. However, all the botanical insecticides remained significantly superior over the untreated control.

**iii) Pooled mean of DH recorded at 4, 7 and 10 DAA, during 2016 and 2017**

Overall mean results of two years experiment (Table 4.4.2) indicated that the insecticidal treatments remained statistically significant. The rice plant treated with

the botanical insecticides after spray on dead heart due to yellow stem borer indicated that the result remained significant and as such, Achook (Aza.0.03% EC) recorded the lowest dead heart of 2.21 per cent, which was superior among all the test insecticides, but it was at par with rynaxypyr 20 SC (2.79% DH) and followed by dinotefuran 20 SG (2.97% DH) and Neem Baan (Aza.1% EC) (3.22% DH). However, all the botanical insecticides remained significantly superior over the untreated control. The highest dead heart damage of 9.70 per cent was observed in case of the untreated crop of rice (var. IR-64Drt.) in the present studies.

#### **4.4.3: Effect of certain botanicals based insecticides on the incidence of yellow stem borer (*Scirpophaga incertulas* Walker) in terms of white ear (WE %)**

The results obtained during, 2016 and 2017 on the observation recorded on the incidence of the white ear (WE) caused by yellow stem borer at dough stage & pre-maturity stage of the crop are shown in Table-4.4.3. Peak duration of occurrence of yellow stem borer (WE) was observed almost from 95 DAT and onward period during both of years of the experimentations.

##### **a) Incidence of white ear (WE) recorded at dough stage**

###### **i) Incidence of WE recorded at dough stage, during 2016**

The perusal of data revealed that all the treatments were found significantly superior over untreated control with regard to white ear head infestation caused by rice yellow stem borer. The experimental results indicated that Achook (Aza.0.03% EC) (2.51% WE) proved to be the most effective in reducing the incidence of white ear head and rynaxypyr 20 SC (3.02% WE) and dinotefuran 20 SG (3.28% WE) remained at par in suppressing the incidence of white ear whereas untreated control received the highest incidence of white ear (WE) amounting to the tune of 10.74 per cent recorded at dough stage of rice.

###### **ii) Incidence of WE recorded at dough stage, during 2017**

A perusal of results pertaining to the bio-efficacy of botanical insecticides indicated that almost the lowest incidence of white ear (WE) was registered in rice plants treated with Achook (Aza.0.03% EC) (3.08% WE), which was superior among all the test insecticides, but it was at par with rynaxypyr 20 SC with 3.59 per cent WE, dinotefuran 20 SG (3.85% WE) and Neem Baan (Aza.1% EC) (4.17% WE). However, all the botanical insecticides remained significantly superior over the untreated control, receiving the highest incidence of the white ear (WE) amounting to

the tune of 11.31 per cent recorded at dough stage in untreated crop of rice (var. IR-64Drt.).

**iii) Pooled mean incidence of WE recorded at dough stage, during 2016 and 2017**

The plants treated with the Achook (Aza.0.03% EC) received the minimum incidence of white ear (2.80%), which was superior to almost among all the test insecticides, but it was at par with rynaxypyr 20 SC (3.30% WE), and followed by dinotefuran 20 SG (3.57% WE), Neem Baan (Aza.1% EC) (3.89% WE) and Neemazal (Aza.1% EC) (4.22% WE). However, all the botanical insecticides remained significantly superior over the untreated control, receiving the highest incidence of the white ear (WE) amounting to the tune of 11.03 per cent recorded at dough stage in untreated crop of rice (var. IR-64Drt.).

**b) Incidence of white ear (WE) recorded at pre-maturity stage**

**i) Incidence of WE recorded at pre-maturity stage, during 2016**

The effect of botanical insecticides, on the incidence white ear due to yellow stem borer at pre-maturity stage was found to be statistically significant and as such, the Achook (Aza.0.03% EC) recorded the lowest incidence of white ear head to the tune of 3.26 per cent, which appeared to be superior among all the test insecticides, but it was at par with rynaxypyr 20 SC (3.75% WE), dinotefuran 20 SG (4.03% WE), Neem Baan (Aza.1% EC) (4.33% WE) and Neemazal (Aza.1% EC) (4.68% WE). The highest incidence of white ear damage of 12.32 per cent was observed in untreated plot.

**ii) Incidence of WE recorded at pre-maturity stage, during 2017**

The effect of botanical insecticides on the incidence the per cent white ear (WE) due to yellow stem borer at pre-maturity stage also remained significant. The rice plants treated with Achook (Aza.0.03% EC) recorded the lowest incidence of white ear head to the tune of 4.10 per cent, which appeared to be superior among all the test insecticides, but it was at par with rynaxypyr 20 SC (4.58% WE), dinotefuran 20 SG (4.86% WE), Neem Baan (Aza.1% EC) (5.17% WE) and Neemazal (Aza.1% EC) (5.51% WE). The highest incidence of white ear (13.15%) was observed in unprotected crop.

**iii) Pooled mean incidence of WE recorded at pre-maturity stage, during 2016 and 2017**

The pooled data pertaining to the effect of botanical insecticides on the incidence of white ear due to yellow stem borer at pre-maturity stage gave rise to the

significant results and the plants treated with the Ahook (Aza.0.03% EC) recorded the lowest incidence of white ear head to the tune of 3.68 per cent, which appeared to be superior among all the test insecticides, but it was at par with rynaxypyr 20 SC (4.17% WE) and dinotefuran 20 SG (4.44% WE), and followed by Neem Baan (Aza.1% EC) (4.75% WE), Neemazal (Aza.1% EC) (5.09% WE) and pongamia oil (5.48% WE). The highest incidence of white ear damage of (12.73%) was observed in case of the unprotected crop. However, all the botanical insecticides remained significantly superior over the untreated control plot.

**c) Overall mean of white ear (WE) recorded at dough stage and pre-maturity stage**

**i) Mean of WE recorded at dough stage and pre-maturity stage, during 2016**

The effect of botanical insecticides on the incidence of white ear in terms of mean of two observations (dough & pre-maturity stage) was found to be significant. The results are shown in Table 4.4.3. it was found that rice plants treated with the Ahook (Aza.0.03% EC) received the lowest incidence of white ear head to the tune of 2.89 per cent, which appeared to be superior among all the test insecticides, but it was at par with rynaxypyr 20 SC (3.38% WE), dinotefuran 20 SG (3.65% WE) and Neem Baan (Aza.1% EC) (3.97% WE). The highest white ear damage (11.53%) was observed in case of untreated control plot.

**ii) Mean of WE recorded at dough stage and pre-maturity stage, during 2017**

The effect of insecticides the incidence of white ear due to yellow stem borer based on the mean observations of two dates (dough & pre-maturity stage) gave rise to the significant results and the rice plants treated with Ahook (Aza.0.03% EC) recorded the minimum incidence of white ear (3.59%), which was superior to almost all the test insecticides, but it was at par with rynaxypyr 20 SC (4.09% WE), dinotefuran 20 SG (4.36% WE) and Neem Baan (Aza.1% EC) (4.67% WE). The highest white ear damage of 12.23 per cent was observed in the untreated control plot.

**iii) Pooled mean of WE recorded at dough stage and pre-maturity stage, during 2016 and 2017**

The data received in the form of the overall mean of white ear head recorded at the dough and pre-maturity stage of the crop, of 2016 and 2017 are presented in Table 4.4.3. The experimental data remained significant, the rice plants kept under the protection with Ahook (Aza.0.03% EC) resulted to the minimum incidence of white ear (3.24%), which was superior to almost all the test insecticides, but it was at par

with rynaxypyr 20 SC (3.73% WE) and followed by dinotefuran 20 SG (4.00% WE), Neem Baan (Aza.1% EC) (4.32% WE) and Neemazal (Aza.1% EC) (4.66% WE). The highest white ear damage of 11.88 per cent was observed in case of the untreated crop of rice (var. IR-64Drt.). However, all the botanical insecticides remained significantly superior over the untreated control plot.

Various workers evaluated the efficacy of botanical insecticide against yellow stem borer in rice at certain few locations of the country. The findings of the present investigation are agreement with the findings of Kaul and Sharma (1999) who reported that neem formulations viz. Nimbecidine, Neemark, Neem Gold, Econeem, Neemzal and Fortune were statistically at par with chlorpyrifos in terms of suppression in the incidence of stem borer, hispa and leaf folder infesting rice varieties, Kasturi and Basmati. They found that significantly higher grains yield (30-31 q/ha) were obtained in treated plots as compared to 28 q/ha in the untreated plots. The similar observations were also obtained by Dhaliwal *et al.*, (2002) which indicated that the minimum incidence of dead heart and white ear (WE) was obtained with monocrotophos which remained at par with Neemzal resulting in higher grain's yield almost in the similar trends to that of the finding of the present studies indicating grain's yield of 50.50 q/ha in case of monocrotophos followed by 46.40 q/ha through foliar spray with Neemazal as compared with the lowest grains yield (34.30 q/ha) in case of untreated control. Earlier the results on botanical insecticides obtained by Chakraborty *et al.*, (2011) on yellow stem borer were found to fall in line with those of findings of the present investigation indicating that maximum efficacy, against the major prevailing pest species was registered in case of monocrotophos followed by carbofuran, nimbecidine, *B. thuringiensis*, NSKE, NLE, mahua oil, neem oil, KSKE, *V. negundo* and plant mixture in descending order. The results on the efficacy of botanical insecticide obtained through the present studies are also in the line of that of revealed in neem extracts reduced dead heart and white head by 38.38 and 58.08 respectively. Considering the efficacy and eco-friendly nature of neem extract it could be considered as an effective botanical insecticide in the successful management of the pest yellow rice stem borer (Islam *et al.*, 2013). These findings have also endorsed the results of the present studies.

**4.4.4: Effect of botanical insecticides on the incidence of gall midge (*Orseolia oryzae* Wood Mason) in terms of silver shoots (SS %)**

Results are shown in Table-4.4.4. The observations on the incidence of gall midge in terms of the silver shoot (SS) were recorded at 4, 7 & 10 days after application (DAA) of botanical insecticide treatments, during *khari*f 2016 & 2017. Peak duration of occurrence of gall midge (bio-type-3) was observed almost from 40 DAT and onward period during both of years of the experimentations.

**a) Incidence of silver shoots (SS) recorded at 4 days after application (4 DAA)**

**i) Incidence of SS recorded at 4 DAA, during 2016**

At 4 DAA, the data on the incidence of gall midge in terms of the silver shoot (SS) as influenced by different test treatments were found to be statistically significant. The lowest incidence of silver shoot (1.01% SS) was recorded in case of Achook (Aza.0.03% EC), which was superior to almost all the test insecticides and which was followed by rynaxypyr 20 SC (1.76% SS), dinotefuran 20 SG (1.90% SS) and Neem Baan (Aza.1% EC) (2.21% SS). The highest incidence of silver shoot (10.11%) was observed in case of the unprotected crop of rice (var. IR-64Drt.).

**ii) Incidence of SS recorded at 4 DAA, during 2017**

At 4 DAA, the data of botanical insecticides used against gall midge in terms of the silver shoot (SS) gave rise to the significant results (Table 4.4.4). The minimum damage was found in terms of silver shoot in the treatments comprising of Achook (Aza.0.03% EC) recorded the lowest incidence of silver shoot (1.39% SS), which in turn, remained superior among all the test insecticides, but it was at par with rynaxypyr 20 SC (2.16% SS) and which was followed by dinotefuran 20 SG (2.31% SS), Neem Baan (Aza.1% EC) (2.62% SS) and Neemazal (Aza.1% EC) (3.06% SS). The highest incidence of silver shoot (10.81%) was observed in unprotected crop of rice (var. IR-64Drt.).

**iii) Pooled mean incidence of SS recorded at 4 DAA, during 2016 and 2017**

The two years of pooled data of botanical insecticides used against gall midge in terms of the silver shoot (SS) recorded significant results (Table 4.4.4). The minimum silver shoot was found in case of rice plants grown under the protection of Achook (Aza.0.03% EC) recorded the lowest incidence of silver shoot (1.20% SS), which, in turn, remained superior among all test insecticides that was followed by rynaxypyr 20 SC (1.96% SS), dinotefuran 20 SG (2.10% SS) and Neem Baan

(Aza.1% EC) (2.42% SS). The highest silver shoot damage of 10.46 per cent was observed in unprotected crop of rice.

**b) Incidence of silver shoots (SS) recorded at 7 days after application (7 DAA)**

**i) Incidence of SS recorded at 7 DAA, during 2016**

At 7 DAA, the data of botanical insecticides used against gall midge in terms of the silver shoot (SS) gave rise to the significant results (Table 4.4.4). The minimum incidence of gall midge in terms of silver shoot in the treatments comprising of Ahook (Aza.0.03% EC) received minimum SS (1.70%), which was superior to almost all the test insecticides, but it was at par with rynaxypyr 20 SC (2.45% SS) and dinotefuran 20 SG (2.70% SS) which was followed by Neem Baan (Aza.1% EC) (2.98% SS), Neemazal (Aza.1% EC) (3.32% SS), pongamia oil (3.49% SS) and Nimbecidine (Aza.0.03% EC) (3.65% SS). The highest incidence silver shoot 11.69% was observed in the untreated crop of rice.

**ii) Incidence of SS recorded at 7 DAA, during 2017**

At 7 DAA, the data of botanical insecticides used against gall midge in terms of the silver shoot (SS) gave rise to the significant results (Table 4.4.4). The minimum damage of rice was found in terms of silver shoot in the treatment comprising of Ahook (Aza.0.03% EC) received minimum SS (1.94%), which was superior to almost all the test insecticides, but it was at par with rynaxypyr 20 SC (2.81% SS) followed by dinotefuran 20 SG (3.06% SS), Neem Baan (Aza.1% EC) (3.35% SS), Neemazal (Aza.1% EC) (3.70% SS), pongamia oil (3.88% SS) and Nimbecidine (Aza.0.03% EC) (4.05% SS). The highest silver shoot of 12.90 per cent was observed in the untreated crop of rice.

**iii) Pooled mean incidence of SS recorded at 7 DAA, during 2016 and 2017**

The two years of pooled data of botanical insecticides used against gall midge in terms of the silver shoot (SS) recorded significant results (Table 4.4.4). The minimum damage of rice was found in terms of the silver shoot in the treatment comprising of Ahook (Aza.0.03% EC) recorded the lowest incidence of silver shoot (1.82% SS), which in turn, remained was superior among all test insecticides and which was followed by the rynaxypyr 20 SC (2.63% SS), dinotefuran 20 SG (2.88% SS) and Neem Baan (Aza.1% EC) (3.16% SS). The highest silver shoot of 12.29 per cent was observed in the unprotected crop of rice.

**c) Incidence of silver shoots (SS) recorded at 10 days after application (10 DAA)**

**i) Incidence of SS recorded at 10 DAA, during 2016**

At 10 DAA, the data of botanical insecticides used against gall midge in terms of the silver shoot (SS) gave rise to the significant results (Table 4.4.4). The minimum damage of rice was found in terms of silver shoot in the treatment comprising of Ahook (Aza.0.03% EC) which recorded the lowest incidence of silver shoot (2.56% SS), which in turn, remained superior to almost all the test insecticides, but it was at par with rynaxypyr 20 SC (3.41% SS) which was followed by dinotefuran 20 SG (3.79% SS), Neem Baan (Aza.1% EC) (4.24% SS), Neemazal (Aza.1% EC) (4.72% SS), pongamia oil (5.17% SS). The highest incidence of silver shoot (12.57%) was observed in case of the crop which was left untreated crop of rice.

**ii) Incidence of SS recorded at 10 DAA, during 2017**

At 10 DAA, the data of botanical insecticides used against gall midge in terms of the silver shoot (SS) gave rise to the significant results (Table 4.4.4). The minimum damage of the crop was found in terms of silver shoot in the treatment comprising of Ahook (Aza.0.03% EC) which recorded the lowest incidence of silver shoot (4.97% SS) that, in turn, was superior among all the test insecticides, but it was at par with rynaxypyr 20 SC (5.84% SS), dinotefuran 20 SG (6.24% SS) and Neem Baan (Aza.1% EC) (6.71% SS). The highest incidence silver shoot (14.24%) was observed in the untreated crop of rice.

**iii) Pooled mean incidence of SS recorded at 10 DAA, during 2016 and 2017**

The pooled data of botanical insecticides used against gall midge in terms of the silver shoot (SS) recorded significant results (Table 4.4.4). The minimum damage of rice was found in terms of silver shoot in the treatment comprising of Ahook (Aza.0.03% EC) recorded the lowest incidence of silver shoot (3.77% SS), which was superior among all insecticides, but it was at par with rynaxypyr 20 SC (4.63% SS) followed by dinotefuran 20 SG (5.02% SS), Neem Baan (Aza.1% EC) (5.48% SS) and Neemazal (Aza.1% EC) (5.96% SS). The highest incidence of silver shoot (13.41%) was observed in the unprotected crop of rice.

**d) Overall mean of silver shoot (SS) recorded at 4, 7 and 10 days after application (DAA)**

**i) Mean of SS recorded at 4, 7 and 10 DAA, during 2016**

The overall mean values of silver shoot of three dates of observations (4, 7 & 10 DAA), in terms of the data of botanical insecticides were found to be significant (Table 4.4.4). The minimum damage of the crop was found in terms of silver shoot in the treatment comprising of Ahook (Aza.0.03% EC) received the lowest incidence of

silver shoot (1.76% SS), which was superior among all the test insecticides followed by rynaxypyr 20 SC (2.54% SS), dinotefuran 20 SG (2.80% SS) and Neem Baan (Aza.1% EC) (3.14% SS). The highest incidence of silver shoot (11.46%) was observed in case of untreated crop of rice.

**ii) Mean of SS recorded at 4, 7 and 10 DAA, during 2017**

The overall mean values of three dates observations (4, 7 & 10 DAA) in terms of the data of botanical insecticides used against gall midge in terms of the silver shoot (SS) recorded significant results (Table 4.4.4). The minimum damage of rice was found in terms of silver shoot in the treatment of Achook (Aza.0.03% EC) recorded the lowest incidence of silver shoot (2.77% SS), which was superior among all the test insecticides, but it was at par with rynaxypyr 20 SC (3.60% SS) and followed by dinotefuran 20 SG (3.87% SS), Neem Baan (Aza.1% EC) (4.23% SS) and Neemazal (Aza.1% EC) (4.65% SS). The highest silver shoot damage of 12.45 per cent was observed in the untreated crop of rice.

**iii) Overall pooled mean of SS recorded at 4, 7 and 10 DAA, during 2016 and 2017**

The overall pooled mean values of three dates observations (4, 7 & 10 DAA), in the form of the data of botanical insecticides used against gall midge in terms of the silver shoot (SS) recorded significant results (Table 4.4.4). The minimum damage of rice was found in terms of silver shoot in the treatment comprising of Achook (Aza.0.03% EC) recorded the lowest incidence of silver shoot (2.26% SS), which it was superior among all insecticides and that was followed by rynaxypyr 20 SC (3.07% SS) and dinotefuran 20 SG (3.33% SS). The highest incidence of silver shoot (12.05%) was observed in the untreated control plot. However, all the botanical insecticides remained significantly superior over the untreated crop of rice.

Various workers evaluated the bioefficacy of different botanical insecticides against gall midge in rice at different locations. The findings of the present investigation are in close agreement with the results of Mahalingam (1984) who recorded that neem oil (5.0%) used as foliar spray could be able cause significant reduction of gall midge infestation in rice. The similar observations were also reported in Anonymous 2015 (AICRIP), the result reported from the different AICRIP center, gall midge infestation was high at Jagdalpur which ranged from 33.2 to 53.5% SS across treatments and 68.5% SS control at 50 DAT. At other locations, the SS damage varied between 1.2 and 24.6%SS. There was a significant difference in the

efficacy of the treatments at 3 locations viz., Jagdalpur, Sambalpur and Titabar. However, mean infestation over 6 locations was at par in all the treatments except Neembaan (9.8 to 10.8% SS) and they were significantly superior to control (18.3%SS). The present findings are in close agreement with Anonymous 2016 (AICRIP) as they reported that the result was from the different AICRIP center, the SS damage varied between 1.03-13.03% SS in treatments and 6.13 to 20.10% SS in control. There were significant differences in the efficacy of the treatments at 5 locations. Among botanical treatments, the lowest mean infestation was recorded in Neemazal (8.4%SS) and the efficacy was on par with insecticides and significantly superior to control (14.70%SS). This finding also endorsed the results of the present studies.

**4.4.5: Effect of botanical insecticides on the incidence of leaf folder (*Cnephalocrosis medinalis*) in terms of leaf damage (LDLF %)**

The results are presented in Table -4.4.5. The observations of the leaf damage, caused by leaf folder, (LDLF) were noticed in the late vegetative stage to pre-maturity stage of the crop. As such, observations on the percentage of leaf damage, due to leaf folder (LDLF %) was recorded at 4, 7 & 10 DAA (days after application) during *Kharif* 2016 and 2017. Peak duration of occurrence of leaf folder was observed almost from 80 DAT and onward period during both of years of the experimentations.

**a) Incidence of leaf damage (LDLF) recorded at 4 days after application (4 DAA)**

**i) Incidence of LDLF recorded at 4 DAA, during 2016**

The effect of the test botanical insecticides used against leaf folder in terms of leaf damage was found to be significant. The minimum damage of the crop was found in terms of leaf damage (2.22%) in the treatment of Achook (Aza.0.03% EC), which was found to be superior over all the test insecticides, but it was at par with rynaxypyr 20 SC (2.78% LDLF), dinotefuran 20 SG (3.05% LDLF), Neem Baan (Aza.1% EC) (3.36% LDLF) and Neemazal (Aza.1% EC) (3.89% LDLF). The highest leaf damage of 13.84 per cent was observed in case of the untreated crop of rice.

**ii) Incidence of LDLF recorded at 4 DAA, during 2017**

The effects of the all test botanical insecticides on the incidence of leaf folder in terms of leaf damage were found to be significant. The minimum damage of the crop was found in terms of leaf damage (2.19%) in the treatment consisting the of Achook (Aza.0.03% EC) which remained superior over all the test insecticides, but it was at par with rynaxypyr 20 SC (3.33% LDLF), dinotefuran 20 SG (3.55% LDLF)

and Neem Baan (Aza.1% EC) (4.02% LDLF). The highest leaf damage of 16.40 per cent was observed in case of the untreated crop of rice.

**iii) Pooled mean incidence of LDLF recorded at 4 DAA, during 2016 and 2017**

A perusal of the pooled data of the all test botanical insecticides used against leaf folder in terms of leaf damage was found to be significant (Table 4.4.5). The minimum damage (2.20%) was found in terms of leaf damage in the treatment comprising of Achook (Aza.0.03% EC), which was found to be superior among all the test insecticides, but it was at par with rynaxypyr 20 SC (3.06% LDLF) and dinotefuran 20 SG (3.30% LDLF), in turn, which was followed by Neem Baan (Aza.1% EC) (3.69% LDLF) and Neemazal (Aza.1% EC) (4.28% LDLF) and pongamia oil (4.95% LDLF). The highest leaf damage of 15.15 per cent was observed in case of the unprotected crop of rice. However, all the botanical insecticides remained significantly superior over the untreated crop of rice.

**b) Incidence of leaf damage (LDLF) recorded at 7 days after application (7 DAA)**

**i) Incidence of LDLF recorded at 7 DAA, during 2016**

The effect of the test insecticides used against leaf folder in terms of leaf damage remained significant (Table 4.4.4). The minimum damage of the crop were found in terms of leaf damage (3.55%) in the treatment comprising of Achook (Aza.0.03% EC), which, in turn, was superior over all the test insecticides, but it was at par with rynaxypyr 20 SC (4.11% LDLF), dinotefuran 20 SG (4.38% LDLF), Neem Baan (Aza.1% EC) (4.69% LDLF), Neemazal (Aza.1% EC) (5.22% LDLF) and pongamia oil (5.73% LDLF).. The highest leaf damage of 18.51per cent was observed in case of the untreated crop of rice.

**ii) Incidence of LDLF recorded at 7 DAA, during 2017**

The effects of insecticides on the incidence of leaf folder in terms of leaf damage gave rise to the significant results (Table 4.4.4). The minimum damage were found in terms of leaf damage (3.87%) in the treatment with Achook (Aza.0.03% EC), which was superior over all the test insecticides, but it was at par with rynaxypyr 20 SC (4.97% LDLF), dinotefuran 20 SG (5.17% LDLF), Neem Baan (Aza.1% EC) (5.62% LDLF) and Neemazal (Aza.1% EC) (6.24% LDLF). The highest leaf damage of 16.51 per cent was observed in case of unprotected crop of rice.

**iii) Pooled mean incidence of LDLF recorded at 7 DAA, during 2016 and 2017**

A perusal of the pooled data of the test insecticides against leaf folder in terms of leaf damage was found to be significant. The minimum damage (3.71%) was found

in terms of leaf damage in the treatments comprising of Achook (Aza.0.03% EC), which was superior over all the test insecticides, but it was at par with rynaxypyr 20 SC (4.54% LDLF), dinotefuran 20 SG (4.78% LDLF) and Neem Baan (Aza.1% EC) (5.16% LDLF). The highest leaf damage of 17.51 per cent was observed in case of the untreated crop. However, all the botanical insecticides remained significantly superior over the untreated crop of rice.

**c) Incidence of leaf damage (LDLF) recorded at 10 days after application (10 DAA)**

**i) Incidence of LDLF recorded at 10 DAA, during 2016**

The effects of insecticides against leaf folder in terms of leaf damage were found to be significant. The minimum damage of the crop was found in terms of leaf damage (4.90%) in the treatment comprising of Achook (Aza.0.03% EC), which in turn, remained superior over all the test insecticides, but it was at par with rynaxypyr 20 SC (5.46% LDLF), dinotefuran 20 SG (5.73% LDLF), Neem Baan (Aza.1% EC) (6.04% LDLF), Neemazal (Aza.1% EC) (6.57% LDLF), pongamia oil (7.07% LDLF) and Nimbecidine (Aza.0.03% EC) (7.42% LDLF). The highest leaf damage of 19.85 per cent was observed in case of unprotected crop.

**ii) Incidence of LDLF recorded at 10 DAA, during 2017**

The effect of insecticides on the incidence of leaf folder in terms of leaf damage was found to be significant. The minimum damage of the was found in terms of leaf damage (5.68%) in the treatment of having foliar spray with the Achook (Aza.0.03% EC), which was superior over all the test insecticides, but it was at par with rynaxypyr 20 SC (6.27% LDLF), dinotefuran 20 SG (6.55% LDLF), Neem Baan (Aza.1% EC) (6.88% LDLF), Neemazal (Aza.1% EC) (7.43% LDLF), pongamia oil (7.97% LDLF) and Nimbecidine (Aza.0.03% EC) (8.33% LDLF). The highest leaf damage of 20.69 per cent was observed in the unprotected crop of rice.

**iii) Pooled mean incidence of LDLF recorded at 10 DAA, during 2016 and 2017**

A perusal of results based on the pooled data of insecticides, against leaf folder in terms of leaf damage was found to be significant. The minimum damage of rice was found in terms of leaf damage (5.29%) in the treatment of Achook (Aza.0.03% EC), which was superior among all the test insecticides, but it was at par with rynaxypyr 20 SC (5.87% LDLF), dinotefuran 20 SG (6.14% LDLF) and Neem Baan (Aza.1% EC) (6.46% LDLF). The highest leaf damage of 20.27 per cent was

observed in case of the untreated crop. However, all the botanical insecticides remained significantly superior over the untreated crop of rice.

**d) Overall mean of leaf damage (LDLF) recorded at 4, 7 and 10 days after application (DAA)**

**i) Mean of LDLF recorded at 4, 7 and 10 DAA, during 2016**

A perusal of overall mean of three dates of observations (4, 7 & 10 DAA), in the form of the effect of insecticides on the incidence leaf folder in terms of leaf damage was found significant. The minimum damage of rice was found in terms of leaf damage (3.56%) in the treatment consisting of Achook (Aza.0.03% EC), which, in turn, was superior over all the test insecticides, but it was at par with rynaxypyr 20 SC (4.12% LDLF), dinotefuran 20 SG (4.38% LDLF), Neem Baan (Aza.1% EC) (4.70% LDLF), Neemazal (Aza.1% EC) (5.22% LDLF) and pongamia oil (5.73% LDLF). The highest leaf damage (17.40) was observed in case of the untreated crop of rice.

**ii) Mean of LDLF recorded at 4, 7 and 10 DAA, during 2017**

A perusal of overall mean values of three dates of observations (4, 7 & 10 DAA), in the form of the effect of insecticides against leaf folder in terms of leaf damage was found to be significant. The minimum damage of the crop was found in terms of leaf damage (3.91%) in the treatment comprising of Achook (Aza.0.03% EC), which in turn, remained superior over all the test insecticides, but it was at par with rynaxypyr 20 SC (4.86% LDLF), dinotefuran 20 SG (5.09% LDLF), Neem Baan (Aza.1% EC) (5.51% LDLF) and Neemazal (Aza.1% EC) (6.11% LDLF). The highest leaf damage (17.86%) was observed in case of the untreated crop.

**iii) Pooled mean of LDLF recorded at 4, 7 and 10 DAA, during 2016 and 2017**

A perusal of result on the overall mean results of three dates observations (4, 7 & 10 DAA), the pooled mean data of insecticides used against leaf folder in terms of leaf damage was found to be significant. The minimum leaf damage (3.74%) was found in terms of leaf damage in the treatments of Achook (Aza.0.03% EC), which was superior among over all the test insecticides, but it was at par with rynaxypyr 20 SC (4.49% LDLF), dinotefuran 20 SG (4.74% LDLF) and Neem Baan (Aza.1% EC) (5.10% LDLF). The highest leaf damage of 17.63 per cent was observed in case of the unprotected crop. However, all the botanical insecticides remained significantly superior over the untreated crop of rice.

Earlier, some scientists evaluated the bioefficacy of different botanical insecticides against leaf folder in rice at different locations of India. The present findings are in close agreement with Kaul and Sharma (1999) who reported that all the test neem based formulation viz. Neemazal, Neemaz, Neemgold, Econeem and Fortune proved to be statistically at par with chemical insecticide, chlorpyrifos in reducing the incidence of major pests viz. stem borer, hispa and leaf folder. The similar observations were also reported by Dhaliwal *et al.*, (2002), who noticed that four high potency azadirachtin based neem formulation, 1% and 5% Neem Azal and 0.03% Nimbecidine were evaluated against two major insects pests of rice, namely rice leaf folder (RLF), *C. medinalis* and yellow stem borer (YSB), *S. incertulas* for two kharif seasons. The incidence of RLF was minimum in case of monocrotophos, which was at par with 5 per cent Neemazal @ 1.00 and 2.00 ml/lit of water. Similarly in case of YSB it was minimum in monocrotophos and was at par with 5% Neemazal @ 0.05ml/lit. The highest yield of rice grains was obtained with monocrotophos followed by 1 % Neemazal @ 1.25ml/lit. The highest paddy yield (50.50q/ha) was recorded in monocrotophos followed by 46.40q/ha in 5% Neemazal @ 2.00ml/lit. As compared with 34.30q/ha in untreated control. The present findings are in close agreement with Nigam *et al.*, (2010), who evaluated comparative efficacy of some conventional and ecofriendly insecticides comprising of botanical and botanical based insecticides against rice leaf folder. All the conventional insecticides and neem oil were applied once and NSKE, Biolep, Dipel applied thrice during kharif, 2004-05 and 2005-06. Among the synthetic insecticides, monocrotophos 36 SL @ 0.4 kg a.i./ha treated plots showed lowest leaf infestation and gave higher grain yield 37.66 q/ha (2004-05) and 38.58 q/ha (2005-06). The neem oil @ 5% also gave better yield (32.25 and 33.91 q/ha) than the three sprays of NSKE 5% (31.83 and 32.91 q/ha) during both years, respectively. This finding also endorsed the results of the present studies up to major extent.

#### **4.4.6: Effect of botanical insecticides on the incidence of green leaf hopper, (GLH) (*Nephtottetix nigropictus* and *N. virescence*)**

The results are presented in Table-4.4.6, the incidence of GLH was found to occur almost throughout the cropping season. The observations on the incidence of the mixed population of the *N. nigropictus* and *N. virescence* were recorded to determine the bio-efficacy of the test botanical insecticides at 4, 7 & 10 DAA (days after application) during both of the year of experimentations, 2016 and 2017, during

*kharif*. The experimental results are shown in Table 4.4.6. Peak duration of occurrence of green leaf hopper was observed almost from 80 DAT and onward period during both of years of the experimentations.

**a) Incidence of GLH recorded at 4 days after application (4 DAA)**

**i) Incidence of GLH recorded at 4 DAA, during 2016**

The effect of the test insecticides on the incidence of green leaf hopper population (GLH/10 hills) was found to be significant (Table 4.4.6). The minimum GLH was found in the treatment of rynaxypyr 20 SC to the tune of 4.27 GLH/10 hills, which was superior over all the test insecticides, but it was at par with dinotefuran 20 SG (5.41 GLH/10 hills) and which was followed by Achook (Aza.0.03% EC) (8.66 GLH/10 hills), Neem Baan (Aza.1% EC) (9.58 GLH/10 hills) and Neemazal (Aza.1% EC) (12.14 GLH/10 hills). The highest GLH i.e. 26.78 GLH/10 hills were observed in case of the untreated plant of rice.

**ii) Incidence of GLH recorded at 4 DAA, during 2017**

The effect of insecticides on the incidence of green leaf hopper was remained significant (Table 4.4.6). The minimum incidence of the pest (4.36 GLH/10 hills) was found in the treatment of rynaxypyr 20 SC, which was superior over all the test insecticides, but it was at par with dinotefuran 20 SG (5.54 GLH/10 hills), and which was followed by Achook (Aza.0.03% EC) (8.84 GLH/10 hills), Neem Baan (Aza.1% EC) (9.68 GLH/10 hills) and Neemazal (Aza.1% EC) (12.19 GLH/10 hills). The highest incidence of the pest (27.11 GLH/10 hills) was observed in case of the unprotected plants of rice.

**iii) Pooled mean incidence of GLH recorded at 4 DAA, during 2016 and 2017**

The effect of insecticides on the incidence of green leaf hopper was found to be significant. The results are shown in Table 4.4.6. The minimum population of GLH was harboured by the plants treated with the rynaxypyr 20 SC which recorded 4.32 GLH/10 hills. This was superior among all insecticides, but it was at par with dinotefuran 20 SG (5.47 GLH/10 hills), and which was followed by Achook (Aza.0.03% EC) (8.75 GLH/10 hills) and Neem Baan (Aza.1% EC) (9.63 GLH/10 hills). The highest incidence of the pest i.e. 26.95 GLH/10 hills was observed in case of the unprotected crop of rice. However, all the botanical insecticides remained significantly superior over the untreated control plot.

**b) Incidence of GLH recorded at 7 days after application (7 DAA)**

**i) Incidence of GLH recorded at 7 DAA, during 2016**

The effect of the test insecticides on the incidence of green leaf hopper was found to be significantly effective (Table 4.4.6). The minimum GLH (5.92 GLH/10 hills) were found in the treatment of rynaxypyr 20 SC, which was superior over all the test insecticides, but it was at par with dinotefuran 20 SG (6.98 GLH/10 hills) and which was followed by Achook (Aza.0.03% EC) (9.23 GLH/10 hills), Neem Baan (Aza.1% EC) (11.02 GLH/10 hills) and Neemazal (Aza.1% EC) (12.88 GLH/10 hills). The highest GLH i.e. 27.94 GLH/10 hills was observed in case of the unprotected crop of rice.

**ii) Incidence of GLH recorded at 7 DAA, during 2017**

The effect of insecticides against green leaf hopper was found to be significantly effective. The minimum GLH (6.35 GLH/10 hills) was found in the treatment of rynaxypyr 20 SC, which was superior over all the test insecticides, but it was at par with dinotefuran 20 SG (7.41 GLH/10 hills) and which was followed by Achook (Aza.0.03% EC) (9.66 GLH/10 hills), Neem Baan (Aza.1% EC) (11.45 GLH/10 hills) and Neemazal (Aza.1% EC) (13.31 GLH/10 hills). The highest population of the pest (28.37 GLH/10 hills) was observed in case of the untreated crop.

**iii) Pooled mean incidence of GLH recorded at 7 DAA, during 2016 and 2017**

The population of GLH varied from 6.14 to 28.15 GLH/10 hills. The treatments were found to be significant (Table 4.4.6). The minimum population of the insect was harboured by the plants treated with rynaxypyr 20 SC which recorded 6.14 GLH/10 hills. This was superior among all the test insecticides, but was at par with dinotefuran 20 SG (7.20 GLH/10 hills) and which was followed by Achook (Aza.0.03% EC) (9.44 GLH/10 hills) and Neem Baan (Aza.1% EC) (11.24 GLH/10 hills). The highest incidence of the pest i.e. 28.15 GLH/10 hills was observed in unprotected crop of rice. However, all the botanical insecticides remained significantly superior over the untreated crop of rice.

**c) Incidence of GLH recorded at 10 days after application (10 DAA)**

**i) Incidence of GLH recorded at 10 DAA, during 2016**

The effect of insecticides on the incidence of green leaf hopper was found to be significant (Table 4.4.6). The minimum GLH was found in the treatment of rynaxypyr 20 SC, which had the lowest population (8.22 GLH/10 hills), that was superior among all insecticides, but was at par with dinotefuran 20 SG (9.01 GLH/10

hills) and Achook (Aza.0.03% EC) (11.22 GLH/10 hills). The highest GLH i.e. 31.57 GLH/10 hills was observed in case of the unprotected crop of rice.

**ii) Incidence of GLH recorded at 10 DAA, during 2017**

The effect of insecticides on the incidence of green leaf hopper was significant. The minimum GLH (8.65 GLH/10 hills) was found in the treatment of rynaxypyr 20 SC which was superior over all the test insecticides, but it was at par with dinotefuran 20 SG (9.44 GLH/10 hills) and Achook (Aza.0.03% EC) (11.65 GLH/10 hills). The highest population of the pest (32.00 GLH/10 hills) was registered in case of the unprotected crop of rice.

**iii) Pooled mean incidence of GLH recorded at 10 DAA, during 2016 and 2017**

The population of GLH varied from 8.43 to 31.78 GLH/10 hills in the test treatments. The treatments were found to be significant in reducing the incidence of GLH (Table 4.4.6). The minimum of the pest population was harboured by the plants treated with rynaxypyr 20 SC which recorded as low as 8.43 GLH/10 hills. This was superior among all insecticides, but it was at par with dinotefuran 20 SG (9.23 GLH/10 hills) and which was followed by Achook (Aza.0.03% EC) (11.44 GLH/10 hills) and Neem Baan (Aza.1% EC) (13.15 GLH/10 hills). The highest incidence of the pest i.e. 31.78 GLH/10 hills was observed in case of the unprotected crop of rice. However, all the botanical insecticides remained significantly superior over the untreated crop of rice.

**d) Overall mean of GLH recorded at 4, 7 and 10 days after application (DAA)**

**i) Mean of GLH recorded at 4, 7 and 10 DAA, during 2016**

A perusal of mean values of three dates of observations (4, 7 & 10 DAA), indicated that the effect of insecticides on the incidence of green leaf hopper (GLH/10 hills) was found to be significant. The minimum population of the pest (6.14 GLH/10 hills) was found in the treatment of rynaxypyr 20 SC, which was found superior among all insecticides, but it was at par with dinotefuran 20 SG (7.13 GLH/10 hills), and which was followed by Achook (Aza.0.03% EC) (9.70 GLH/10 hills), Neem Baan (Aza.1% EC) (11.18 GLH/10 hills) and Neemazal (Aza.1% EC) (13.03 GLH/10 hills). The highest population of GLH (28.76 GLH/10 hills) was observed by the rice plants which were left unprotected for a natural population of the pest.

**ii) Mean of GLH recorded at 4, 7 and 10 DAA, during 2017**

A perusal of the mean of three date's observations (4, 7 & 10 DAA) indicated that the effect of insecticides against the incidence of green leaf hopper was found to

be significant (Table 4.4.6). The minimum population of the pest was harboured by the plants treated with rynaxypyr 20 SC which recorded the lowest number of the insect pest (6.45 GLH/10 hills). This remained superior among all insecticides, but it was also at par with dinotefuran 20 SG (7.46 GLH/10 hills) and which was followed by Achook (Aza.0.03% EC) (10.05 GLH/10 hills), Neem Baan (Aza.1% EC) (11.50 GLH/10 hills) and Neemazal (Aza.1% EC) (13.34 GLH/10 hills). The highest population of the pest (29.16 GLH/10 hills) was registered in case of the unprotected crop of rice.

**iii) Pooled mean of GLH recorded at 4, 7 and 10 DAA, during 2016 and 2017**

A perusal of the overall mean values of the pest population recorded at three dates of observations (4, 7 & 10 DAA), the reflected the effect of insecticides against green leaf hopper was found to be significant (Table 4.4.6). The population of GLH varied from 6.30 to 28.96 GLH/10 hills. The minimum population of the pest (4.29 GLH/10 hills) was found in the treatment of rynaxypyr 20 SC which was apparently superior among all the insecticides but it was statistically at par with dinotefuran 20 SG (7.46 GLH/10 hills) and which was followed by Achook (Aza.0.03% EC) (10.05 GLH/10 hills) and Neem Baan (Aza.1% EC) (11.50 GLH/10 hills). The highest incidence of the pest i.e. 28.96 GLH/10 hills was observed in case of the unprotected crop of rice. However, all the test botanical insecticides remained significantly superior over the untreated plats of rice.

Earlier, some scientists also evaluated the bioefficacy of different botanical insecticides against green leaf hopper in rice at certain locations. The botanical formulation of insecticides remained almost at par to each other in terms of suppression of the pest in the present investigations. Although, previous work on the efficacy of botanical insecticides are not available in the literature on rice in relation to green leaf hopper. However, Kaul and Sharma (1999) reported that certain neem formulations viz. Neemzal, Neemax, Neem Gold, Econeem and Fortune remained almost equally effective to that of chlorpyrifos in terms of efficacy for suppression of incidence of stem borer, hispa and leaf folder. The similar observations were also obtained by Nigam and Sen (1989) who found neem oil applied @ 1,2,3 & 4 per cent could be highly effective in reducing the incidence of green leaf hopper, *Nephotettix virescence* population. Their results are almost in the agreement of the findings of the present experimentations.

**4.5.7: Effect of botanical insecticides on the incidence of gundhi bug /ear bug (*Leptocorsia oratorius*)**

The observations pertaining to the incidence of mixed population of ear bug (*Leptocorisa oratorius* and *L. acuta*) were recorded at milking stage of the crop to determine the bioefficacy of certain test insecticides against the pest during both of the years of experimentations, 2016 and 2017 during *kharif*. The results are presented in Table-4.4.7. the ear bug(EB) is also known as gundhi bug (GB). Peak duration of occurrence of gundhi bug was observed almost from 95 DAT and onward period during both of years of the experimentations.

**a) Incidence of GB recorded at 4 days after application (4 DAA)**

**i) Incidence of GB recorded at 4 DAA, during 2016**

The effect of botanical insecticides against ear bug was remained significant results (Table 4.4.7). The minimum population gundhi bug (1.77 GB/10 hills) was recorded in the treatment comprising of rynaxypyr 20 SC which was apparently superior among all the test insecticides, but it was at par with dinotefuran 20 SG (2.26 GB/10 hills) and which was followed by Achook (Aza.0.03% EC) (3.81 GB/10 hills), Neem Baan (Aza.1% EC) (4.87 GB/10 hills) and Neemazal (Aza.1% EC) (5.77 GB/10 hills). The highest population of the pest (14.61 GB/10 hills) was harboured by the rice plants which were left unprotected.

**ii) Incidence of GB recorded at 4 DAA, during 2017**

The effect of botanical insecticides against ear bug gave rise to the significantly positive results (Table 4.4.7). The minimum population of gundhi bug (2.14 GB/10 hills) was found in the treatment comprising of rynaxypyr 20 SC which was apparently superior among all the test insecticides, but it was at par with dinotefuran 20 SG (2.72 GB/10 hills) and which was followed by Achook (Aza.0.03% EC) (4.15 GB/10 hills), Neem Baan (Aza.1% EC) (5.09 GB/10 hills) and Neemazal (Aza.1% EC) (6.09 GB/10 hills). The highest population of the pest (14.73 GB/10 hills) was observed in the untreated crop of rice.

**iii) Pooled mean incidence of GB recorded at 4 DAA, during 2016 and 2017**

Based on the pooled data, effect of botanical insecticides against ear bug gave rise to they was recorded significant results (Table 4.4.7). The minimum population gundhi bug (1.96GB/10 hills) was found in the treatment comprising of rynaxypyr 20 SC which was apparently superior among all the test insecticides but it was at par with dinotefuran 20 SG (2.49 GB/10 hills) and which was followed by Achook

(Aza.0.03% EC) (3.98 GB/10 hills) and Neem Baan (Aza.1% EC) (4.98 GB/10 hills). The highest population of the pest (14.67 GB/10 hills) was observed in case of the unprotected plants of rice. However, all the botanical insecticides remained significantly superior over the untreated crop of rice.

**b) Incidence of GB recorded at 7 days after application (7 DAA)**

**i) Incidence of GB recorded at 7 DAA, during 2016**

The effect of botanical insecticides against ear bug recorded gave rise to the significantly positive results. The minimum population of gundhi bug (2.57 GB/10 hills) was found in the treatment comprising of rynaxypyr 20 SC which was apparently superior among all the test insecticides but it was at par with dinotefuran 20 SG (3.09 GB/10 hills) and which was followed by Achook (Aza.0.03% EC) (5.14 GB/10 hills) and Neem Baan (Aza.1% EC) (6.57 GB/10 hills). The highest population of the pest (16.94 GB/10 hills) was observed in the untreated crop of rice.

**ii) Incidence of GB recorded at 7 DAA, during 2017**

The effect of botanical insecticides against ear bug remained significant. The minimum population of gundhi bug (3.05 GB/10 hills) was found in the treatment comprising of rynaxypyr 20 SC which was apparently superior among all the test insecticides but it was at par with dinotefuran 20 SG (3.49 GB/10 hills) which was followed by Achook (Aza.0.03% EC) (5.68 GB/10 hills) and Neem Baan (Aza.1% EC) (7.09 GB/10 hills). The highest population of the pest (17.54 GB/10 hills) was observed in the untreated crop of rice.

**iii) Pooled mean incidence of GB recorded at 7 DAA, during 2016 and 2017**

The effect pooled of botanical insecticides used, against ear bug resulted in to significant and positive results. The minimum population gundhi bug (2.81 GB/10 hills) was found in the treatment comprising of rynaxypyr 20 SC which was apparently superior among all the test insecticides but it was at par with dinotefuran 20 SG (3.29 GB/10 hills) and which was followed by Achook (Aza.0.03% EC) (5.41 GB/10 hills). The highest population of the pest (17.24 GB/10 hills) was observed in case of the unprotected plants of rice. However, all the botanical insecticides remained significantly superior over the untreated crop of rice.

**c) Incidence of GB recorded at 10 days after application (10 DAA)**

**i) Incidence of GB recorded at 10 DAA, during 2016**

The effect of insecticides against ear bug recorded significant results. The minimum population of gundhi bug (2.90 GB/10 hills) was found in the treatment

comprising of rynaxypyr 20 SC which was apparently superior among all the test insecticides but it was at par with dinotefuran 20 SG (3.44 GB/10 hills) which was followed by Achook (Aza.0.03% EC) (5.68 GB/10 hills), Neem Baan (Aza.1% EC) (7.36 GB/10 hills) and Neemazal (Aza.1% EC) (7.91 GB/10 hills). The highest population of the pest (17.34 GB/10 hills) was observed in the untreated crop of rice.

**ii) Incidence of GB recorded at 10 DAA, during 2017**

The effect of insecticides against ear bug resulted in to the significant and positive results. The minimum population of gundhi bug (2.97 GB/10 hills) was found in the treatment comprising of rynaxypyr 20 SC which was apparently superior among all the test insecticides but it was at par with dinotefuran 20 SG (3.60 GB/10 hills) which was followed by Achook (Aza.0.03% EC) (5.95 GB/10 hills), Neem Baan (Aza.1% EC) (7.57 GB/10 hills) and Neemazal (Aza.1% EC) (8.04 GB/10 hills). The highest population of the pest (18.44 GB/10 hills) was observed in the untreated crop of rice.

**iii) Pooled mean incidence of GB recorded at 10 DAA, during 2016 and 2017**

The pooled data of the test insecticides used against ear bug (GB/10 hills) reflected the effect of the insecticidal treatments which resulted to the positive and significant results (Table 4.4.7). The minimum population gundhi bug (2.94 GB/10 hills) was found in the treatment comprising of rynaxypyr 20 SC which was apparently superior among all the test insecticides but it was at par with dinotefuran 20 SG (3.52 GB/10 hills) and which was followed by Achook (Aza.0.03% EC) (5.81 GB/10 hills). The highest population of the pest (17.89 GB/10 hills) was observed in case of the unprotected plants of rice. However, all the botanical insecticides remained significantly superior over the untreated crop of rice.

**d) Overall mean of GB recorded at 4, 7 and 10 days after application (DAA)**

**i) Mean of GB recorded at 4, 7 and 10 DAA, during 2016**

The overall mean values of three dates of observations (4, 7 & 10 DAA), pertaining to the effect of insecticides against ear bug was gave rise to the significant and positive results. The minimum population gundhi bug (2.41 GB/10 hills) was found in the treatment comprising of rynaxypyr 20 SC which was apparently superior among all the test insecticides but it was at par with dinotefuran 20 SG (2.93 GB/10 hills) was followed by Achook (Aza.0.03% EC) (4.88 GB/10 hills), Neem Baan (Aza.1% EC) (6.26 GB/10 hills) and Neemazal (Aza.1% EC) (7.06 GB/10 hills). The

highest population of the pest (16.30GB/10 hills) was observed in the untreated crop of rice.

**ii) Mean of GB recorded at 4, 7 and 10 DAA, during 2017**

The overall mean values of three dates of observations (4, 7 & 10 DAA), pertaining to the effect of insecticides against ear bug gave rise to the significant and positive results. The minimum population of gundhi bug (2.72 GB/10 hills) was found in the treatment comprising of rynaxypyr 20 SC which was apparently superior among all the test insecticides but it was at par with dinotefuran 20 SG (3.27 GB/10 hills) and which was followed by Achook (Aza.0.03% EC) (5.26 GB/10 hills) and Neem Baan (Aza.1% EC) (6.58 GB/10 hills). The highest population of the pest (11.67 GB/10 hills) was observed in case of the unprotected plants of rice.

**iii) Pooled mean of GB recorded at 4, 7 and 10 DAA, during 2016 and 2017**

The overall pooled mean values of three dates observations (4, 7 & 10 DAA), pertaining to the effects of insecticides against the incidence of gundhi bug gave rise to the significant results. The minimum population gundhi bug (2.57 GB/10 hills) was found in the treatment comprising of rynaxypyr 20 SC, which was apparently superior among all the test insecticides but it was at par with dinotefuran 20 SG (3.10 GB/10 hills) and which was followed by Achook (Aza.0.03% EC) (5.07 GB/10 hills). The highest population of the pest (16.90 GB/10 hills) was observed in case of the unprotected plants of rice. However, all the botanical insecticides remained significantly superior over the untreated crop of rice.

Earlier, various scientists evaluated the bioefficacy of different chemical insecticides against gundhi bug in rice at different locations of the country. Almost no information on bio-efficacy of neem based insecticides against ear bugs on rice are available in the literature so far. However, the experimental results of Kaul and Sharma (1999) indicating the neem based insecticides viz. Neemzal, Neemax, Neemgold, Econeem and Fortune proved almost as efficacious as chlorpyrifos in the effective control of major insect pest of rice viz. stem borer, hispa and leaf folder. Their results are almost in the agreement of the findings of the present experimentations.

**4.4.8: Effect of botanical insecticides on grain's yield of rice**

The observations on grain's yield of rice as influenced by the effect of botanical insecticides are shown in Table –4.4.8.

**a) Yield of rice recoded during first year, *kharif* 2016:**

The results revealed that the highest yield of grains of rice (49.00q/ha) obtained through protection against the major prevailing insect pest complex was provided by foliar spray with Achook (Aza.0.03% EC), as against the lowest yield of 34.40 q/ha which was recorded when the crop was left in the unprotected situations but it was at par with rynaxypyr 20 SC (47.83 q/ha), dinotefuran 20 SG (47.10 q/ha), Neem Baan (Aza.1% EC) (45.80 q/ha), Neemazal (Aza.1% EC) (45.03 q/ha) and pongamia oil (44.10 q/ha).

**b) Yield of rice recorded during second year, *kharif* 2017:**

The results revealed that the highest yield of grains of rice (50.40 q/ha) was obtained through protection against the prevailing major insect pest complex provided by foliar spray with Achook (Aza.0.03% EC), as against the lowest yield of 35.57 q/ha which was recorded when the crop was left in the unprotected conditions but it was at par with rynaxypyr 20 SC (49.17 q/ha), dinotefuran 20 SG (48.40 q/ha), Neem Baan (Aza.1% EC) (47.00 q/ha), Neemazal (Aza.1% EC) (46.30 q/ha) and pongamia oil (45.33 q/ha).

**c) Two years pooled mean yield of rice recorded during, *kharif* 2016 and 2017:**

The results (Table 4.4.8) revealed that the highest yield of grains of rice (49.70 q/ha) was obtained through protection against the major prevailing insect pest complex was provided by foliar spray with Achook (Aza.0.03% EC), as against the lowest yield of 34.98 q/ha which was recorded when the crop was left in the unprotected situations but it was at par with rynaxypyr 20 SC (48.50 q/ha) and dinotefuran 20 SG (47.75 q/ha) and which was followed by Neem Baan (Aza.1% EC) (46.40 q/ha), Neemazal (Aza.1% EC) (45.67 q/ha), pongamia oil (44.72 q/ha) and Nimbecidine (Aza.0.03% EC) (43.98 q/ha).

Earlier, few scientists evaluated the bioefficacy of the different botanical insecticides against the prevailing major insect pests in rice and their resultant impact on grains' yield at some locations of India. However, yield obtained through protection provided by the some botanical formulations of insecticides remained significantly superior over the grain yield resulting out from the unprotected crop in the present studies. It is noteworthy to mention here that not much information is available in the literature pertaining to bio-efficacy of botanical insecticides and their ultimate impact on grains yield of rice. However, findings of Dhaliwal *et al.* (2006) indicating the higher yield of rice (50.50q/ha) was recorded through foliar spray with monocrotophos followed by 46.4q/ha when the protection to the crop was provided

through the need based foliar application Neemazal @ 2.00 ml/lit of water as compared with that the unprotected crop of rice which gave rise to the minimum yield (34.3q/ha). As such, the finding of Dhaliwal *et al.*, (2006) are in the line of the results of the present investigation.

**4.4.9: Computation of economics of foliar application of some botanical insecticides for management of the major prevailing insect pest complex of rice (var. IR-64Drt.):**

The economics of protection of rice (var. IR-64Drt.) against major insect pest complex through need based application of foliar spray of some botanical insecticides was computed based on the pooled mean yield of rice of two years experimentations in the present investigation.

A perusal of results (Table-4.4.9) revealed that foliar sprays with Achook (0.03% Aza.) @ 2500 ml/ha over the standing crop of rice at 25, 40, 80 and 95 DAT on need based basis realized the highest net profit of Rs 22,679.20/ha with benefit cost ratio of 3.28:1 followed by four rounds of foliar sprays with Neem Baan (1% Aza.) @ 1000ml/ha with net income of Rs. 17,966.20/ha and benefit cost ratio of 3.60:1, four sprays of Neemazal (1% Aza.) @ 1000 ml/ha with net profit of Rs. 16,778.90/ha and benefit cost ratio of 3.56:1, pongamia oil @ 2500 ml/ha realizing net income of Rs. 16,169.40/ha and the maximum benefit cost ratio of 4.74:1 when the economics of the test botanical insecticides is considered.

However, need based foliar sprays applied over the standing crop of rice (var. IR-64Drt.) at 25, 40, 80 and 95 DAT either one of with the chemical insecticides viz. dinotefuran 20SG @ 200 g/ha or rynaxypyr 20SC @ 150 ml/ha as separate treatment, could be able to realize almost overall maximum net monetary return of Rs. 23,679.70/ha with benefit cost ratio (B:C ratio) of 11.91:1 and Rs. 21,167.20 with B:C ratio 2.52:1 with the respective chemical insecticides.

As such, rynaxypyr 20 SC applied as foliar spray @ 150 ml/ha, although, realized very high net profit of Rs. 21,167.20/ha but it could give rise to relatively lesser B:C ratio of 3.52:1 only because of its much higher price of Rs.8500/lit. in the present studies.

Findings of Prasad and Prasad (2012) realizing appreciably higher reduction in the incidence of major prevailing insect pest fauna with gain of substantially higher grains yield, net profit and benefit cost ratios which were obtained through use of neem and karanj cakes owing to azadirachtin and karanjin content as insecticidal

values in the respective cakes. Their findings endorsed the results of the present studies. The experimental findings of Prasad *et al.* (2018) also endorsed the results of the present investigation up to major extent.

Foregoing elaboration of the results, pertaining to the field bio-efficacy of the test botanical insecticides revealed four rounds of need based application of foliar sprays of some botanical derivatives viz. Achook (0.03% Aza.), Neem Baan (1% Aza.) and Neemazal (1% Aza.) applied at 25, 40, 80 and 95 DAT could be able to reduce the incidence of major prevailing insect pests viz. hispa, YSB, gall midge, leaf folder, GLH and ear bug up to the significant level, resulting in the appreciably higher grains yield, net profit and benefit cost ratios among botanicals.

However, need based foliar spray of the chemical insecticides dinotefuran 20SG and rynaxypyr 20SC applied as four rounds of foliar sprays at 25, 40, 80, and 95 DAT could be able to suppress the pest fauna up to the greater extent resulting in the overall higher grains yield, net profit and benefit cost ratios as compared to almost those of all the test botanical insecticides based on the mean results of two years experimentation in the present investigation.

#### **4.5 Evaluation of field bio- efficacy of newer molecules of insecticides against major insect-pests of rice.**

Among the biotic stresses causing threats in successful cultivation of rice, insect pest fauna occupy significant place in causing loss in yield. Need based and judicious application of the chemical insecticides is considered as one of the important tools of IPM for sustainable production of rice. Newer molecules of chemical insecticides are coming up in the market day by day and older molecules of the insecticides going to be gradually Banned in year to come. Hence, it is need of the hour to evaluate some newer molecules of the insecticides against major prevailing insect pests of rice in order to provide various options for farming communities for their choice in the availability of the insecticides for use in the rice-ecosystem. Keeping these objectives in mind the field efficacy of certain newer molecules of insecticides either in the form of the ready mix combination products or in their sole use were evaluated for two consecutive year in *kharif* during, 2016 and 2017 with rice (var. Naveen). These were ten treatments comprising of different insecticides including the untreated check for evaluation of their relative bio-efficacy against the major prevailing insect pest fauna in the agro-climate conditions of Jharkhand.

Altogether four rounds of foliar spray of aqueous solution these insecticides starting at 25 and fallowed at 40, 80 and 95 DAT (days after transplanting) on need based basis were applied against prevailing major insect pest species. Yellow stem borer (*Scirpophaga incertulas*), gall midge (*Orseolia oryzae*), hisa (*Dicladispa armigera*), leaf folder (*Cnaphalocrosis medinalis*), green leaf hopper (*Nephotettix spp.*) and ear bug (*Leptocorisa oratorius* and *L. acuta*) were found to occur in succession and also in overlapping manner as major insect pests in the rice agro-ecosystem. The observations pertaining to the bio-efficacy of the test chemical insecticides were recorded for the respective pest species. Results of field experiment were statistically analyzed and discussed under following heads and subheads.

##### **4.5.1: Effect of chemical insecticides on the incidence of rice hispa (*Dicladispa armigera*) in terms of leaf damage (LDH %)**

The result are presented in Table -4.5.1. The observations of the leaf damage, caused by hispa, (LDH) was noticed in the middle vegetative stage of the crop. As such, observations on per centage of leaf damage, due to hispa (LDH %) was recorded at 4, 7 & 10 DAA (days after application) during *Kharif* 2016 and 2017. Peak

duration of occurrence of hispa was observed almost from 25 DAT and onward period during both of years of the experimentations.

**a) Incidence of leaf damage (LDH) recorded at 4 days after application (4 DAA)**

**i) Incidence of LDH recorded at 4 DAA, during 2016**

At 4 DAA, the experimental data of insecticides used against rice hispa in terms of leaf damage were found to be statistically significant. The minimum leaf damage (0.44% LDH) was found in terms of leaf damage in the treatment comprising of the new combination product spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was found superior over all the test insecticides, but it was found to be at par with its own lower dose of spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (0.50% LDH). The highest leaf damage of 5.57 per cent was observed in case of unprotected crop of rice (var. Naveen).

**ii) Incidence of LDH recorded at 4 DAA, during 2017**

At 4 DAA, the experimental data of insecticides used against rice hispa in terms of leaf damage LDH remained recorded statistically significant (Table 4.5.1). The minimum damage was found in terms of leaf damage (0.72% LDH) in case of the combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was statistically superior among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (0.78% LDH), flubendiamide 48SC @ 50 ml/ha (0.88% LDH) and carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (1.01% LDH). The highest leaf damage of 5.85 per cent LDH was observed in case of the unprotected crop of rice.

**iii) Pooled mean value of incidence of LDH recorded at 4 DAA, during 2016 and 2017**

The pooled data of insecticides used against rice hispa in terms of leaf damage could be able to realize significant results. The minimum damage was found in terms of leaf damage 0.58 per cent LDH in the treatment of the new combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which in turn remained superior over all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (0.64% LDH) and flubendiamide 48SC @ 50 ml/ha (0.74% LDH). The highest leaf damage of 5.71 per cent was observed in untreated control plot.

**b) Incidence of leaf damage (LDH) recorded at 7 days after application (7 DAA)**

**i) Incidence of LDH recorded at 7 DAA, during 2016**

At 7 DAA, the data on the impact of insecticides used against rice hispa in terms of leaf damage (LDH) were found to be statistically significant. The minimum leaf damage (0.56% LDH) was found in terms of leaf damage in the treatment consisting of the new combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which remained superior among all the test insecticides, but it was found to be at par with the lower dose of spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (0.64% LDH), flubendiamide 48SC @ 50 ml/ha (0.74% LDH), carbofuran 3G @ 30 kg/ha followed by need based foliar spray of triazophos 40EC @ 1500 ml/ha (0.85% LDH) and acephate 95SG @ 526g/ha (0.94% LDH). The highest leaf damage of 7.20 per cent LDH was observed in case of the untreated crop of rice (var. Naveen).

**ii) Incidence of LDH recorded at 7 DAA, during 2017**

At 7 DAA, the experimental data on the impact of the test insecticides used against rice hispa in terms of leaf damage LDH were found to be significant. The minimum damage was found in terms of leaf damage (0.92% LDH) in case of the combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was statistically superior among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.00% LDH), flubendiamide 48SC @ 50 ml/ha (1.10% LDH), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (1.21% LDH) and acephate 95SG @ 526g/ha (1.30% LDH). The highest leaf damage of 7.56 per cent LDH was observed in case of the unprotected crop of rice (var. Naveen).

**iii) Pooled mean incidence of LDH recorded at 7 DAA during 2016 and 2017**

The pooled experimental data on the impact of the insecticides used against rice hispa in terms of leaf damage (LDH) was found to be significant. The minimum damage was found in terms of leaf damage (0.74% LDH) in the combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which in turn remained superior over all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (0.82% LDH) and flubendiamide 48SC @ 50 ml/ha (0.92% LDH). The highest leaf damage of 7.38 per cent LDH was observed in unprotected rice crop.

**c) Incidence of leaf damage (LDH) recorded at 10 days after application (10 DAA)**

**i) Incidence of LDH recorded at 10 DAA, during 2016**

At 10 DAA, the data on the impact of the insecticides used against rice hispa in terms of leaf damage (LDH) were found to be statistically significant. The minimum damage was found in terms of leaf damage (0.74% LDH) in the treatment of combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which remained superior among all the test insecticides, but it was found to be at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (0.83% LDH), flubendiamide 48SC @ 50 ml/ha (0.92% LDH) and carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (1.11% LDH). The highest leaf damage of 8.11 per cent was observed in case of the unprotected crop of rice (var. Naveen).

**ii) Incidence of LDH recorded at 10 DAA, during 2017**

At 10 DAA, the impact of the test insecticides used against rice hispa in terms of leaf damage (LDH) was found to be significant. The minimum leaf damage 1.19 per cent LDH were found in terms of leaf damage in the treatment consisting of the ready mix combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was significantly superior among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.29% LDH), flubendiamide 48SC @ 50 ml/ha (1.37% LDH), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (1.56% LDH) and acephate 95SG @ 526g/ha (1.70% LDH). The highest leaf damage of 8.56 per cent LDH was observed in case of the untreated crop of rice.

**iii) Pooled mean incidence of LDH recorded at 10 DAA, 2016 and 2017**

The impact of the test insecticides against rice hispa in terms of leaf damage (LDH) was found to be significant. The minimum damage were found in terms of leaf damage 0.97 per cent LDH in the treatment of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was superior over all the test insecticides, but was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.06% LDH) and flubendiamide 48SC @ 50 ml/ha (1.15% LDH). The highest leaf damage of 8.34 per cent LDH was observed in case of untreated crop.

**d) Overall mean of leaf damage (LDH) recorded at 4, 7 and 10 days after application (DAA)**

**i) Mean LDH recorded at 4, 7 and 10 DAA during 2016**

Overall mean LDH of three dates of observations (4, 7 & 10 DAA), the data on the impact of the insecticides used against rice hispa in terms of leaf damage (LDH) was found to be significant. The minimum damage were found in terms of leaf damage (0.58% LDH) in the treatment comprising of the readymade new combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which remained superior among all the test insecticides, but it was found to be almost at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (0.66% LDH), flubendiamide 48SC @ 50 ml/ha (0.75% LDH) and carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (0.89% LDH). The highest leaf damage of 6.96 per cent LDH was observed in case of the unprotected crop of rice.

**ii) Mean of LDH recorded at 4, 7 and 10 DAA, during 2017**

Overall mean of LDH recorded at the three date's observations (4, 7 & 10 DAA), the impact of the test insecticides used against rice hispa in terms of leaf damage was found to be significant. The minimum damage was found in terms of leaf damage 0.94 per cent LDH in case of the new combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was statistically superior among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.02% LDH), flubendiamide 48SC @ 50 ml/ha (1.12% LDH) and carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (1.26% LDH). The highest leaf damage of 7.33 per cent LDH was observed in case of the unprotected crop of rice.

**iii) Pooled mean of LDH recorded at 4, 7 and 10 DAA , during 2016 and 2017**

Overall mean results of the three dates observations (4, 7 & 10 DAA), in terms of leaf damage were realized significant. The minimum damage was found in terms of leaf damage 0.76 per cent LDH in case of the readymade combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which in turn was superior among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (0.84% LDH) and flubendiamide 48SC @ 50 ml/ha (0.94% LDH). The highest leaf damage of 7.14 per cent LDH was observed in case of untreated crop.

Earlier, various scientists evaluated the bioefficacy of different chemical insecticide against hispa in rice at different locations of the country. The findings of the present investigation are more or less in agreement with Kaul and Sharma (1999)

as they found that foliar spray with chlorpyrifos 20 EC @ 2.5 lit/ha proved to be highly effective against hispa and leaf folder infesting rice (var. Kasturi Basmati). The results of Prasad and Prasad (2011) are almost in the line of findings of the present studies, indicating that the combination product of imidacloprid 40% plus ethiprole 40% (80 WG) @ 125 g/ha proved to be superior over sole use of monocrotophos 36 WSC @ 1300 mlit./ha against hispa. Similarly, Super-D consisting of chlorpyrifos plus cypermethrin remained the most effective, among all the treatments, against hispa.

**4.5.2: Effect of chemical insecticides on the incidence of yellow stem borer (*Scirpophaga incertulas* Walker) in terms of dead heart (DH %)**

Results are shown in (Table-4.5.2). The observations on the incidence of dead heart (DH) infesting rice (var. Naveen) were recorded in the vegetative stage of the crop at 4, 7 & 10 (days after application) during, 2016 and 2017. Peak duration of occurrence of yellow stem borer (DH) was observed almost from 40 DAT and onward period during both of years of the experimentations.

**a) Incidence of dead heart (DH) recorded at 4 days after application (4 DAA)**

**i) Incidence of DH recorded at 4 DAA, during 2016**

The effect of insecticides after spray on per cent dead heart due to yellow stem borer recorded at 4 DAA (Table 4.5.2) indicated the significant results and as such, the combination product i.e. spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha recorded the lowest incidence of dead hearts (0.86% DH), which was superior among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (0.93% DH), flubendiamide 48SC @ 50 ml/ha (1.07% DH), carbofuran 3G @ 30 kg/ha followed by triazophos 40EC @ 1500 ml/ha (1.16% DH), acephate 95SG @ 526g/ha @ 526g/ha (1.21% DH) and triazophos 40EC @ 1500 ml/ha (1.31% DH). The highest dead heart damage of 6.07 per cent was observed in unprotected crop.

**ii) Incidence of DH recorded at 4 DAA, during 2017**

The effect of insecticides after spray on per cent dead heart due to yellow stem borer recorded at 4 DAA (Table 4.5.2) gave rise to the significant results and the new combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha recorded the lowest DH of 1.29 per cent, which appeared to be superior to all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.36% DH), flubendiamide 48SC @ 50 ml/ha (1.51% DH), carbofuran 3G

@ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (1.59% DH), acephate 95SG @ 526g/ha (1.65% DH), triazophos 40EC @ 1500 ml/ha (1.74% DH) and triflumezopyrim 106SC @ 237.5 ml/ha (1.88% DH). The highest dead heart damage of 6.51 per cent was observed in the untreated control plot.

**iii) Pooled mean incidence of DH recorded at 4 DAA, during 2016 and 2017**

The impact of application of insecticides on mean values of dead heart of 2016 and 2017 at 4DAA, caused by yellow stem borer gave rise to the significant results and as such, the ready mix combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha recorded the lowest incidence of dead hearts 1.07 per cent, which was almost superior among all the test insecticides, but it was at par with lower dose of the same ready mix product of spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.15% DH), flubendiamide 48SC @ 50 ml/ha (1.29% DH) and carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (1.38% DH). The highest dead heart damage of 6.29 per cent was registered in case of untreated control plot.

**b) Incidence of dead heart (DH) at 7 days after application (7 DAA)**

**i) Incidence of DH recorded at 7 DAA, during 2016**

The outcome of insecticides after spray on per cent dead heart due to yellow stem borer at 7 DAA indicated that the result remained significant and as such, spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha recorded the lowest dead heart 1.06 per cent, which was superior among all the test insecticides, but it was at par with the lower dose of the same product i.e. spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.26% DH), flubendiamide 48SC @ 50 ml/ha (1.43% DH) and carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (1.62% DH). The highest dead heart damage of 7.79 per cent was observed in case of the unprotected crop.

**ii) Incidence of DH recorded at 7 DAA, during 2017**

The effect of insecticides after spray on per cent dead heart due to yellow stem borer at 7 DAA gave rise to the significant results and as such the combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha recorded the minimum DH (1.50%), which was almost superior among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.70% DH), flubendiamide 48SC @ 50 ml/ha (1.87% DH) and carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (2.06%

DH) and acephate 95SG @ 526g/ha (2.25% DH). The highest dead heart damage of 8.23 per cent was observed in the untreated control plot.

**iii) Pooled mean incidence of DH recorded at 7 DAA, during 2016 and 2017**

The effect of insecticides on the pooled results of 2016 and 2017 at 7 DAA the after spray on dead heart due to yellow stem borer remained significant and as such, the ready mixed combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha received the lowest incidence of dead heart to the tune of 1.28 per cent DH, which was found almost superior among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.48% DH) and flubendiamide 48SC @ 50 ml/ha (1.65% DH). The highest dead heart damage of 8.01 per cent was observed in the untreated control plot.

**c) Incidence of dead heart (DH) recorded at 10 days after application (10 DAA)**

**i) Incidence of DH recorded at 10 DAA, during 2016**

The results on the effect of insecticides after spray on per cent dead heart due to yellow stem borer at 10 DAA was found to be significant and as such, the new combination product i.e. spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha recorded the lowest DH (1.40%), which appeared to be superior among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.63% DH). The highest dead heart damage of 10.24 per cent was recorded when the crop was left unprotected.

**ii) Incidence of DH recorded at 10 DAA, during 2017**

The impact of insecticides after spray on per cent dead heart due to yellow stem borer at 10 DAA realized the significant results and the combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha recorded the minimum DH of 1.84 per cent, which was found to be almost superior among all the test insecticides, but was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (2.07% DH), flubendiamide 48SC @ 50 ml/ha (2.48% DH) and carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (2.74% DH). The highest dead heart damage of 10.68 per cent was observed in case of untreated control plot.

**iii) Pooled mean incidence of DH recorded at 10 DAA, during 2016 and 2017**

The results on the effect of insecticides on the incidence dead heart due to yellow stem borer recorded at 10 DAA remained statistically significant and as such, the rice plant treated with the ready mixed combination product of spinetoram 6SC

plus methoxyfenozide 30SC @ 400 ml/ha received the lowest incidence of the dead heart to the tune of 1.62 per cent, which remained almost superior among all the test insecticides, but it was at par with lower dose of the same product i.e. spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.85% DH). The highest dead heart damage of 10.46 per cent was observed in case of the untreated control plot.

**d) Overall mean of dead heart (DH) recorded at 4, 7 and 10 days after application (DAA)**

**i) Mean of DH recorded at 4, 7 and 10 DAA, during 2016**

The dead heart incidence in terms of mean of three (4, 7 & 10 DAA) observational dates, the treatment effect was found to be significant and as such, the new combination product i.e. spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha recorded the lowest incidence of dead hearts (1.11%), which appeared to be superior to all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.27% DH) and flubendiamide 48SC @ 50 ml/ha (1.51% DH). The highest dead heart of 8.04 per cent was observed in case of untreated control plot.

**ii) Mean of DH recorded at 4, 7 and 10 DAA, during 2017**

The mean results of DH of three dates (4, 7 & 10 DAA) of observations with respect to the effect of insecticides after spray on per cent dead heart due to yellow stem borer realized significant results and as such, the ready mix combination of spinetoram 6% plus methoxyfenozide 30% SC @ 400 ml/ha recorded minimum incidence dead hearts of 1.54 per cent, which was superior among almost all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.71% DH), flubendiamide 48SC @ 50 ml/ha (1.95% DH) and carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (2.13% DH). The highest dead heart damage of 8.47 per cent was observed in case of untreated control plot.

**iii) Pooled mean of DH recorded at 4, 7 and 10 DAA during, 2016 and 2017**

The impact on pooled mean results of DH of three dates (4, 7 & 10 DAA) observations dead heart due to yellow stem borer remained almost statistically significant and as such, the rice plant treated with the ready mixed combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha recorded could be able to protect the crop up to the maximum extent resulting in the lowest dead heart of 1.33 per cent, which was almost superior to almost all the test insecticides,

but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.49% DH). The highest dead heart damage of 8.25 per cent was observed in case of untreated control plot in the present studies.

Earlier, various scientists evaluated the efficacy of different chemical insecticide against yellow stem borer in rice at different locations of the country. Rao (2003) found that triazophos, ethofenprox and chlorphriphos used as foliar spray could be highly effective against rice stem bore (*S. incertulas*) and these findings are more or less in consonance with the results of the present field experiment. Das and Mukherjee (2003) obtained significant suppression of *S. incertulas* through foliar spray of chlorphriphos 20EC @ 2.5 lit/ha almost in accordance with the findings of the present studies. Prasad and Prasad (2011) also obtained similar result almost in the line of findings of the present studies indicating that the combination product of certain insecticides viz. (imidacloprid 40% + ethiprole 40%) 80 WG @ 125 g/ha remained significantly more effective against YSB as compared to that sole use of the imidacloprid and ethiprole used as individual treatments. These findings was also endorsed the results of the present studies.

#### **4.5.3: Effect of chemical insecticides on the incidence of yellow stem borer (*Scirpophaga incertulas* Walker) in terms of white ear (WE %)**

The results on the observations recorded on the incidence of white ear (WE) caused by yellow stem borer at dough stage & pre-maturity stage of the crop are shown in Table-4.5.3. The perusal of data revealed that during *kharif*, 2016 and 2017 all the treatments were found significantly superior over untreated control with regard to white ear head infestation caused by rice yellow stem borer. Peak duration of occurrence of yellow stem borer (WE) was observed almost from 95 DAT and onward period during both of years of the experimentations.

##### **a) Incidence of white ear (WE) recorded at dough stage**

##### **i) Incidence of WE recorded at dough stage, during 2016**

The effect of insecticides, after spray, on per cent white ear due to yellow stem borer at dough stage was found to be statistically significant and as such the readymade combination product of the newer molecules i.e. spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha recorded the lowest incidence of white ear head to the tune of 1.44 per cent, which appeared to be superior among all the test insecticides, but it was found almost at par with the lower dose of the same combination product i.e. spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha

(1.68% WE), flubendiamide 48SC @ 50 ml/ha (1.84% WE), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (2.08% WE) and acephate 95SG @ 526g/ha (2.35% WE). The highest white ear damage of 9.72 per cent was observed in case of the untreated crop of rice (var. Naveen).

**ii) Incidence of WE recorded at dough stage, during 2017**

The effect of insecticides after spray on per cent white ear due to yellow stem borer at dough remained significant and as such, the rice plants treated with combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha received the lowest white ear of 1.87 per cent, which appeared to be superior among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (2.11% WE), flubendiamide 48SC @ 50 ml/ha (2.27% WE), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (2.52% WE), acephate 95SG @ 526g/ha (2.73% WE) and triazophos 40EC @ 1500 ml/ha (2.97% WE). The highest white ear damage of 10.16 per cent was observed in case of untreated of rice plants which were left in the unprotected condition.

**iii) Pooled mean incidence of WE recorded at dough stage during, 2016 and 2017**

The pooled data on the effect of insecticides after spray on per cent white ear due to yellow stem borer at dough gave rise to the significant results and the plants treated with the ready mixcombination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha received the minimum incidence of white ear (1.99%), which was superior to almost among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.89% WE), flubendiamide 48SC @ 50 ml/ha (2.05% WE) and carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (2.30% WE). The highest white ear damage of 9.94 per cent was observed in untreated control plot.

**b) Incidence of white ear (WE) recorded at pre-maturity stage**

**i) Incidence of WE recorded at pre-maturity stage, during, 2016**

The effect of insecticides, after spray, on per cent white ear due to yellow stem borer at pre-maturity stage was found to be statistically significant and as such, the readymade combination product of the newer molecules i.e. spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha recorded the lowest incidence of white ear head to the tune of 1.76 per cent, which appeared to be superior among all the test

insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.93% WE), flubendiamide 48SC @ 50 ml/ha (2.11% WE), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (2.25% WE), acephate 95SG @ 526g/ha (2.58% WE), triazophos 40EC @ 1500 ml/ha (2.76%) and triflumezopyrim 106SC @ 237.5 ml/ha (2.93% WE). The highest white ear damage of 11.80 per cent was observed in case of control plot.

**ii) Incidence of WE recorded at pre-maturity stage, during 2017**

The effect of insecticides after spray on per cent white ear (WE) due to yellow stem borer at pre-maturity stage gave rise to the significant results. The ready mix combination of the newer molecules of the insecticide i.e. spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha recorded the minimum incidence of white ear head to the extent of 2.22 per cent, which was superior to almost all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (2.38% WE), flubendiamide 48SC @ 50 ml/ha (2.56% WE), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (2.71% WE), acephate 95SG @ 526g/ha (3.04% WE), triazophos 40EC @ 1500 ml/ha (3.22% WE) and triflumezopyrim 106SC @ 237.5 ml/ha (3.38% WE). The highest white ear damage of 12.26 per cent was observed in case of the untreated control plot.

**iii) Pooled mean incidence of WE recorded at pre-maturity stage, during 2016 and 2017**

The pooled data on the effect of insecticides after spray on per cent white ear due to yellow stem borer at dough gave rise to the significant results and the plants treated with the ready mix combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha received the minimum incidence of white ear (1.99% WE), which was superior to almost among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (2.16% WE), flubendiamide 48SC @ 50 ml/ha (2.34% WE) and carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (2.48% WE). The highest white ear damage of 12.03 per cent was observed in untreated control plot.

**c) Overall mean of white ear (WE) recorded at dough stage and pre-maturity stage**

**i) Mean of WE, recorded at dough stage and pre-maturity stage during, 2016**

The effect of insecticides on the incidence of mean values of white ear of two observations (dough & pre-maturity stage) was found to be significant. The results are shown in Table 4.5.3. revealed that rice plants treated with spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha recorded the lowest incidence of white ear 1.60 per cent, which was almost superior among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.80% WE), flubendiamide 48SC @ 50 ml/ha (1.97% WE), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (2.17% WE), acephate 95SG @ 526g/ha (2.47% WE) and triazophos 40EC @ 1500 ml/ha (2.65% WE). The highest white ear damage of 10.76 per cent was observed in case of untreated control plot.

**ii) Mean of WE, recorded at dough stage and pre-maturity stage, during 2017**

The effect of insecticides after spray on per cent white ear due to yellow stem borer based on the mean observations of two dates (dough & pre-maturity stage) indicated significant results and the ready mixcombination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha recorded the minimum incidence of 2.04 per cent, which was superior to almost all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (2.25% WE), flubendiamide 48SC @ 50 ml/ha (2.42% WE), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (2.61% WE), acephate 95SG @ 526g/ha (2.91% WE) and triazophos 40EC @ 1500 ml/ha (3.10% WE). The highest white ear damage of 11.21 per cent was observed in the untreated control plot.

**iii) Over all pooled mean of WE recorded at dough stage and pre-maturity stage, during 2016 and 2017**

The data received in the form of overall mean of white ear head, recorded at the dough and pre-maturity stage of the crop, of 2016 and 2017 are presented in Table 4.5.2. The experimental data remained significant. The readymade combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha resulted to the minimum incidence of white ear (1.82%), which was superior to almost all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (2.02%), flubendiamide 48SC @ 50 ml/ha (2.19%) and carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha

(2.39%). The highest white ear damage of 10.99 per cent was observed in case of untreated control plot.

Earlier, various scientists evaluated the efficacy of different different chemical insecticides against rice yellow stem borer in rice at different locations of the country. Rao (2003) found that triazophos, ethofenprox and chlorphriphos used as foliar spray could be highly effective against rice stem bore (*S. incertulas*). These findings are in consonance with the results of the present field experiment. Das and Mukherjee (2003) obtained significant suppression of *S. incertulas* through foliar spray of chlorphriphos 20EC @ 2.5 lit/ha almost in accordance with the findings of the present studies. Prasad and Prasad (2011) also obtained and similar results which was almost in the line of findings of the present studies indicating that the combination product of certain insecticides viz. (imidacloprid 40% + ethiprole 40%) 80 WG @ 125 g/ha remained significantly more effective against YSB as compared to that sole use of the recommended insecticides.

#### **4.5.4: Effect of chemical insecticides on the incidence of gall midge (*Orseolia oryzae* Wood mason) in terms of silver shoots (SS %)**

Results are shown in Table-4.5.4. The observations on incidence of gall midge in terms of silver shoot (SS) were recorded at 4, 7 & 10 days after application (DAA) of insecticidal treatment during *khaif* 2016 & 2017. In general, all the treatments proved superior over untreated control, almost throughout the cropping season in suppressing the incidence of silver shoot, caused by gall midge. Peak duration of occurrence of gall midge (bio-type-3) was observed almost from 40 DAT and onward period during both of years of the experimentations.

##### **a) Incidence of silver shoots (SS) recorded at 4 days after application (4 DAA)**

###### **i) Incidence of SS recorded at 4 DAA, during 2016**

At 4 DAA, the data resulted from the test of insecticides against gall midge in terms of silver shoot (SS) were found to be statistically significant. The minimum damage was found in terms of incidence of silver shoot (0.25% SS) in the treatment comprising of ready mix combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was superior to almost all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (0.35% SS) and flubendiamide 48SC @ 50 ml/ha (0.48% SS). The highest silver shoot damage of 5.64 per cent was observed in case of the unprotected crop of rice (var. Naveen).

###### **ii) Incidence of SS recorded at 4 DAA, during 2017**

At 4 DAA, the data resulted from the test of insecticides used against gall midge in terms of silver shoot (SS) gave rise to the significant results. The minimum damage was found in terms of silver shoot in the treatments comprising of ready mix combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha recorded the lowest incidence of silver shoot (0.44% SS), which was superior among all insecticides, but was at par with that of the lower dose of the same product, i.e. spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (0.57% SS) and flubendiamide 48SC @ 50 ml/ha (0.66% SS). The highest incidence silver shoot damage of 5.87 per cent was observed in case of untreated control plot.

**iii) Pooled mean incidence of SS recorded at 4 DAA, during 2016 and 2017**

The pooled data the impact of insecticides used against gall midge in terms of silver shoot (SS) recorded significant results. The minimum damage were found in terms of silver shoot in the treatments comprising of the new combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha recorded the lowest incidence of silver shoot (0.35% SS), which it was superior among all the test insecticides, but was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (0.46% SS). The highest silver shoot damage of 5.75 per cent was observed in case of untreated control plot.

**b) Incidence of silver shoots (SS) recorded at 7 days after application (7 DAA)**

**i) Incidence of SS recorded at 7 DAA, during 2016**

At 7 DAA, the data on the effect of insecticides used against gall midge in terms of silver shoot (SS) gave rise to the significant results. The minimum damage in terms of silver shoot was found in the treatments comprising of ready mix combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha with (0.68%), which was superior to almost all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (0.85% SS) and flubendiamide 48SC @ 50 ml/ha (1.01% SS). The highest silver shoot damage of 6.08 per cent was observed in untreated control plot.

**ii) Incidence of SS recorded at 7 DAA, during 2017**

At 7 DAA, the data on the effect of insecticides used against gall midge in terms of silver shoot (SS) gave rise to the significant results. The minimum damage (1.00% SS) was found in terms of silver shoot was found in case of in the treatment comprising of new combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was superior among all the test insecticides, but it was at par with

spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.17% SS), flubendiamide 48SC @ 50 ml/ha (1.34% SS) and carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (1.47% SS). The highest silver shoot damage of 6.74 per cent was observed in untreated control plot.

**iii) Pooled mean of the incidence of SS recorded at 7 DAA, during 2016 and 2017**

The pooled data of the impact of the test insecticides used against gall midge in terms of silver shoot (SS) reflected the significant results. The minimum damage were found in terms of silver shoot in the treatment comprising of the new combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha recorded the lowest incidence of silver shoot (0.84% SS), which it was superior among all insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.01% SS). The highest silver shoot damage of 6.41 per cent was observed in control plot.

**c) Incidence of silver shoots (SS) recorded at 10 days after application (10 DAA)**

**i) Incidence of SS recorded at 10 DAA, during 2016**

At 10 DAA, the data of insecticides used against gall midge in terms of silver shoot (SS) gave raise to the significant results. The minimum damage were found in terms of silver shoot in the treatment comprising of ready mix combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha recorded the lowest incidence of silver shoot (1.19% SS), which was superior to almost all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.34% SS), flubendiamide 48SC @ 50 ml/ha (1.55% SS), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (1.80% SS) and acephate 95SG @ 526g/ha (1.92% SS). The highest silver shoot damage of 7.26 per cent was observed in case of untreated control plot.

**ii) Incidence of SS recorded at 10 DAA, during 2017**

At 10 DAA, data on the impact of insecticides used against gall midge in terms of silver shoot (SS) gave rise to the significant results. The minimum damage was found in terms of silver shoot in the treatment comprising of new combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha recorded the lowest incidence of silver shoot (1.66% SS), which was superior among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.81% SS), flubendiamide 48SC @ 50 ml/ha (2.02% SS), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha

(2.28% SS) and acephate 95SG @ 526g/ha (2.39% SS). The highest silver shoot damage of 7.73 per cent was observed in untreated control plot.

**iii) Pooled mean incidence of SS recorded at 10 DAA, during 2016 and 2017**

The pooled data of impact of insecticides used against gall midge in terms of silver shoot (SS) recorded significant results. The minimum damage was found in terms of silver shoot in the treatment comprising of the new combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha recorded the lowest incidence of silver shoot (1.43% SS), which was superior among all the test insecticides, but was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.58% SS) and flubendiamide 48SC @ 50 ml/ha (1.79% SS). The highest silver shoot damage of 7.50 per cent was observed in unprotected control plot.

**d) Overall mean of silver shoot (SS) recorded at 4, 7 and 10 DAA (days after application)**

**i) Mean of SS recorded at 4, 7 and 10 DAA, during 2016**

Overall mean of three dates of observations (4, 7 & 10 DAA), the data of insecticides used against gall midge in terms of silver shoot (SS) were recorded significant results. The minimum damage was found in terms of silver shoot in the treatment comprising of ready mix combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha recorded the lowest incidence of silver shoot (0.71% SS), which was superior among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (0.85% SS). The highest silver shoot damage of 6.33 per cent was observed in case of untreated control plot.

**ii) Mean of SS recorded at 4, 7 and 10 DAA, during 2017**

Overall mean values of SS of three dates observations (4, 7 & 10 DAA), in terms of silver shoot (SS) caused by gall midge recorded significant results. The minimum damage was found in terms of silver shoot in the treatment of the new combination product of spinetoram 6% plus methoxyfenozide 30% SC @ 400 ml/ha recorded the lowest incidence of silver shoot (1.04% SS), which was superior among all the test insecticides, but was at par with the lower dose of same insecticide, spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.18% SS). The highest silver shoot damage of 6.77 per cent was observed in untreated control plot.

**iii) Pooled mean of SS recorded at 4, 7 and 10 DAA, during 2016 and 2017**

Overall pooled mean values of SS of three dates observations (4, 7 & 10 DAA), caused by gall midge in terms of silver shoot (SS) recorded significant results.

The minimum damage was found in terms of silver shoot in the treatment comprising of the new combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha recorded the lowest incidence of silver shoot (0.87% SS), which was superior among all insecticides, but was at par with the lower dose of the same insecticide combination product i.e. spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.01% SS). The highest silver shoot damage of 6.55 per cent was observed in the untreated control plot.

Earlier, various scientists evaluated the bio-efficacy of insecticide of different chemical insecticide against gall midge in rice at different locations. Rao (2003) conducted field experiment in the agro-climate conditions of Andhra Pradesh, India, for two consecutive years (years not given) for evaluation of efficacy of triazophos, carbofuran and chlorpyrifos etc. against *S. incertulas* and *O. oryzae*. The results showed that 0.5 and 0.75 kg (a.i) triazophos @ 1500 ml/ha proved to be most effective in reducing the incidence of *O. oryzae* and *S. incertulas* followed by chlorpyrifos and carbofuran. These findings are almost in agreement with the results of the present experiment. Prasad and Prasad (2011) also obtained the similar results there are almost in the line of the findings of the present results indicating the combination products of certain insecticides viz. (imidacloprid 40% + ethiprole 40%) 80 WG @ 125g per hectare or sole use of either of bifenthrin 10EC @ 500 mlit./ha or imidacloprid 200 SL@ 100 mlit./ha could be successfully used as foliar spray on the standing crop on need based basis for optimized management of gall midge, green leaf hopper and hispa to reduce the crop-loss and to enhance grains yield of rice. They also found that monocrotophos 36 WSC @ 1300 ml/ha proved effective against gall midge, GLH and hispa which is more or less similar in accordance with the findings of the present studies.

#### **4.5.5: Effect of chemical insecticides on the incidence of leaf folder (*Cnephalocrosis medinalis*) in terms of leaf damage (LDLF %)**

The results are presented in Table -4.5.5. The observations on the leaf damage, caused by leaf folder (LDLF) were recorded in the late vegetative stage to pre-maturity stage of the crop. As such, observations on per centage of leaf damage, due to leaf folder (LDLF %) was recorded at 4, 7 and 10 DAA (days after application) during *Kharif* 2016 and 2017. Peak duration of occurrence of leaf folder was observed almost from 80 DAT and onward period during both of years of the experimentations.

##### **a) Incidence of leaf damage (LDLF) recorded at 4 days after application (4 DAA)**

**i) Incidence of LDLF recorded at 4 DAA, during 2016**

The effect of insecticides used against leaf folder in terms of leaf damage was found to be significant. The minimum leaf damage (0.44%) was found in the treatment of ready mix combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was found to be superior over all the test insecticides, but it was at par with that of leaf damage due to the pest under the production cover provided with the lower combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (0.52% LDLF) and flubendiamide 48SC @ 50 ml/ha (0.65% LDLF). The highest leaf damage of 7.58 per cent LDLF was observed in case of the unprotected crop.

**ii) Incidence of LDLF recorded at 4 DAA, during 2017**

The effects of the test insecticides on the incidence of leaf folder in terms of leaf damage were found to be significant results (Table 4.5.4). The minimum leaf damage was found in terms of leaf damage 0.44 per cent LDLF in the treatment consisting of the readymade combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which remained superior over all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (0.52% LDLF) and flubendiamide 48SC @ 50 ml/ha (0.65% LDLF). The highest leaf damage of 7.58 per cent LDLF was observed in case of the untreated crop of rice.

**iii) Pooled mean incidence LDLF of recorded at 4 DAA, during 2016 and 2017**

A perusal of the pooled data of the test insecticides against leaf folder in terms of leaf damage was found to be significant. The minimum leaf damage (0.65%) was found in the treatments comprising of the ready mix new combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was found to be superior among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (0.74%). The highest leaf damage of 7.79 per cent LDLF was observed in case of the unprotected crop.

**b) Incidence of leaf damage (LDLF) recorded at 7 days after application (7 DAA)**

**i) Incidence of LDLF recorded at 7 DAA, during 2016**

The effect of the test insecticides used against leaf folder in terms of leaf damage remained significant. The minimum leaf damage (1.00%) was found in the treatment comprising of the ready mix combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which, in turn, remained superior over all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC

@ 375 ml/ha (1.15% LDLF), flubendiamide 48SC @ 50 ml/ha (1.32% LDLF) and carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (1.47% LDLF). The highest leaf damage of 8.85 per cent was observed in case of the untreated crop of rice.

**ii) Incidence of LDLF recorded at 7 DAA, during 2017**

The effect of insecticides on the incidence of leaf folder was found significant. The minimum leaf damage (1.46%) were found in the treatment with the new combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was superior over all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.62% LDLF), flubendiamide 48SC @ 50 ml/ha (1.79% LDLF), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (1.94% LDLF) and acephate 95SG @ 526g/ha (2.08% LDLF). The highest leaf damage of 9.31 per cent LDLF was observed in case unprotected crop of rice.

**iii) Pooled mean incidence of LDLF recorded at 7 DAA, during 2016 and 2017**

A perusal of the pooled data of the test insecticides against leaf folder in terms of leaf damage was found to be significant. The minimum leaf damage of 1.23 per cent was found in the treatment comprising of the new combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was superior over all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.38% LDLF) and flubendiamide 48SC @ 50 ml/ha (1.56% LDLF). The highest leaf damage of 9.08 per cent LDLF was observed in case of the unprotected crop.

**c) Incidence of leaf damage (LDLF) recorded at 10 days after application (10 DAA)**

**i) Incidence of LDLF recorded at 10 DAA, during 2016**

The effects of insecticides used against leaf folder in terms of leaf damage remained significant results. The minimum leaf (1.59%) damage was found in the treatment comprising of the ready mix combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which in turn, remained superior over all the test insecticides, but it was at par with to lower dose of the same combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.82% LDLF), flubendiamide 48SC @ 50 ml/ha (2.03% LDLF) and carbofuran 3G @ 30 kg/ha

followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (2.16%). The highest leaf damage of 9.88 per cent was observed in case of unprotected crop.

**ii) Incidence of LDLF recorded at 10 DAA, during 2017**

The effect of insecticides on the incidence of leaf folder was found significant. The minimum leaf damage (2.03%) was found in the treatment having foliar spray with the combination product spinetoram 6% plus methoxyfenozide 30% SC @ 400 ml/ha, which was superior over all the test insecticides, but it was at par with spinetoram 6% plus methoxyfenozide 30% SC @ 375 ml/ha (2.27% LDLF), flubendiamide 48SC @ 50 ml/ha (2.48% LDLF), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (2.61% LDLF) and acephate 95SG @ 526g/ha (2.77% LDLF). The highest leaf damage of 10.33 per cent was observed in unprotected crop of rice.

**iii) Pooled mean incidence of LDLF recorded at 10 DAA, during 2016 and 2017**

A perusal of results of insecticides, against leaf folder was found to be significant. The minimum leaf damage (1.81%) was found in the treatment of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was superior among all the test insecticides, but it was at par with the lower dose of spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (2.05% LDLF). The highest leaf damage of 10.11 per cent LDLF was observed in case of untreated crop.

**d) Overall mean of leaf damage (LDLF) recorded at 4, 7 and 10 days after application (DAA)**

**i) Mean of LDLF recorded at 4, 7 and 10 DAA, during 2016**

A perusal of results of overall mean of three dates observations (4, 7 & 10 DAA), the effect was found significant. The minimum leaf damage (1.01%) was found in the treatment consisting of the readymade combination of spinetoram 6% plus methoxyfenozide 30% SC @ 400 ml/ha, which in turn, was superior over all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.17% LDLF) and flubendiamide 48SC @ 50 ml/ha (1.33% LDLF). The highest leaf damage of 8.77 per cent LDLF was observed in case of the untreated crop of rice.

**ii) Mean of LDLF recorded at 4, 7 and 10 DAA, during 2017**

A perusal of results of overall mean of three dates observations (4, 7 & 10 DAA), indicated that the effect of insecticides against leaf folder was found to be significant. The minimum leaf damage (1.45%) was found in the treatment

comprising of the new combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which in turn, remained superior over all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.61% LDLF) and flubendiamide 48SC @ 50 ml/ha (1.78% LDLF). The highest leaf damage of 9.22 per cent was observed in case of the untreated crop.

**iii) Pooled mean of LDLF recorded at 4, 7 and 10 DAA, during 2016 and 2017**

A perusal of results pertaining to the overall mean of three dates of observations (4, 7 & 10 DAA), indicated that the impact of the insecticides used against leaf folder in terms of leaf damage was found to be significant. The minimum leaf damage of 1.23 per cent was found in the treatment of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was superior to all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.39% LDLF). The highest leaf damage of 8.99 per cent was observed in case of the unprotected crop.

Earlier, various scientists evaluated the bioefficacy of different chemical insecticide against leaf folder in rice at different locations of India. Findings of earlier workers (Berman and Hussain, 2000; Dash and Mukherjee, 2003; Rao, 2003) are more or less in the agreement with the results of the present field investigation. Prasad (2010) found that combination product (imidacloprid 40WG @+ ethiprole 40%) 80 WG @ 125 g a.i/ha as well as efficacy the combination of cypermethrin 5% EC + chlorpyrifos 50% EC i.e. Super -D @ 1500 ml/ha which could be the most efficacious against leaf folder. These findings of earlier workers also endorsed the results of the present studies. The highest incidence of leaf folder to the tune of 28.55 and 17.84 per cent LDLF were recorded, when the crop was left unprotected in the present field studies in 2016 and 2017, respectively.

**4.5.6: Effect of certain chemical based insecticides on the incidence of green leaf hopper, (GLH) (*Nephtottetix nigropictus* and *N. virescence*), infesting rice**

The results are presented in Table-4.5.6. The incidence of GLH was found to occur almost throughout the cropping season. The observations on the incidence of the pest were recorded to determine the bio-efficacy of the test insecticides at 4, 7 & 10 DAA (days after application) during both of the year of experimentations, 2016 and 2017. Peak duration of occurrence of green leaf hopper was observed almost from 80 DAT and onward period during both of years of the experimentations.

**a) Incidence of GLH recorded at 4 days after application (4 DAA)**

**i) Incidence of GLH recorded at 4 DAA, during 2016**

The effect of the test insecticides on the incidence of green leaf hopper (GLH/10 hills) was found to be significant. The minimum GLH of the pest (3.24 GLH/10 hills) was found in the treatment of the combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was superior over all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (3.57 GLH/10 hills), flubendiamide 48SC @ 50 ml/ha (3.81 GLH/10 hills), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with either of triazophos 40EC @ 1500 ml/ha (4.02 GLH/10 hills), acephate 95SG @ 526g/ha (4.25 GLH/10 hills), triazophos 40EC @ 1500 ml/ha (4.34 GLH/10 hills), triflumezopyrim 106SC @ 237.5 ml/ha (4.55 GLH/10 hills) and rynaxypyr 20SC (4.97 GLH/10 hills). The highest GLH i.e.17.64 GLH/10 hills were observed in case of the untreated plant of rice.

**ii) Incidence of GLH recorded at 4 DAA, during 2017**

The effect of insecticides on the incidence of green leaf hopper was found to be significant. The minimum population of the pest (3.86 GLH/10 hills) was found in the treatment of ready made combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was superior over all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (4.19 GLH/10 hills), flubendiamide 48SC @ 50 ml/ha (4.43 GLH/10 hills), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (4.65 GLH/10 hills), acephate 95SG @ 526g/ha (4.87 GLH/10 hills), triazophos 40EC @ 1500 ml/ha (4.96 GLH/10 hills), triflumezopyrim 106SC @ 237.5 ml/ha (5.17 GLH/10 hills) and rynaxypyr 20SC (5.59 GLH/10 hills). The next best treatment was dinotefurain 20 SG with 6.05 GLH/10 hills was recorded. The highest population of the pest (18.26 GLH/10 hills) was observed in case of the unprotected plants of rice.

**iii) Pooled mean incidence of GLH recorded at 4 DAA, during 2016 and 2017**

The effect of insecticides on the incidence of green leaf hopper was found to be significant. The minimum population the pest was harboured by the plants treated with the combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha which recorded 3.55 GLH/10 hills. This was superior among all insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (3.88 GLH/10 hills), flubendiamide 48SC @ 50 ml/ha (4.12 GLH/10 hills), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha

(4.34 GLH/10 hills) and acephate 95SG @ 526g/ha (4.56 GLH/10 hills). The next best treatments were triazophos 40EC @ 1500 ml/ha (4.65 GLH/10 hills), triflumezopyrim 106SC @ 237.5 ml/ha (4.86 GLH/10 hills), rynaxypyr 20SC (5.23 GLH/10 hills) and dinotefurain 20SG (5.74 GLH/10 hills) recorded and found at par with each others. The highest incidence of the pest i.e. 17.95 GLH/10 hills was observed in case of the unprotected crop of rice.

**b) Incidence of GLH recorded at 7 days after application (7 DAA)**

**i) Incidence of GLH recorded at 7 DAA, during 2016**

The effect of the test insecticides on the incidence green leaf hopper remained significant results. The minimum GLH (4.49 GLH/10 hills) was found in the treatment of the new combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was superior over all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (4.67 GLH/10 hills), flubendiamide 48SC @ 50 ml/ha (4.90 GLH/10 hills), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (5.20 GLH/10 hills), acephate 95SG @ 526g/ha (5.32 GLH/10 hills), triazophos 40EC @ 1500 ml/ha (5.55 GLH/10 hills), triflumezopyrim 106SC @ 237.5 ml/ha (5.88 GLH/10 hills), rynaxypyr 20SC (6.23 GLH/10 hills) and dinotefurain 20 SG (7.06 GLH/10 hills). The highest GLH i.e. 21.71 GLH/10 hills was observed in case of the unprotected crop of rice.

**ii) Incidence of GLH recorded at 7 DAA, during 2017**

The effect of insecticides against green leaf hopper was found to be significantly effective. The minimum pest population (5.15 GLH/10 hills) was found in the ready mix combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was superior over all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (5.33 GLH/10 hills), flubendiamide 48SC @ 50 ml/ha (5.56 GLH/10 hills), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (5.85 GLH/10 hills), acephate 95SG @ 526g/ha (5.98 GLH/10 hills), triazophos 40EC @ 1500 ml/ha (6.20 GLH/10 hills), triflumezopyrim 106SC @ 237.5 ml/ha (6.53 GLH/10 hills), rynaxypyr 20SC (6.89 GLH/10 hills) and dinotefurain 20 SG (7.72 GLH/10 hills). The highest population of the pest (22.37 GLH/10 hills) was observed in in case of the untreated crop of rice.

**iii) Pooled mean of incidence of GLH recorded at 7 DAA, during 2016 and 2017**

The population of the pest varied from 4.82 to 22.04 GLH/10 hills. The treatments were found to be significant. The minimum population was harboured by the rice plants having the protection cover provided with the combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha which recorded lowest pest population (4.82 GLH/10 hills). This was superior among all insecticides, but was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (5.00 GLH/10 hills), flubendiamide 48SC @ 50 ml/ha (5.23 GLH/10 hills), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (5.53 GLH/10 hills), acephate 95SG @ 526g/ha (5.65 GLH/10 hills), triazophos 40EC @ 1500 ml/ha (5.88 GLH/10 hills), triflumezopyrim 106SC @ 237.5 ml/ha (6.21 GLH/10 hills) and rynaxypyr 20SC (6.56 GLH/10 hills). The highest incidence of the pest i.e. 22.04 GLH/10 hills was observed in case of the unprotected crop of rice.

**c) Incidence of GLH recorded at 10 days after application (10 DAA)**

**i) Incidence of GLH recorded at 10 DAA, during 2016**

The effect of insecticides on the incidence of green leaf hopper was found to be significant. The minimum GLH of the pest (6.02 GLH/10 hills) was found in the treatment of new combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was superior among all insecticides, but was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (6.42 GLH/10 hills), flubendiamide 48SC @ 50 ml/ha (6.79 GLH/10 hills), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (7.04 GLH/10 hills), acephate 95SG @ 526g/ha (7.30 GLH/10 hills), triazophos 40EC @ 1500 ml/ha (7.61 GLH/10 hills), triflumezopyrim 106SC @ 237.5 ml/ha (8.08 GLH/10 hills), rynaxypyr 20SC (8.40 GLH/10 hills) and dinotefurain 20 SG (9.04 GLH/10 hills). The highest pest population i.e. 25.87 GLH/10 hills was observed in case of unprotected crop of rice.

**ii) Incidence of GLH recorded at 10 DAA, during 2017**

The effect of insecticides on the incidence of green leaf hopper was significant. The minimum pest population (6.76 GLH/10 hills) was found in the treatment of the ready mix combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was superior over all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (7.16 GLH/10 hills), flubendiamide 48SC @ 50 ml/ha (7.53 GLH/10 hills), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (7.78

GLH/10 hills), acephate 95SG @ 526g/ha (8.03 GLH/10 hills), triazophos 40EC @ 1500 ml/ha (8.34 GLH/10 hills), triflumezopyrim 106SC @ 237.5 ml/ha (8.82 GLH/10 hills), rynaxypyr 20SC (9.13 GLH/10 hills) and dinotefuran 20 SG (9.77 GLH/10 hills). The highest population of the pest (26.60 GLH/10 hills) was registered in case of the unprotected crop of rice.

**iii) Pooled mean incidence of GLH recorded at 10 DAA, during 2016 and 2017**

The population of the insect pest varied from 6.39 to 26.24 GLH/10 hills. The treatments were found to be significant. The minimum pest population (6.39 GLH/10 hills) was harboured by the plants receiving treatment with the combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha. This treatment was found superior among all test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (6.79 GLH/10 hills), flubendiamide 48SC @ 50 ml/ha (7.16 GLH/10 hills), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (7.41 GLH/10 hills), acephate 95SG @ 526g/ha (7.67 GLH/10 hills) and triazophos 40EC @ 1500 ml/ha (7.98 GLH/10 hills). The highest incidence of the pest i.e. 26.24 GLH/10 hills was harboured in case of the unprotected crop of rice.

**d) Overall mean population of GLH recorded at 4, 7 and 10 days after application (DAA)**

**i) Mean of GLH of recorded at 4, 7 and 10 DAA, during 2016**

A perusal of results pertaining mean pest population of three dates observations (4, 7 & 10 DAA), indicated that the effect of insecticides on the incidence of green leaf hopper was found to be significant (Table 4.5.6). The minimum population of the pest (4.58 GLH/10 hills) was found in the treatment of the ready mix combination of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was found superior among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (4.89 GLH/10 hills), flubendiamide 48SC @ 50 ml/ha (5.17 GLH/10 hills), granular application of carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (5.42 GLH/10 hills), acephate 95SG @ 526g/ha (5.62 GLH/10 hills), triazophos 40EC @ 1500 ml/ha (5.83 GLH/10 hills), triflumezopyrim 106SC @ 237.5 ml/ha (6.17 GLH/10 hills) and rynaxypyr 20SC (6.53 GLH/10 hills). The highest population of the insect pest (21.74 GLH/10 hills) was harboured by the rice plants which were left unprotected for natural infestation population of the pest.

**ii) Mean of GLH recorded at 4, 7 and 10 DAA, during 2017**

A perusal result of the mean population of the pest of three dates observations (4, 7 & 10 DAA) indicated that, the effect of insecticides against the incidence of green leaf hopper was found to be significant. The minimum pest population (5.26 GLH/10 hills) was harboured by the plants receiving treatment with the combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha. The combination product of spinetoram 6SC methoxyfenozide 30SC @ 400 ml/ha remained superior among all the test insecticides, but it was also at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (5.56 GLH/10 hills), flubendiamide 48SC @ 50 ml/ha (5.84 GLH/10 hills), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (6.09 GLH/10 hills), acephate 95SG @ 526g/ha (6.30 GLH/10 hills), triazophos 40EC @ 1500 ml/ha (6.50 GLH/10 hills), triflumezopyrim 106SC @ 237.5 ml/ha (6.84 GLH/10 hills), rynaxypyr 20SC (7.21GLH/10 hills) and dinotefurain 20 SG (7.85 GLH/10 hills). The highest population of the pest (22.41 GLH/10 hills) was registered in case of the unprotected crop of rice.

**iii) Pooled mean of GLH recorded at 4, 7 and 10 DAA, during 2016 and 2017**

Overall mean of GLH of three dates of observations (4, 7 & 10 DAA), in respect of the different test treatments remained significant. The population of the pest varied from 4.92 to 22.08 GLH/10 hills. The minimum pest population (4.29 GLH/10 hills) was found in case of the treatment new combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was apparently superior among all insecticides, but it was statistically at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (5.22 GLH/10 hills), flubendiamide 48SC @ 50 ml/ha (5.50 GLH/10 hills), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (5.76 GLH/10 hills), acephate 95SG @ 526g/ha (5.96 GLH/10 hills), triazophos 40EC @ 1500 ml/ha (6.17 GLH/10 hills) and triflumezopyrim 106SC @ 237.5 ml/ha (6.51 GLH/10 hills). The highest incidence of the pest i.e. 22.08 GLH/10 hills was observed in case of the unprotected crop of rice.

Earlier, various scientists evaluated the bioefficacy of different chemical insecticides against green leaf hopper in rice. Nigam *et al.* (1989) found that among the various test treatments, carbofuran 3G and cartap 4G @ each @ 1.0 kg ai/ha and phosalone 35 EC @ 0.50 kg ai/ha proved substantially effective against GLH, leaf folder, ear bug and ear cutting caterpillar infesting rice. Their results are almost in the

agreement of the findings of the present experimentations. Prasad and Prasad (2011) found almost the similar results almost in line of the present findings indicating the highest superiority of the combination product comprising of (imidacloprid 40EC plus ethiprole 40%) 80 WG @ 125 g/ha over the sole use of individual form of the test insecticide(s). In the present studies also the combination product, spinetoram 6SC plus methoxyfenozide 30SC proved superior over the sole use of the individual form of test insecticides in reducing the incidence of GLH. Prasad and Prasad (2011) also found effective reduction of the pest (GLH) through foliar spray of monocrotophos, which also endorsed the findings of the present studies.

#### **4.5.7: Effect of chemical insecticides on the incidence of gundhi /ear bug (*Leptocorsia oratorius* and *L. acuta*) infesting rice**

The observations pertaining to gundhi bug/ear bug (*Leptocorisa oratorius* and *L. acuta*) were recorded at milking stage of the crop to determine the bioefficacy of certain test insecticides against the pest during both of the years of experimentations, 2016 and 2017. The results are presented in Table-4.5.7. Peak duration of occurrence of gundhi bug was observed almost from 95 DAT and onward period during both of years of the experimentations.

##### **a) Incidence of gundhi bug recorded at 4 days after application (4 DAA)**

###### **i) Incidence of GB recorded at 4 DAA, during 2016**

The effect of different insecticides against ear bug was found significant results. The minimum pest population (0.85 GB/10 hills) was recorded in the treatment comprising of the new combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was apparently superior among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (0.98 GB/10 hills), flubendiamide 48SC @ 50 ml/ha (1.13 GB/10 hills), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (1.23 GB/10 hills), acephate 95SG @ 526g/ha (1.33 GB/10 hills), triazophos 40EC @ 1500 ml/ha (1.54 GB/10 hills) and triflumezopyrim 106SC @ 237.5 ml/ha (1.75 GB/10 hills). The highest population of the pest (9.28 GB/10 hills) was harboured by the rice plants which were left unprotected.

###### **ii) Incidence of GB recorded at 4 DAA, during 2017**

The effect of different insecticides against ear bug was found significant. The minimum pest population of the pest (1.18 GB/10 hills) was found in the treatment comprising of the new combination product of spinetoram 6SC plus

methoxyfenozide 30SC @ 400 ml/ha, which was apparently superior among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.31 GB/10 hills), flubendiamide 48SC @ 50 ml/ha (1.47 GB/10 hills), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (1.57 GB/10 hills), acephate 95SG @ 526g/ha (1.66 GB/10 hills), triazophos 40EC @ 1500 ml/ha (1.87 GB/10 hills) and triflumezopyrim 106SC @ 237.5 ml/ha (2.08 GB/10 hills). The highest population of the pest (9.61 GB/10 hills) was observed in the untreated crop of rice.

**iii) Pooled mean incidence of GB recorded at 4DAA, during 2016 and 2017**

The effect of insecticides against ear bug based on the mean pest population of 2016 and 2017 at 4DAA was found significant results. The minimum pest population (1.02GB/10 hills) was found in the treatment comprising of the new combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was apparently superior among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.14 GB/10 hills), flubendiamide 48SC @ 50 ml/ha (1.30 GB/10 hills), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (1.40 GB/10 hills) and acephate 95SG @ 526g/ha (1.50 GB/10 hills). The highest population of the pest (9.45 GB/10 hills) was observed in case of the unprotected plants of rice.

**b) Incidence of GB recorded at 7 days after application (7 DAA)**

**i) Incidence of GB recorded at 7 DAA, during 2016**

The effect of insecticides on the incidence gundhi bug recorded was found significant. The minimum pest population (1.22 GB/10 hills) was found in the treatment comprising of the new combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was apparently superior among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.46 GB/10 hills), flubendiamide 48SC @ 50 ml/ha (1.64 GB/10 hills), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (1.79 GB/10 hills), acephate 95SG @ 526g/ha (1.99 GB/10 hills) and triazophos 40EC @ 1500 ml/ha (2.16 GB/10 hills). The highest population of the pest (11.53 GB/10 hills) was observed in case of unprotected crop of rice.

**ii) Incidence of GB recorded at 7 DAA, during 2017**

The effect of different insecticides gundhi bug remained significant. The minimum pest population (1.60 GB/10 hills) was found in the treatment comprising of

the new combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was apparently superior among all the test insecticides, but it was at par with Spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.84 GB/10 hills), flubendiamide 48SC @ 50 ml/ha (2.02 GB/10 hills), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (2.17 GB/10 hills), acephate 95SG @ 526g/ha (2.37 GB/10 hills), triazophos 40EC @ 1500 ml/ha (2.54 GB/10 hills) and triflumezopyrim 106SC @ 237.5 ml/ha (2.70 GB/10 hills). The highest population of the pest (11.91 GB/10 hills) was observed in case the untreated plants of rice.

**iii) Pooled mean incidence of GB recorded at 7DAA, during 2016 and 2017**

The results in this regards remained to be significant. The minimum pest population (1.41GB/10 hills) was found in the treatment comprising of the new combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was apparently superior among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.65 GB/10 hills), flubendiamide 48SC @ 50 ml/ha (1.83 GB/10 hills) and carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (1.98 GB/10 hills). The highest population of the pest (11.72 GB/10 hills) was observed in case of the unprotected plants of rice.

**c) Incidence of GB recorded at 10 days after application (10 DAA)**

**i) Incidence of GB recorded at 10 DAA, during 2016**

The effect of insecticides on the incidence ear bug recorded of the significant. The minimum population gundhi bug (1.38 GB/10 hills) was found in the treatment comprising of the new combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was apparently superior among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.61 GB/10 hills), flubendiamide 48SC @ 50 ml/ha (1.81GB/10 hills), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (1.99 GB/10 hills), acephate 95SG @ 526g/ha (2.23 GB/10 hills), triazophos 40EC @ 1500 ml/ha (2.41 GB/10 hills) and triflumezopyrim 106SC @ 237.5 ml/ha (2.66 GB/10 hills). The highest population of the pest (12.97 GB/10 hills) was observed in case of the untreated plants of rice.

**ii) Incidence of GB recorded at 10 DAA, during 2017**

The effect of insecticides against on the incidence ear bug recorded remained significant. The minimum pest population gundhi bug (1.95 GB/10 hills) was found in the treatment comprising of the new combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was apparently superior among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (2.14 GB/10 hills), flubendiamide 48SC @ 50 ml/ha (2.34 GB/10 hills), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (2.52 GB/10 hills), acephate 95SG @ 526g/ha (2.76 GB/10 hills), triazophos 40EC @ 1500 ml/ha (2.94 GB/10 hills) and triflumezopyrim 106SC @ 237.5 ml/ha (3.19 GB/10 hills). The highest population of the pest (13.50 GB/10 hills) was observed in the untreated control plot.

**iii) Pooled mean incidence of GB recorded at 10 DAA, during 2016 and 2017**

The insecticidal treatments differed significantly. The minimum pest population (1.69GB/10 hills) was found in the treatment comprising of the new combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was apparently superior among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.88 GB/10 hills), flubendiamide 48SC @ 50 ml/ha (2.08 GB/10 hills) and carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (2.25 GB/10 hills). The highest population of the pest (13.24 GB/10 hills) was observed in case of the unprotected plants of rice.

**d) Overall mean of GB recorded at 4, 7 and 10 days after application (DAA)**

**i) Mean of GB recorded at 4, 7 and 10 DAA, during 2016**

Overall mean of GB of three dates of observations (4, 7 & 10 DAA), in respect of the effect of insecticides against ear bug was found to be significant. The minimum population of gundhi bug (1.16 GB/10 hills) was found in the treatment comprising of the new combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was apparently superior among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.35 GB/10 hills), flubendiamide 48SC @ 50 ml/ha (1.53 GB/10 hills), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (1.67 GB/10 hills) and acephate 95SG @ 526g/ha (1.85 GB/10 hills). The highest population of the pest (11.26 GB/10 hills) was observed in the untreated crop of rice.

**ii) Mean of GB recorded at 4, 7 and 10 DAA, during 2017**

Overall mean of GB three dates of observations (4, 7 & 10 DAA), in respect of the effect of insecticides against the pest was also found significant. The minimum population of gundhi bug (1.58GB/10 hills) was found in the treatment comprising of the new combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was apparently superior among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.77 GB/10 hills), flubendiamide 48SC @ 50 ml/ha (1.94 GB/10 hills), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (2.08 GB/10 hills), acephate 95SG @ 526g/ha (2.27 GB/10 hills) and triazophos 40EC @ 1500 ml/ha (2.45 GB/10 hills). The highest population of the pest (11.67 GB/10 hills) was observed in case of the unprotected plants of rice.

### **iii) Pooled mean of GB recorded at 4, 7 and 10 DAA, during 2016 and 2017**

There was significant effect of the insecticidal treatments in this regards. The minimum population of gundhi bug (1.37GB/10 hills) was found in the treatment comprising of the new combination product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, which was apparently superior among all the test insecticides, but it was at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (1.56 GB/10 hills), flubendiamide 48SC @ 50 ml/ha (1.74 GB/10 hills) and carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (1.88 GB/10 hills). The highest population of the pest (11.47 GB/10 hills) was observed in case of the unprotected plants of rice.

Earlier, very few scientists evaluated the bioefficacy of different chemical insecticides against gundhi bug in rice at different locations of the country. Nigam *et al.* (1989) found that carbofuran 3G @ 30 kg/ha, cartap hydrochloride 4G @ 25kg/ha and phosalone 35 EC @ 0.05 kg ai/ha proved more efficacious than other insecticidal treatments including the untreated control against major insect pests of rice. Their findings are in consonance with that of the present results.

### **4.5.8: Effect of certain chemical based insecticides on grains' yield of rice**

The observations of the grains yield of rice as influenced by effect of chemical insecticides are shown in (Table –4.5.8).

#### **a) Yield of rice grains recorded during first year (*Kharif 2016*):**

The results revealed that the highest yield of grains of rice (47.95 q/ha) was obtained through protection against the pest complex that provided by foliar spray with the ready mix insecticidal combination product of spinetoram 6SC plus

methoxyfenozide 30SC @ 400 ml/ha, as against the lowest yield of 35.73 q/ha which was recorded when the crop was left in the unprotected conditions. The lower dose of the same combination product with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha realized grains yield (47.23q/ha) which remained at par with its own higher dose which in turn, realized the yield at par with flubendiamide 48SC @ 50 ml/ha (46.27 q/ha), granular application of carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (45.10 q/ha), acephate 95SG @ 526g/ha (44.03 q/ha), triazophos 40EC @ 1500 ml/ha (43.95 q/ha) and triflumezopyrim 106SC @ 237.5 ml/ha (42.97 q/ha) .

**b) Yield of rice grain recorded during second year (*Kharif* 2017):**

The results revealed that the highest yield of grains of rice (48.85 q/ha) was obtained through protection against the pest complex provided by foliar spray with the new combination product comprising of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, as against the lowest yield of 36.63 q/ha which recorded when the crop was left in the unprotected condition. The lower dose of the same combination product of with spinetoram 6SC plus methoxyfenozide 30SC applied @ 375 ml/ha realized grains yield (48.13q/ha) which remained at par with its own higher dose which in turn, realized the yield at par with flubendiamide 48SC @ 50 ml/ha (47.17 q/ha), granular application of carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (46.00 q/ha), acephate 95SG @ 526g/ha (44.93 q/ha), triazophos 40EC @ 1500 ml/ha (44.40 q/ha) and triflumezopyrim 106SC @ 237.5 ml/ha (43.87 q/ha) .

**c) Two years' pooled mean yield of rice grains recorded during *kharif* 2016 and 2017:**

The results revealed that the highest yield of grains of rice (48.40 q/ha) was obtained through protection against the major insect pest complex was provided by foliar spray with the new combination comprising product of spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha, as against the lowest yield of 36.18 q/ha which was recorded when the crop was left in the unprotected condition. The lower dose of the same combination product of with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha realized grains yield (47.68q/ha) which remained at par with its own higher dose which in turn, realized the yield at par with flubendiamide 48SC @ 50 ml/ha (46.72 q/ha) and granular application of carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (45.55 q/ha).

Various workers evaluated the bioefficacy of different chemical insecticides against the major insect pests of rice and their resultant impact on grains yield, at some locations of India. It is note worthy to mention here that not much information is available in the literatures pertaining to bio-efficacy of botanical insecticides and their ultimate impact on grains yield of rice, however, findings of Dhaliwal *et al.* (2006) indicating the highest yield of rice grains (50.50q/ha) was obtained in case of monocrotophos treated rice plants followed by 46.4q/ha that was obtained when rice plants received protection with sprays of Neemazal as compared with the lowest yield of 34.3q/ha in the untreated rice plants that findings of Dhaliwal *et al.* (2006) almost in the line of the results of the present field investigations. Rath *et al.* (2015) found that the grain yield obtained with the treatment of imidacloprid 17.8% @ 300 g/ha was highest (5.28 and 5.21 t/ha) that remained significantly superior to the check insecticide monocrotophus 36SL @ 1390 ml/ha (4.65 and 4.62 t/ha) and at par with thiamethoxam 25SG @ 100 g/ha (4.9 and 4.85 t/ha), triazophos 40EC @ 625 g/ha (4.78 and 4.8 t/ha) and new insecticide Sulfoxaflor 24% @ 375 g/ha (4.96 and 4.92 t/ha) during 2011 and 2012 respectively, which remained more or less similar to the result of the present studies.

**4.5.9: Computation of economics of judicious and need based foliar application of some chemical insecticides for management of the major prevailing insect pest complex of rice (var. Naveen):**

The economics was calculated based the mean yield of two year's experimentations. A perusal results (Table-5.4.9) revealed that four foliar application of acephate 95SG@ 526g/ha realizing net income of Rs. 13,881.40/ha and maximum B:C ratio of 4.95:1 and followed by dinotefuran 20SG @ 200g/ha with net income of Rs. 9810.70/ha and B:C ratio of 4.93:1. Four foliar spray with spinotoram 6SC plus methoxyfenozide 30SC (i.e. 36SC) @ 400 ml/ha applied over the standing rice crop at 25, 40, 80 and 95 DAT realized the highest net profit of Rs.19,654.20/ha with benefit cost ratio (B:C ratio) of 4.00:1 followed by four foliar spray with the ready mix new combination product of spinotoram 6SC plus methoxyfenozide 30SC (i.e. 36SC) @ 375 ml/ha with B:C ratio of 3.96:1 and net profit of Rs. 18,457.20/ha followed by flubendaiamide 48SC @50ml/ha with net profit of Rs. 17,477.4/ha and B:C ratio of 4.71:1, granular application of cabofuran 3G @ 30kg/ha at 25DAT followed by two

rounds of foliar spray with triazophos 40EC @1500ml/ha at 80 and 95 DAT with net income of Rs. 14,852.70/ha and B:C ratio of 3.73:1.

As such, all the test insecticidal treatments could found to be able to realize appreciably higher net profit ranging from Rs. 11,264.40/ha to Rs. 19,654.20/ha and benefit cost ratios from 3.33:1 to 4.95:1 except rynaxypyr 20SC @ 150 ml/ha and dinotefuran 20SG @ 200g/ha which resulted to net profit below Rs. 10,000/ha owing to the their higher price in the present studies.

Prasad and Prasad (2010) obtained highest net profit and benefit cost ratio with granular application of carbofuran 3G @ 30 kg/ha coupled with need based foliar sprays with monocrotophos 36 WSC @ 1390 ml/ha. As such, finding of Prasad and Prasad (2010) are more or less in the consonance with the results of the present investigation. Abrol *et al.* (2013) reported that the maximum benefit cost ratio of 50.3:1 which was obtained with application of cartap hydrochloride followed by carbofuran (26.45:1) and fipronil (1:24.24:1).

Hembrom and Prasad (2014) obtained the higher net profit of Rs. 19,187/ha when the rice crop was provided protection through need based foliar spray with triazophos 40 EC @1500ml/ha followed by cartap hydrochloride 50 SP @ 1000 ml/ ha. These findings are more or less in the agreement of the present studies. Prasad *et al.* (2018) also obtained the similar results to that of the present studies.

Accordingly, based on the overall results of two years experimentation, it may be concluded that the newer ready mix combination product of spinetoram 6SC plus methoxyfenozide 30SC (i.e 36SC) @ 375 to 400 ml/ha applied as need based basis as foliar spray at 25, 40, 80 and 95 DAT could be able to cause substantial suppression in the incidence of major insect pest fauna, which, in turn, resulted higher grains yield, net profit and benefit cost ratio, followed by the other treatments viz. flubendiamide, triazophos and triflumezopyrim etc.



*SUMMARY  
AND  
CONCLUSION*

## Summary and Conclusion

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Rice (*Oryza Sativa* L.) is one of the most important staple foods of India including the state of Jharkhand. Insect pest fauna are posing serious threats, responsible for causing substantial loss in yield of rice in the country and the state of Jharkhand as well.

Rice crop is adversely affected by various insect species starting from seedling to maturity stage, Out of one dozen insect pests species prevailing in rice – agro- ecosystem in the state of Jharkhand, half of a dozen of them are considered as major insect pests which are responsible for causing loss in yield ranging from 20 to 35 per cent in general in the state (Prasad *et al*, 2006 and Krishnaiah *et al*, 2008). Appropriate and suitable integrated pest management technologies are required by farmers to overcome pest problems and to minimize the yield loss for sustainable production of rice for ensuring food security. Information in this regards is almost lacking in the state of Jharkhand.

Hence, the present field investigation entitled “**Management of insect pest complex of rice**” was undertaken to explore certain valuable information for successful management of prevailing major insect pest fauna for eco-friendly and sustainable cultivation of rice through monitoring, staggering in date of planting, use of HPR, judicious and need based use of botanical and newer molecules of chemical insecticides.

Accordingly, the thesis protocol was undertaken with the five sets of field experiments to meet the requirements of five objectives of the present field investigations which are briefly summarized as below:

- i) Study on biodiversity of insect-pest species in the agro-ecosystem of rice in Jharkhand.
- ii) Evaluation certain rice varieties and genotypes against major insect-pests of rice.
- iii) Study the effect of staggering in date of transplanting on the incidence of insect-pest complex of rice.
- iv) Evaluation field bio- efficacy of botanical based insecticides against major insect-pests of rice.
- v) Evaluation field bio- efficacy of newer molecules of insecticides against major insect-pests of rice.

The salients of findings are briefly described as below:

**i) Biodiversity of insect-pest species in the agro-ecosystem of rice in Jharkhand.**

The result revealed that as many as more two dozen of insect pests are prevalent in the state but only eighteen pest species were found to be more prominent which usually to attack rice crop in the field condition. It was found that nine insect pest species viz. yellow stem borer, gall midge, leaf folder, gundhi bug, green leafhopper, brown plant hopper, rice hispa, termite, grass hoppers were found to be prevalent in almost through the whole state of Jharkhand. These pest species were found to attack rice crop in the field conditions. Out of eighteen pest species, six of them (yellow stem borer, gall midge, leaf folder, gundhi bug, brown plant hopper and termite) were found to occupy major pest status in 24 districts in Jharkhand, rests eight insect pest species (green leafhopper, rice hispa, grass hoppers, rice mealy bug, white grubs, yellow hairy caterpillar, whorl maggot and thrips) occupied the status of minor pests and four of them (case worm, swarming caterpillar, hairy caterpillar and cut worm) were took the place of sporadic pest status in Jharkhand state. Depending upon topography, land in Jharkhand is broadly classified into six groups. In *Don I* and *Don II* lands, major pest were yellow stem borer, gall midge, leaf folder, gundhi bug, green leaf hopper, brown plant hopper, rice hispa, case worm and grass hoppers and in *Don III* and *Tanr III* lands was i.e. in medium land of this region major problem of pest were yellow stem borer, gall midge, leaf folder, gundhi bug, green leaf hopper, brown plant hopper, rice hispa, grass hoppers, rice mealy bug, swarming caterpillar, yellow hairy caterpillar, black hairy caterpillar and thrips. *Tanr I* and *Tanr II* land which are considered as pure upland condition in this area which have major problem of termite, yellow stem borer, rice hispa, yellow hairy caterpillar and white grubs. Since last 4-5 years, brown plant hopper is gradually emerging as pest of major economic significance in medium and low land ecologies in the state of Jharkhand.

**ii) Field evaluation certain rice varieties and genotypes against major insect pests of rice.**

The experimental results of field screening of 20 rice genotypes/ varieties against six major insect pest species (yellow stem borer, gall midge, hispa, leaf folder, GLH and gundhi bug) revealed that Suraksha, Kavya, Lalat, CR Dhan – 303, CR Dhan – 205, CR

Dhan – 304, Sahbhagi Dhan, IR-36 and Naveen were found to be tolerant/ resistant to these pests. However, Lalat was resistant to the five pests only and it was found to be moderately susceptible to leaf folder. As such considerably higher grain yield of rice grains were obtained. The test varieties could be arranged in descending order of: Achhay Dhan (61.15 q/ha) > Advanta-801<sup>+</sup> (59.30 q/ha) > CR Dhan -205 (52.58 q/ha) > CR Dhan – 303 (51.16 q/ha) > Lalat (50.95 q/ha) > IR-36 (50.34 q/ha) > Abhisek (49.78 q/ha) in terms of grains yield and all these seven varieties remained statistically at par. TN-1 appeared as susceptible to almost all the six major insect pest species.

**iii) Effect of staggering in date of transplanting on the incidence of major insect-pest complex of rice.**

It was found that earlier was the dates of planting, lesser was the intensity of the pests' (yellow stem borer, gall midge, hispa, leaf folder, GLH and gundhi bug) incidence. As such, pests' incidence, in general, was found to be in descending order of: early planting < normal planting < late planting, except gundhi bug, which was reverse in order of occurrence. Quantum of grains yield also varied almost in similar trends indicating 48.38, 44.53 and 39.02 q/ha, respectively in case of early, normal and late planted crop of rice (var. Sahbhagi Dhan).

**iv) Field bio- efficacy of botanical based insecticides against major insect pests of rice.**

Seven botanical insecticides (Neem Ban (1% Aza. EC), Neemazal (1% Aza. EC), Nimbecidine (0.3% Aza. EC), Multineem (0.3% Aza. EC), neem oil, Achook (0.3% Aza. EC) and pongamia oil) and two chemical insecticides (dinotefuran 20SG and rynaxypyr 20 SC) were tested in the field conditions against the major prevailing insect pests of rice and compared with untreated control. As such, there were 10 treatments including untreated check. All the 9 treatments remained superior to the untreated control in terms of pests' suppression and realization of grain's yield of rice (var: IR-64Drt.). Efficacy of all botanical insecticides appeared to be almost at par in terms of reduction in the incidence of prevailing major insect pests viz. YSB, gall midge, hispa, leaf folder, GLH and gundhi bug. A yield of grain's obtained with the test treatments were also found to be almost at par. The significantly lowest yield of (34.98 q/ha) was obtained with untreated control. Achook (0.03 % Aza.EC) @2500 ml/ha proved to be the most effective in

reducing the incidence of the prevailing major insect pests, which, in turn realized the highest yield of grains (49.70 q/ha). However, chemical insecticides viz. rynaxypyr 20 SC @ 150 ml/ha and dinotefuran 20SG @ 200g/ha proved more effective as compared to other botanicals. Those of the test botanical insecticides in reducing the incidence of major pests of rice. Need based use of foliar sprays of the test botanical insecticides viz. Achook (0.03% Aza.) @ 2500 ml/ha realized the highest yield of grains (49.70 q/ha) of rice (var. IR-64Drt.), net profit (Rs. 22,679.20/ha) with B:C ratio of 3.28:1 followed by Neem Baan (1%Aza.) @1000 ml/ha with higher grains yield of 46.40 q/ha, net profit of Rs. 17,966.20/ha and B:C ratio of 3.60:1, followed by pongamia oil @ 2500 ml/ha realizing higher grains yield of 44.72 q/ha, net profit of Rs.16,169.40/ha and the highest B:C ratio of 4.74:1 among the test botanical insecticides, based on mean of two years experimentation under the present studies.

**v) Field bio- efficacy of newer molecules of insecticides against major insect pests of rice.**

The field bio-efficacy of a newer ready mixed combination product viz spinetoram plus methoxy-fenozide and other newer and conventionally recommended insecticides and few popular insecticides were evaluated in the field conditions with rice (var. Naveen). As such, there were 10 treatments and 3 replications in the experiment to determine the relative efficacy of the test chemical insecticides against the prevailing major insect pests of rice viz. YSB, gall midge, hispa, leaf folder, GLH and gundhi bug and their consequent impact on grains yields. It was observed that the newer ready mixed combination product viz. spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha remained the most effective against almost all the prevailing major insect pests of rice, which, in turn, found at par with the same combination product of the insecticide, spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha, flubendiamide 48SC @ 50 ml/ha and carbofuran 3G @ 30 kg/ha plus triazophos 40 EC @ 1500 ml/ha against all the prevailing major insect pests of rice. The new combination product (viz. spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha could be also responsible for realizing the highest yield of rice grains (48.40 q/ha) which, in turn, remained at par with spinetoram 6SC plus methoxyfenozide 30SC @ 375 ml/ha (47.68 q/ha), flubendiamide 48SC @ 50 ml/ha (46.72 q/ha) and carbofuran 3G @ 30 kg/ha plus triazophos 40 EC @ 1500 ml/ha

(45.55 q/ha). Although, all the nine treatments remained superior over untreated control in terms of pest suppression and realization grains yield of rice. The lowest yield of 36.18 q/ha was obtained when the crop was left unprotected.

### **CONCLUSION**

1. Among the 18 prevailing insect pest species occurring in the rice agro-ecosystem in the state of Jharkhand, six of them occurred as major insect pests viz. yellow stem borer, gall midge, leaf folder, gundhi bug, brown plant hopper and termite. Brown plant hopper is gradually emerging as pest of major economic significance in medium and low land ecologies in the state of Jharkhand.
2. The rice varieties, Suraksha, Kavya, Lalat, CR Dhan – 303, CR Dhan – 205, CR Dhan – 304, Sabhagi Dhan, IR-36 and Naveen appeared as resistant and tolerant to six major insect pest species (YSB, gall midge, hispa, leaf folder, GLH and ear bug) where as Lalat emerged resistant to five major pest species (YSB, gall midge, hispa, GLH and ear bug) remained susceptible to leaf folder.
3. It was interesting to note that earlier was the date of planting, lesser was the intensity of incidence and abundance of the major pest species indicating the pest intensity was in order of: early planting < normal planting < late planting resulting in grains yield to the tune of 48.38, 44.53 and 39.02 q/ha, respectively obtained from rice variety, Sahbhagi Dhan.
4. Need based use of foliar sprays of the test botanical insecticides viz. Achook (0.03% Aza.) @ 2500 ml/ha realized the highest yield of grains (49.70 q/ha) of rice (var. IR-64Drt.), net profit (Rs. 22,679.20/ha) with B:C ratio of 3.28:1 followed by Neem Baan (1% Aza.) @ 1000 ml/ha with higher grains yield of 46.40 q/ha, net profit of Rs. 17,966.20/ha and B:C ratio of 3.60:1, followed by pongamia oil @ 2500 ml/ha realizing higher grains yield of 44.72 q/ha, net profit of Rs.16,169.40/ha and the highest B:C ratio of 4.74:1 among the test botanical insecticides, based on mean of two years experimentation under the present studies.
5. The results obtained from two years field investigation revealed that judicious and need based use of the ready mix new combination of spinetoram 6SC plus methoxyfenozide 30SC (i.e 36SC) applied as foliar spray at 25, 40, 80 and 95

DAT@ 400ml/ha resulted in to significantly higher yield of grains of rice (var. Naveen) to the tune of 48.40q/ha with net profit of Rs. 19,654.20 q/ha, B:C ratio 4:1 followed by spinetoram 6SC plus methoxyfenozide 30SC (i.e 36SC) @ 375ml/ha with grain yield of 47.68 q/ha, net income of Rs 18,457/ha and B:C ratio of 3.96:1 and flubendiamide 48SC @ 50 ml/ha realizing grains yield of 46.72 q/ha, the highest net monetary return of Rs. 17,477.40 q/ha and B:C ratio of 4.71:1 based on the mean results of two years experimentation on the insecticide evaluation programme under the percent field investigation.

In nut shell, it may be concluded that use of host plant resistance (HPR) coupled with optimal (i.e. early) dates of planting and judicious foliar application of the botanical insecticides viz. Achook (0.03 % Aza.EC) @ 2500 ml/ha, Neem Ban (1% Aza. EC) @ 1000 ml/ha, Neemazal (1% Aza. EC) @ 1000 ml/ha, etc. and judicious use of the new combination product, spinetoram 6SC plus methoxyfenozide 30SC @ 400 ml/ha could be able to realize promising IPM tools for significant reduction in the incidence of the major prevailing insect pests resulting in minimization of the yield loss caused by the major insect pest species and maximization of yield of rice grains for its sustainable cultivation of the crop with higher net profit and benefit cost ratios with the minimum or no harm to the rice ecologies.



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**Appendix I:: Physical and chemical properties of the experimental site**

No.	Particulars	Values	Rating
<b>A. Physical-Mechanical composition</b>			
	Sand (%)	37.3	-
	Silt (%)	30.2	-
	Clay (%)	32.5	-
	Textured class	clay loam	-
	Bulk density(Mg/m <sup>3</sup> )	1.37	-
<b>B. Chemical composition</b>			
1.	Available nitrogen (kg/ha)	206.00	Low
2.	Available phosphorus(P <sub>2</sub> O <sub>5</sub> ) (kg/ha)	31.35	Medium
3.	Available potassium(K <sub>2</sub> O) (kg/ha)	185.06	Medium
4.	pH (1:2.5, Soil : water)	5.9	Acidic
5.	Organic carbon (g/kg)	3.8	Low

**Appendix II:: Weekly average meteorological data during the period of investigation  
2016**

Period	Week	Temperature (°C)		Relative humidity (%)		Rain fall (mm)	Wind Speed (km/hr)	Sun shine hours
	No.	Maxi.	Mini.	7.0 AM	2.0 P.M			
28th May- 3rd Jun	22	34.4	22.7	82.1	57.1	12.5	3.8	53.4
4th Jun - 10th Jun	23	37.6	23.7	76.6	58.4	28.9	5.1	67.4
11th Jun- 17th Jun	24	37.7	24.2	77.3	56.0	38.6	5.9	48.2
18th Jun- 24th Jun	25	32.2	23.0	82.4	67.9	70.1	4.5	38.0
25th Jun- 1st Jul	26	33.4	24.9	79.9	61.9	77.1	4.5	52.8
2nd Jul-8th Jul	27	30.3	20.3	82.0	57.9	65.0	6.6	13.7
9th Jul-15th Jul	28	29.5	20.7	82.3	71.7	82.0	4.5	27.6
16th Jul-22nd Jul	29	28.7	20.9	82.0	70.1	87.1	5.6	5.9
23rd Jul-29th Jul	30	30.6	22.3	83.9	71.6	90.9	4.4	29.7
30th Jul-5th Aug	31	30.5	22.6	84.1	71.3	77.4	4.7	31.5
6th Aug- 12th Aug	32	29.0	20.9	82.6	67.6	73.6	5.0	13.1
13th Aug- 19th Aug	33	29.9	21.5	85.1	70.6	71.7	4.9	27.6
20th Aug- 26th Aug	34	30.6	21.1	81.7	70.3	65.1	4.1	35.4
27th Aug-2nd Sep	35	33.0	23.1	81.9	50.7	68.8	3.4	59.7
3rd Sep- 9th Sep	36	27.9	21.3	85.1	65.0	72.0	5.1	6.9
10th Sep-16th Sep	37	29.8	21.3	83.3	70.9	75.0	3.7	26.2
17th sep-23rd Sep	38	30.9	22.1	80.0	60.6	50.9	3.1	50.6
24th Sep- 30th Sep	39	29.9	21.0	84.3	68.1	40.4	4.0	39.8
1st Oct-07th Oct	40	30.0	20.7	83.7	69.4	28.6	2.5	57.8
8th Oct-14th Oct	41	28.7	19.0	82.4	70.7	21.2	3.5	47.3
15th Oct- 21st Oct	42	28.2	14.6	85.4	59.4	13.7	1.5	65.5
22nd Oct- 28th Oct	43	28.6	14.5	87.3	46.9	11.9	2.1	63.2
29th Oct- 4th Nov	44	28.1	14.6	85.9	58.1	7.7	2.9	60.9
5th Nov- 11th Nov	45	26.9	12.1	86.4	59.0	3.6	2.6	56.7
12th Nov- 18th Nov	46	27.0	10.9	87.1	49.0	2.0	2.2	60.5

### Appendix III:: Weekly average meteorological data during the period of investigation

2017

Period	Week	Temperature (°C)		Relative humidity (%)		Rain fall (mm)	Wind Speed (km/hr)	Sun shine hours
	No.	Maxi.	Mini.	7.0 AM	2.0 P.M			
28th May- 3rd Jun	22	33.2	20.2	84.3	69.3	12.5	5.4	52.9
4th Jun - 10th Jun	23	34.3	20.9	84.7	69.4	28.9	6.1	34.3
11th Jun- 17th Jun	24	34.4	21.6	84.9	69.1	38.6	3.9	59.8
18th Jun- 24th Jun	25	30.7	19.5	82.4	69.6	70.1	3.4	46.5
25th Jun- 1st Jul	26	30.1	20.5	86.6	69.1	77.1	2.2	51.4
2nd Jul-8th Jul	27	26.8	16.6	86.0	70.6	65.0	2.8	6.3
9th Jul-15th Jul	28	27.8	20.4	87.4	70.9	82.0	3.2	0.0
16th Jul-22nd Jul	29	29.5	21.0	85.6	69.4	87.1	3.9	0.0
23rd Jul-29th Jul	30	25.9	18.0	85.3	70.9	90.9	3.9	0.0
30th Jul-5th Aug	31	31.2	18.3	84.6	71.6	77.4	2.0	0.0
6th Aug-12th Aug	32	31.1	20.4	86.9	71.1	73.6	3.6	0.0
13thAug-19th ug	33	29.5	20.7	87.3	69.4	71.7	3.5	0.0
20thAug-26th ug	34	31.5	21.6	85.6	70.4	65.1	3.8	0.0
27th Aug-2nd Sep	35	30.1	21.0	87.7	71.1	68.8	3.2	0.0
3rd Sep- 9th Sep	36	30.5	21.2	84.4	68.6	72.0	2.7	0.0
10th Sep-16th Sep	37	30.8	22.6	86.4	65.0	75.0	2.0	0.0
17th sep-23rd Sep	38	30.3	21.2	85.4	67.4	50.9	1.9	0.0
24th Sep-30th Sep	39	30.6	22.6	87.4	65.3	40.4	2.0	0.0
1st Oct-07th Oct	40	29.9	21.5	85.6	69.9	28.6	1.6	0.0
8th Oct-14th Oct	41	29.5	21.6	85.7	68.3	21.2	2.3	14.7
15th Oct- 21st Oct	42	28.5	16.7	86.0	70.0	13.7	1.5	47.6
22nd Oct-28th Oct	43	29.6	15.3	84.2	69.4	11.9	1.6	48.3
29th Oct- 4th Nov	44	27.1	13.1	83.7	65.9	7.7	2.1	59.2
5th Nov-11th Nov	45	26.4	11.5	85.3	66.3	3.6	1.5	64.9
12thNov-18thNov	46	24.9	12.8	84.0	68.3	2.0	1.7	30.4



**Table – 4.1.1: District-wise distribution of commonly prevailing insect pests of rice in Jharkhand**

S.N.	District	YSB	GM	BPH	RGB	RH	RLF	GLH	CW	RMB	RGH	BhC	WG	YhC	CtW	WM	SwC	Termite	Thrips
1.	Dumka	***	*	**	**	*	**	*	**	*	*	*	*	*	*	*	*	**	*
2.	Ranchi	***	**	***	*	**	***	*	*	#	*	#	#	**	*	#	*	**	#
3.	Chatra	***	**	***	**	*	*	*		#	**	#	#	*	*	*	*	*	*
4.	Garhwa	**	**	**	*	**	*	**	*	*	**	#	#	**	*	*	**	**	*
5.	East Singhbhum	***	*	**	**	*	**	**	**	#	**	#	*	*	*	#	*	*	*
6.	West Singhbhum	***	*	**	**	*	**	**	**	#	**	#	*	*	*	#	*	*	*
7.	Ramgarh	***	**	***	**	*	**	**	*	#	*	#	#	*	*	*	*	**	*
8.	Saraikela Kharsawa	**	**	*	**	*	*	**	**	#	**	#	#	*	*	#	*	*	*
9.	Khunti	**	***	**	**	*	**	**	*	#	**	#	#	**	*	#	*	**	#
10.	Palamu	**	*	*	**	*	**	**	*	#	*	#	#	#	#	#	#	**	#
11.	Bokaro	**	*	*	**	*	*	*	#	#	*	*	#	#	#	#	#	**	#
12.	Lohardaga	***	*	*	**	*	**	*	**	#	*	#	#	*	*	*	*	**	*
13.	Gumla	***	*	***	**	*	**	*	**	#	**	#	#	*	#	*	*	**	#
14.	Latehar	***	**	*	*	*	*	**	**	#	**	#	#	*	#	#	*	*	#
15.	Simdega	**	***	#	*	*	*	*	**	#	**	#	#	*	#	#	*	*	#
16.	Jamtara	**	**	**	**	*	*	*	*	#	*	#	#	#	#	#	#	*	#
17.	Giridih	**	*	**	**	*	**	*	*	#	*	#	#	#	#	#	#	*	#
18.	Godda	***	**	***	**	**	**	**	*	#	*	#	#	*	*	*	*	*	#
19.	Hazaribagh	***	**	***	**	*	**	**	**	#	*	#	#	*	*	*	*	**	*
20.	Pakur	***	#	***	*	*	**	**	**	#	*	*	#	*	*	#	*	*	*
21.	Sahibganj	***	#	***	*	*	**	**	**	#	**	*	#	#	*	#	*	*	*
22.	Deoghar	**	#	**	**	*	*	*	*	#	*	#	#	#	#	#	#	*	#
23.	Dhanbad	**	#	#	**	*	**	*	#	#	*	*	#	*	#	#	#	*	#
24.	Koderma	**	#	*	**	*	*	*	#	#	*	#	#	*	#	#	#	*	#

YSB = Yellow stem borer, GM = gall midge, CW = case worm, RH = rice hispa , RLF = rice leaf folder, GLH = green leaf hopper , RGB = rice gundhi bug, RMB = rice mealy bug, WG = white grub, BPH = brown plant hopper , RGH = rice grass hopper , SwC = swarming caterpillar , YhC=yellow hairy caterpillar, BhC = brown hairy caterpillar , CtW = Cut worm, WM = whorl maggot, \* = low , \*\* = moderate, \*\*\* = severe, #=Negligible.

**Table – 4.1.2: Status of rice insect pests in different districts of Jharkhand**

SN.	Name of Pests	Status	Intensity	Occurrence in Districts
1	Yellow stem borer	Major	Moderate to Severe	Almost the whole state (low to mild incidence). Transplanted rice harboured more incidences as compared to direct sown rice.
2	Gall midge	Major	Low to Moderate	Gall midge incidence was observed more or less in the whole state. However, the intensity of gall midge incidence was higher in the gall midge endemic areas like Simdega, Khunti, Lohardagga, Gumla, Latehar, Saraikela- Kharsawan, Bishun Garh areas of Hazaribag district and certain parts of Ranchi district. The incidence of gall midge was more pronounced during the period of middle of August to end of September probably on account of somewhat delayed rains.
3	Leaf folder	Major	Low to Moderate	Almost the whole state particularly in transplanted rice during August to October.
4	Earhead bug/ Gundhi bug	Major	Low to Moderate	Almost all the 24 districts were affected. Upland rice and some early transplanted rice were more prone to the attack of gundhi bug in milky stage of rice crop
5	Green leafhopper	Minor	Low to Moderate	Almost the whole state was found to be affected by the pest.
6	BPH	Major	Low to Moderate	Slight (traces) incidence of BPH was noticed in certain areas of all districts and Ranchi, Hazaribagh, Ramgarh, Godda, Sahabganj, Pankur, Dumka, Chatra, Gumla Deogarh, Giridih and Jamtara districts of some selected areas moderate to severe incidence of BPH was noticed.
7	Rice hispa	Minor	Low to Moderate	More or less the whole state (low to mild incidence in transplanted rice situation) during July & August.
8	Case worm	Sporadic	Negligible to Low	Only low land areas of rice cultivation in transplanted rice situation during August to September (mild to severe pest pressure), the pest was found to occur.
9	Swarming caterpillar	Sporadic	Negligible to Low	Almost in the whole state the pest appeared in negligible condition. The swarming caterpillar remained sporadic pest in Jharkhand.
10	Thrips	Minor	Negligible to Low	Almost the whole state was found to be affected by the pest in negligible condition in rice nursery.
11	Termite	Major	Low to Moderate	Whole state of Jharkhand in upland situation particularly in direct seeded rice in the months of June, July & August.
12	Grass hoppers	Minor	Low to Moderate	Almost the whole state was found to be affected by low to moderate population of different species of grass hoppers.
13	Black airy caterpillar	Sporadic	Negligible to Low	Almost the whole state was negligible condition but in some area are low condition
14	Cut worm	Sporadic	Negligible to Low	Almost the whole state was found to be affected by the pest in terms of population of the pest.
15	Rice mealy bug	Minor	Negligible to Low	Almost the whole state was negligible to low population of the pest was noticed.
16	Root/white grubs	Minor	Negligible to Low	Almost the whole state was negligible low population of the pest was appeared.
17	Whorl maggot	Minor	Negligible to Low	Almost the whole state the negligible low population of the pest was observed.
18	Yellow hairy caterpillar	Minor	Negligible to Low	Almost the whole state the negligible low population of the pest was noticed.

**Table -4.1.3: Ecology-wise prevalence of insect fauna pest of rice in Jharkhand**

<b>Group</b>	<b>Sub group</b>	<b>Type</b>	<b>Description of land</b>	<b>Rice pest ecology</b>
<i>Don</i> land	<i>Don- I</i>	Low land	Clay-loam soil, lowest in toposequence, suitable for long duration rice crop	<b>YSB, RH, CW, GM, RGH,</b>
<i>Don</i> land	<i>Don -II</i>	Shallow land	Clay loam soil and best for rice production, rarely faces drought, suitable for medium duration rice	<b>YSB, RH, CW ,RLF, GLH, RGB, , BPH, RGH, , GM</b>
<i>Don</i> land	<i>Don- III</i>	Drought prone shallow land	Clay loam soil, transitional lands between don & <i>tanr</i> , upper toposequence and suitable for short duration rice	<b>YSB, RH, RLF, GLH, RGB, RMB, BPH, RGH, SwC, BhC, Thrips, GM,</b>
<i>Tanr</i> land	<i>Tanr- III</i>	Upland	Sandy loam soil, sloppy, poor soil fertility, shallow soil depth, low WHC, Near foothills and acidic in nature	<b>Termite, GM, CW, YSB, RH, RLF, GLH, RGB, RMB, BPH, RGH, SwC, BhC, Thrips, YhC</b>
<i>Tanr</i> land	<i>Tanr – II</i>	Upland	Sandy loam soil, gentle sloppy, good soil depth, low WHC, poor in organic matter, erosion prone, acidic in nature. Land used for vegetables, maize and rice seedlings	<b>Termite, YSB, RH, WG, YhC</b>
<i>Tanr</i> land	<i>Tanr - I</i>	Upland	Loam soil and land immediately adjacent to the houses. Land used for vegetables, maize and rice seedlings	<b>Termite, YSB, RH, WG, YhC</b>

**YSB = Yellow stem borer, GM = gall midge, CW = case worm, RH = rice hispa , RLF = rice leaf folder, GLH = green leaf hopper , RGB = rice gundhi bug, RMB = rice mealy bug, WG = white grub, BPH = brown plant hopper , RGH = rice grass hopper , YhC=yellow hairy caterpillar, SwC = swarming caterpillar , BhC = brown hairy caterpillar , CtW = Cut worm, WM = whorl maggot, WHC = water holding capacity.**

**Table-4.2.1: Relative incidence of hispa (*Diuraphis armigera* Olivier) in some rice cultivars/varieties in terms of leaf damage (LDH %).**

		Leaf damage due to hispa (LDH %) at								
Cultivar		LDH % AT 20 DAT			LDH % AT 35 DAT			Oveall Mean		
SN.		2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean
T1	CR Dhan - 303	12.40 (20.21)	16.47 (23.40)	14.44 (21.80)	14.45 (21.79)	17.64 (24.19)	16.04 (22.99)	13.42 (21.01)	17.06 (23.80)	15.24 (22.40)
T2	IR-20	3.30 (10.29)	5.51 (13.11)	4.40 (11.70)	4.43 (11.88)	10.09 (18.30)	7.26 (15.09)	3.87 (11.11)	7.80 (15.96)	5.83 (13.54)
T3	MTU-1010	6.12 (14.02)	7.60 (15.39)	6.86 (14.71)	7.22 (15.48)	10.42 (18.50)	8.82 (16.99)	6.67 (14.82)	9.01 (17.03)	7.84 (15.93)
T4	IR-64Drt.	7.42 (15.57)	8.60 (16.58)	8.01 (16.08)	8.33 (16.43)	11.38 (19.44)	9.86 (17.94)	7.88 (16.01)	9.99 (18.07)	8.93 (17.04)
T5	Naveen	3.27 (10.19)	5.45 (13.34)	4.36 (11.77)	4.36 (11.81)	9.22 (17.02)	6.79 (14.41)	3.81 (11.03)	7.34 (15.31)	5.57 (13.17)
T6	Sahbhagi	4.23 (11.40)	6.64 (14.61)	5.44 (13.00)	5.23 (12.80)	7.51 (15.15)	6.37 (13.97)	4.73 (12.12)	7.08 (14.90)	5.91 (13.51)
T7	Pusa-1176	8.37 (16.48)	10.36 (17.92)	9.36 (17.20)	9.33 (17.02)	11.06 (19.26)	10.20 (18.14)	8.85 (16.86)	10.71 (18.71)	9.78 (17.79)
T8	Abhisek	9.35 (17.35)	12.44 (20.05)	10.90 (18.70)	10.46 (18.53)	14.57 (22.20)	12.51 (20.36)	9.91 (18.02)	13.50 (21.23)	11.70 (19.62)
T9	IR-36	10.59 (18.65)	14.59 (21.79)	12.59 (20.22)	12.49 (20.16)	18.09 (24.77)	15.29 (22.47)	11.54 (19.42)	16.34 (23.34)	13.94 (21.38)
T10	CR Dhan - 304	5.60 (13.51)	6.48 (14.46)	6.04 (13.99)	5.72 (13.34)	6.65 (14.66)	6.19 (14.00)	5.66 (13.45)	6.57 (14.56)	6.11 (14.01)
T11	Achhay Dhan	7.43 (15.45)	9.55 (17.73)	8.49 (16.59)	8.73 (16.82)	12.65 (20.43)	10.69 (18.63)	8.08 (16.15)	11.10 (19.12)	9.59 (17.63)
T12	IR-64 Sub-1	4.24 (11.64)	5.70 (13.39)	4.97 (12.52)	5.33 (12.93)	6.48 (14.43)	5.91 (13.68)	4.79 (12.36)	6.09 (13.93)	5.44 (13.14)
T13	CR Dhan -205	3.35 (10.26)	5.61 (13.58)	4.48 (11.92)	4.52 (12.02)	4.84 (12.64)	4.68 (12.33)	3.93 (11.22)	5.23 (13.12)	4.58 (12.17)
T14	DRR-44	2.83 (9.60)	5.53 (13.22)	4.18 (11.41)	4.76 (12.38)	6.60 (14.35)	5.68 (13.37)	3.80 (11.21)	6.06 (13.80)	4.93 (12.51)
T15	BVS-1	5.23 (12.70)	5.83 (13.52)	5.53 (13.11)	5.04 (12.61)	7.40 (15.33)	6.22 (13.97)	5.14 (12.66)	6.61 (14.46)	5.88 (13.56)
T16	Kavya	1.61 (6.88)	2.83 (9.37)	2.22 (8.13)	2.38 (8.60)	3.18 (9.90)	2.78 (9.25)	2.00 (7.80)	3.00 (9.64)	2.50 (8.72)
T17	Lalat	5.47 (12.99)	9.78 (17.98)	7.62 (15.48)	7.63 (15.63)	11.68 (19.56)	9.66 (17.59)	6.55 (14.37)	10.73 (18.78)	8.64 (16.58)
T18	Advanta-801+	4.49 (11.64)	6.32 (14.40)	5.41 (13.02)	5.73 (13.57)	7.42 (15.01)	6.58 (14.29)	5.11 (12.67)	6.87 (14.78)	5.99 (13.72)
T19	Suraksha	7.42 (15.41)	9.53 (17.83)	8.48 (16.62)	8.52 (16.80)	11.60 (19.40)	10.06 (18.10)	7.97 (16.18)	10.57 (18.66)	9.27 (17.42)
T20	TN-1	18.73 (25.43)	22.55 (28.11)	20.64 (26.77)	21.15 (26.83)	23.55 (28.67)	22.35 (27.75)	19.94 (26.16)	23.05 (28.39)	21.50 (27.27)
	<b>SEm±</b>	(1.30)	(1.43)	(0.89)	(1.43)	(1.45)	(0.97)	(1.13)	(1.30)	(0.80)
	<b>CD 5%</b>	(3.71)	(4.10)	(2.51)	(4.08)	(4.16)	(2.71)	(3.24)	(3.71)	(2.25)
	<b>CV %</b>	(16.05)	(15.03)	(15.51)	(16.06)	(13.87)	(14.88)	(13.32)	(12.92)	(13.13)

Data in parenthesis is original value were subjected to angular transformed values.  
 DAT-Days after transplanting; LDH-Leaf damage due to hispa

**Table - 4.2.2: Relative incidence of yellow stem borer (*Scirpophaga incertulas* Walker) in some rice cultivars/varieties in terms of dead heart (DH%)**

		Percentage of dead heart (DH) caused by YSB, recorded at								
	Cultivar	DH % AT 30 DAT			DH % AT 45 DAT			Overall Mean		
SN.		2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean
T1	CR Dhan - 303	5.42 (13.23)	4.61 (12.25)	5.02 (12.74)	6.51 (14.33)	7.22 (15.13)	6.87 (14.73)	5.97 (13.80)	5.92 (13.78)	5.94 (13.79)
T2	IR-20	18.60 (25.21)	16.37 (23.76)	17.49 (24.48)	20.63 (26.74)	18.34 (25.21)	19.49 (25.97)	19.62 (25.99)	17.36 (24.51)	18.49 (25.25)
T3	MTU-1010	10.59 (18.91)	8.50 (16.70)	9.55 (17.81)	12.42 (20.45)	10.33 (18.35)	11.38 (19.40)	11.50 (19.72)	9.42 (17.60)	10.46 (18.66)
T4	IR-64 Drt.	8.43 (16.52)	9.75 (17.91)	9.09 (17.22)	10.43 (18.28)	11.72 (19.95)	11.07 (18.91)	9.43 (17.42)	10.73 (18.75)	10.08 (18.09)
T5	Naveen	7.58 (15.84)	5.59 (13.47)	6.59 (14.65)	8.61 (16.84)	7.29 (15.26)	7.95 (16.05)	8.09 (16.48)	6.44 (14.40)	7.27 (15.44)
T6	Sahbhagi	6.40 (14.50)	5.88 (13.76)	6.14 (14.13)	7.75 (15.98)	7.48 (15.41)	7.62 (15.69)	7.08 (15.28)	6.68 (14.61)	6.88 (14.94)
T7	Pusa-1176	13.40 (21.12)	10.26 (18.44)	11.83 (19.78)	16.37 (23.52)	12.29 (20.34)	14.33 (21.93)	14.88 (22.35)	11.28 (19.41)	13.08 (20.88)
T8	Abhisek	10.37 (18.65)	9.77 (17.98)	10.07 (18.31)	13.25 (20.99)	11.44 (19.53)	12.34 (20.26)	11.81 (19.86)	10.60 (18.77)	11.21 (19.31)
T9	IR-36	11.59 (19.52)	9.86 (17.95)	10.73 (18.73)	13.16 (21.11)	9.39 (17.57)	11.28 (19.34)	12.37 (20.34)	9.63 (17.76)	11.00 (19.05)
T10	CR Dhan - 304	6.43 (14.53)	5.83 (13.74)	6.13 (14.14)	8.36 (16.51)	7.46 (15.44)	7.91 (15.97)	7.40 (15.59)	6.65 (14.62)	7.02 (15.10)
T11	Achhay Dhan	9.32 (17.55)	7.68 (15.94)	8.50 (16.74)	12.35 (20.42)	9.39 (17.52)	10.87 (18.97)	10.84 (19.08)	8.54 (16.79)	9.69 (17.93)
T12	IR-64 Sub-1	10.80 (18.88)	8.95 (17.16)	9.87 (18.02)	11.40 (19.55)	8.53 (16.80)	9.97 (18.17)	11.10 (19.23)	8.74 (16.98)	9.92 (18.10)
T13	CR Dhan -205	6.79 (14.77)	5.51 (13.15)	6.15 (13.96)	8.29 (16.41)	6.49 (14.17)	7.39 (15.29)	7.54 (15.66)	6.00 (13.68)	6.77 (14.67)
T14	DRR-44	13.59 (21.50)	12.60 (20.62)	13.10 (21.06)	15.53 (22.95)	14.66 (22.44)	15.10 (22.70)	14.56 (22.27)	13.63 (21.55)	14.10 (21.91)
T15	BVS-1	9.17 (17.33)	7.50 (15.60)	8.33 (16.46)	11.20 (19.21)	7.16 (15.42)	9.18 (17.32)	10.18 (18.29)	7.33 (15.52)	8.76 (16.91)
T16	Kavya	4.58 (12.11)	3.57 (10.65)	4.07 (11.38)	5.61 (13.28)	4.23 (11.54)	4.92 (12.41)	5.10 (12.75)	3.90 (11.15)	4.50 (11.95)
T17	Lalat	5.81 (13.81)	4.31 (11.76)	5.06 (12.78)	6.81 (14.88)	5.41 (13.08)	6.11 (13.98)	6.31 (14.39)	4.86 (12.65)	5.59 (13.52)
T18	Advanta-801+	13.70 (21.38)	10.66 (18.88)	12.18 (20.13)	15.00 (22.63)	11.36 (19.47)	13.18 (21.05)	14.35 (22.03)	11.01 (19.21)	12.68 (20.62)
T19	Suraksha	1.82 (7.60)	1.67 (7.27)	1.75 (7.44)	2.32 (8.69)	1.67 (7.27)	2.00 (7.98)	2.07 (8.18)	1.67 (7.27)	1.87 (7.73)
T20	TN-1	20.72 (26.64)	18.18 (25.16)	19.45 (25.90)	22.35 (28.11)	17.55 (24.72)	19.95 (26.41)	21.54 (27.42)	17.87 (24.94)	19.70 (26.18)
	<b>SEm±</b>	(1.52)	(1.45)	(0.96)	(1.42)	(1.49)	(0.97)	(1.24)	(1.34)	(0.85)
	<b>CD 5%</b>	(4.34)	(4.14)	(2.69)	(4.07)	(4.25)	(2.72)	(3.54)	(3.85)	(2.39)
	<b>CV %</b>	(15.01)	(15.57)	(15.28)	(12.95)	(14.95)	(13.90)	(11.70)	(13.94)	(12.78)

Figures under the parenthesis are angular transformed values. DAT-Days after transplanting; DH- dead heart.

**Table-4.2.3: Relative incidence of yellow stem borer (*Scirpophaga incertulas* Walker) in some rice cultivars/varieties in terms of white ear (WE%)**

		<b>Percentage of white ear (WE) Caused by YSB, recorded at</b>								
	Cultivar	WE % AT Dough Stage			WE % AT Pre-Harvest Stage			Overall Mean		
SN.		2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean
T1	CR Dhan - 303	4.85 (12.46)	5.06 (12.52)	4.96 (12.49)	5.73 (13.43)	7.47 (15.29)	6.60 (14.36)	5.29 (12.96)	6.27 (13.97)	5.78 (13.46)
T2	IR-20	3.19 (9.91)	4.18 (11.54)	3.69 (10.73)	4.48 (11.57)	5.60 (13.18)	5.04 (12.37)	3.84 (10.78)	4.89 (12.39)	4.36 (11.59)
T3	MTU-1010	6.51 (14.50)	7.24 (14.86)	6.87 (14.68)	7.47 (15.46)	8.80 (16.85)	8.14 (16.15)	6.99 (14.99)	8.02 (15.91)	7.51 (15.45)
T4	IR-64 Drt.	8.44 (16.51)	10.26 (18.11)	9.35 (17.31)	9.35 (17.33)	12.40 (20.19)	10.87 (18.76)	8.89 (16.93)	11.33 (19.25)	10.11 (18.09)
T5	Naveen	10.52 (18.35)	11.48 (19.61)	11 (18.98)	12.50 (20.65)	11.83 (20.00)	12.16 (20.32)	11.51 (19.61)	11.66 (19.81)	11.58 (19.71)
T6	Sahbhagi	8.42 (16.35)	9.39 (17.44)	8.91 (16.89)	9.32 (17.64)	11.37 (19.27)	10.35 (18.45)	8.87 (17.04)	10.38 (18.44)	9.63 (17.74)
T7	Pusa-1176	7.59 (15.32)	7.85 (15.71)	7.72 (15.51)	8.76 (16.88)	9.25 (17.38)	9.01 (17.13)	8.18 (16.22)	8.55 (16.58)	8.36 (16.40)
T8	Abhisek	11.68 (19.28)	13.60 (21.36)	12.64 (20.32)	12.41 (20.06)	16.11 (23.20)	14.26 (21.63)	12.04 (19.68)	14.86 (22.35)	13.45 (21.01)
T9	IR-36	3.30 (10.11)	4.18 (11.51)	3.74 (10.81)	4.43 (11.56)	6.10 (13.67)	5.27 (12.62)	3.87 (10.92)	5.14 (12.64)	4.50 (11.78)
T10	CR Dhan - 304	4.50 (12.09)	5.54 (13.30)	5.02 (12.70)	4.87 (12.44)	6.18 (14.01)	5.52 (13.22)	4.69 (12.27)	5.86 (13.66)	5.27 (12.97)
T11	Achhay Dhan	3.04 (9.66)	3.28 (10.13)	3.16 (9.90)	3.72 (10.48)	3.79 (10.83)	3.76 (10.65)	3.38 (10.46)	3.53 (10.49)	3.46 (10.47)
T12	IR-64 Sub-1	4.02 (11.31)	4.63 (12.17)	4.33 (11.74)	4.16 (11.52)	5.75 (13.70)	4.96 (12.61)	4.09 (11.47)	5.19 (12.96)	4.64 (12.21)
T13	CR Dhan -205	10.59 (18.42)	12.28 (20.36)	11.43 (19.39)	11.63 (19.47)	14.37 (21.99)	13.00 (20.73)	11.11 (18.95)	13.32 (21.23)	12.22 (20.09)
T14	DRR-44	7.76 (15.74)	8.54 (16.83)	8.15 (16.29)	8.63 (16.73)	9.35 (17.16)	8.99 (16.95)	8.19 (16.25)	8.95 (17.04)	8.57 (16.64)
T15	BVS-1	14.58 (21.92)	15.60 (22.90)	15.09 (22.41)	15.51 (22.85)	16.75 (23.72)	16.13 (23.28)	15.04 (22.40)	16.18 (23.39)	15.61 (22.89)
T16	Kavya	3.60 (10.73)	4.41 (11.64)	4.01 (11.18)	4.44 (11.77)	4.92 (12.30)	4.68 (12.03)	4.02 (11.27)	4.67 (11.97)	4.34 (11.62)
T17	Lalat	5.62 (13.43)	6.77 (14.84)	6.20 (14.13)	6.66 (14.52)	7.57 (15.60)	7.11 (15.06)	6.14 (13.99)	7.17 (15.23)	6.66 (14.61)
T18	Advanta-801+	7.63 (15.54)	9.27 (17.42)	8.45 (16.48)	8.16 (16.26)	8.40 (16.50)	8.28 (16.38)	7.90 (15.97)	8.84 (17.04)	8.37 (16.51)
T19	Suraksha	2.34 (8.68)	2.80 (9.35)	2.57 (9.01)	3.44 (10.34)	4.07 (11.26)	3.75 (10.80)	2.89 (9.59)	3.43 (10.43)	3.16 (10.01)
T20	TN-1	19.45 (25.94)	22.59 (28.15)	21.02 (27.04)	23.45 (28.61)	25.37 (30.07)	24.41 (29.34)	21.45 (27.30)	23.98 (29.15)	22.71 (28.22)
	<b>SEm±</b>	(1.40)	(1.46)	(0.91)	(1.54)	(1.45)	(0.97)	(1.24)	(1.19)	(0.79)
	<b>CD 5%</b>	(4.00)	(4.18)	(2.56)	(4.40)	(4.16)	(2.72)	(3.56)	(3.40)	(2.20)
	<b>CV %</b>	(16.35)	(15.82)	(14.54)	(16.68)	(14.54)	(14.28)	(13.93)	(12.34)	(11.96)

Figures under the parenthesis are angular transformed values. DAT-Days after transplanting; WE- white ear

**Table-4.2.4: Relative incidence of gall midge (*Orseolia oryzae* Wood mason) in some rice cultivars/varieties in terms of silver shoots (SS%)**

		<b>Percentage of silver shoots (SS) Caused by GM, recorded at</b>								
	Cultivar	SS % 30 DAT			SS % 45 DAT			Overall Mean		
SN.		2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean
T1	CR Dhan - 303	2.17 (8.24)	4.70 (12.33)	3.43 (10.28)	4.21 (11.55)	5.51 (13.24)	4.86 (12.40)	3.19 (10.03)	5.11 (12.79)	4.15 (11.41)
T2	IR-20	3.15 (10.04)	4.53 (12.00)	3.84 (11.02)	3.65 (10.75)	5.78 (13.55)	4.72 (12.15)	3.40 (10.40)	5.16 (12.80)	4.28 (11.60)
T3	MTU-1010	9.17 (17.15)	12.47 (20.16)	10.82 (18.66)	9.63 (17.76)	14.52 (22.27)	12.08 (20.01)	9.40 (17.52)	13.49 (21.33)	11.45 (19.43)
T4	IR-64 Drt.	10.06 (18.30)	16.38 (23.46)	13.22 (20.88)	13.52 (21.32)	15.45 (22.97)	14.48 (22.15)	11.79 (19.86)	15.92 (23.23)	13.85 (21.54)
T5	Naveen	4.46 (12.07)	5.09 (12.93)	4.77 (12.50)	4.72 (12.44)	5.26 (12.89)	4.99 (12.66)	4.59 (12.26)	5.17 (12.93)	4.88 (12.59)
T6	Sahbhagi	7.60 (15.56)	12.61 (20.50)	10.11 (18.03)	9.60 (17.35)	14.24 (22.05)	11.92 (19.70)	8.60 (16.48)	13.43 (21.30)	11.01 (18.89)
T7	Pusa-1176	8.30 (16.39)	13.39 (21.10)	10.85 (18.75)	10.49 (18.32)	13.43 (21.11)	11.96 (19.72)	9.39 (17.38)	13.41 (21.16)	11.40 (19.27)
T8	Abhisek	9.34 (17.34)	14.50 (21.91)	11.92 (19.62)	12.39 (19.82)	14.74 (22.12)	13.57 (20.97)	10.86 (18.70)	14.62 (22.07)	12.74 (20.39)
T9	IR-36	2.59 (9.00)	3.79 (11.00)	3.19 (10.00)	3.39 (10.17)	4.42 (11.81)	3.90 (10.99)	2.99 (9.60)	4.11 (11.42)	3.55 (10.51)
T10	CR Dhan - 304	5.76 (13.72)	7.56 (15.55)	6.66 (14.63)	6.66 (14.42)	10.53 (18.56)	8.60 (16.49)	6.21 (14.10)	9.05 (17.11)	7.63 (15.61)
T11	Achhay Dhan	2.90 (9.65)	3.71 (10.77)	3.31 (10.21)	3.27 (10.19)	5.68 (13.41)	4.47 (11.80)	3.08 (9.92)	4.70 (12.16)	3.89 (11.04)
T12	IR-64 Sub-1	7.37 (15.01)	9.48 (17.23)	8.42 (16.12)	8.33 (16.43)	12.61 (20.62)	10.47 (18.52)	7.85 (15.76)	11.05 (19.05)	9.45 (17.41)
T13	CR Dhan -205	4.25 (11.69)	7.54 (15.35)	5.90 (13.52)	4.65 (12.20)	9.48 (17.81)	7.07 (15.00)	4.45 (11.95)	8.51 (16.68)	6.48 (14.32)
T14	DRR-44	5.49 (13.22)	6.63 (14.39)	6.06 (13.80)	5.79 (13.56)	7.56 (15.74)	6.68 (14.65)	5.64 (13.39)	7.10 (15.10)	6.37 (14.25)
T15	BVS-1	1.90 (7.50)	2.86 (9.42)	2.38 (8.46)	2.68 (9.09)	4.33 (11.75)	3.50 (10.42)	2.29 (8.34)	3.59 (10.65)	2.94 (9.49)
T16	Kavya	1.61 (6.88)	2.83 (9.37)	2.22 (8.13)	2.38 (8.60)	3.08 (9.75)	2.73 (9.17)	2.00 (7.80)	2.96 (9.56)	2.48 (8.68)
T17	Lalat	3.57 (10.54)	3.88 (11.09)	3.72 (10.81)	3.70 (10.75)	4.81 (12.22)	4.26 (11.48)	3.63 (10.64)	4.35 (11.67)	3.99 (11.16)
T18	Advanta-801+	5.57 (13.50)	7.42 (15.54)	6.50 (14.52)	6.77 (14.86)	9.29 (17.57)	8.03 (16.21)	6.17 (14.20)	8.36 (16.59)	7.26 (15.39)
T19	Suraksha	2.29 (8.59)	3.17 (10.02)	2.73 (9.30)	2.62 (9.15)	4.23 (11.44)	3.43 (10.29)	2.46 (8.87)	3.70 (10.76)	3.08 (9.81)
T20	TN-1	12.42 (20.19)	18.62 (25.36)	15.52 (22.77)	15.02 (22.43)	21.62 (27.36)	18.32 (24.89)	13.72 (21.33)	20.12 (26.38)	16.92 (23.86)
	<b>SEm±</b>	(1.10)	(1.10)	(0.77)	(1.09)	(1.13)	(0.76)	(0.98)	(0.89)	(0.65)
	<b>CD 5%</b>	(3.16)	(3.14)	(2.18)	(3.11)	(3.22)	(2.15)	(2.79)	(2.55)	(1.83)
	<b>CV %</b>	(15.02)	(12.30)	(13.53)	(13.40)	(11.54)	(12.38)	(12.58)	(9.50)	(10.91)

Figures under the parenthesis are angular transformed values. DAT-Days after transplanting; SS- silver shoots

**Table-4.2.5: Relative incidence of leaf folder (*Cnaphalocrosis medinalis* Guenee) in some promising rice cultivar/varieties in terms of leaf damage (LDFL %)**

		Leaf damage due to leaf folder (LDFL %)								
Cultivar		LDFL % AT 60 DAT			LDFL % AT 80 DAT			Overall Mean		
SN.		2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean
T1	CR Dhan - 303	8.40 (16.49)	12.55 (20.20)	10.48 (18.35)	10.48 (18.53)	14.47 (21.96)	12.48 (20.25)	9.44 (17.54)	13.51 (21.10)	11.48 (19.32)
T2	IR-20	13.60 (21.01)	17.46 (24.17)	15.53 (22.59)	15.42 (22.46)	18.72 (25.19)	17.07 (23.83)	14.51 (21.75)	18.09 (24.69)	16.30 (23.22)
T3	MTU-1010	10.70 (18.77)	15.63 (22.91)	13.17 (20.84)	12.51 (20.32)	17.12 (23.99)	14.81 (22.15)	11.61 (19.56)	16.38 (23.51)	13.99 (21.53)
T4	IR-64 Drt.	14.53 (21.83)	20.63 (26.72)	17.58 (24.28)	17.30 (23.91)	21.22 (26.93)	19.26 (25.42)	15.92 (22.98)	20.93 (26.83)	18.42 (24.90)
T5	Naveen	6.60 (14.83)	7.84 (16.21)	7.22 (15.52)	8.96 (17.35)	10.32 (18.52)	9.64 (17.93)	7.78 (16.13)	9.08 (17.41)	8.43 (16.77)
T6	Sahbhagi	6.40 (14.37)	9.55 (17.30)	7.98 (15.83)	7.30 (14.92)	10.51 (18.51)	8.91 (16.72)	6.85 (14.68)	10.03 (17.93)	8.44 (16.31)
T7	Pusa-1176	9.59 (17.67)	14.43 (22.05)	12.01 (19.86)	12.43 (20.24)	16.26 (23.32)	14.35 (21.78)	11.01 (18.99)	15.35 (22.75)	13.18 (20.87)
T8	Abhisek	7.49 (15.47)	12.51 (20.32)	10.00 (17.89)	9.42 (17.48)	14.47 (21.90)	11.95 (19.69)	8.46 (16.50)	13.49 (21.18)	10.97 (18.84)
T9	IR-36	9.45 (17.41)	14.53 (22.09)	11.99 (19.75)	13.53 (21.13)	16.63 (23.54)	15.08 (22.33)	11.49 (19.34)	15.58 (22.90)	13.54 (21.12)
T10	CR Dhan - 304	4.60 (12.20)	6.50 (14.48)	5.55 (13.34)	5.02 (12.60)	7.63 (15.62)	6.32 (14.11)	4.81 (12.42)	7.06 (15.06)	5.94 (13.74)
T11	Achhay Dhan	8.60 (16.70)	12.45 (20.12)	10.53 (18.41)	10.65 (18.52)	14.51 (22.11)	12.58 (20.31)	9.63 (17.63)	13.48 (21.21)	11.56 (19.42)
T12	IR-64 Sub-1	5.53 (13.48)	10.37 (18.44)	7.95 (15.96)	7.33 (14.97)	12.48 (20.40)	9.91 (17.68)	6.43 (14.31)	11.43 (19.44)	8.93 (16.87)
T13	CR Dhan -205	4.28 (11.74)	7.38 (15.52)	5.83 (13.63)	5.49 (13.13)	9.44 (17.67)	7.47 (15.40)	4.89 (12.46)	8.41 (16.62)	6.65 (14.54)
T14	DRR-44	3.53 (10.48)	5.66 (13.39)	4.60 (11.94)	4.69 (12.29)	7.00 (14.80)	5.85 (13.55)	4.11 (11.43)	6.33 (14.12)	5.22 (12.77)
T15	BVS-1	14.30 (21.80)	18.55 (24.94)	16.43 (23.37)	16.54 (23.49)	20.36 (26.52)	18.45 (25.01)	15.42 (22.66)	19.46 (25.81)	17.44 (24.24)
T16	Kavya	2.33 (8.56)	4.47 (11.97)	3.40 (10.27)	3.41 (10.13)	6.58 (14.51)	5.00 (12.32)	2.87 (9.39)	5.53 (13.30)	4.20 (11.34)
T17	Lalat	16.33 (23.28)	23.43 (28.59)	19.88 (25.93)	18.57 (24.96)	26.48 (30.66)	22.52 (27.81)	17.45 (24.21)	24.96 (29.69)	21.20 (26.95)
T18	Advanta-801+	6.33 (14.02)	9.33 (17.10)	7.83 (15.56)	7.77 (15.62)	12.42 (20.19)	10.10 (17.91)	7.05 (14.84)	10.88 (18.72)	8.96 (16.78)
T19	Suraksha	2.42 (8.76)	5.49 (13.19)	3.96 (10.97)	3.69 (10.69)	7.33 (15.30)	5.51 (13.00)	3.05 (9.78)	6.41 (14.28)	4.73 (12.03)
T20	TN-1	19.20 (25.23)	29.73 (32.84)	24.47 (29.03)	24.35 (28.83)	33.95 (35.21)	29.15 (32.02)	21.78 (27.07)	31.84 (34.04)	26.81 (30.55)
	<b>SEm±</b>	(1.51)	(1.56)	(1.01)	(1.61)	(1.67)	(1.07)	(1.42)	(1.31)	(0.90)
	<b>CD 5%</b>	(4.31)	(4.47)	(2.85)	(4.62)	(4.77)	(3.02)	(4.06)	(3.76)	(2.54)
	<b>CV %</b>	(16.11)	(13.45)	(14.64)	(15.45)	(13.22)	(14.23)	(14.29)	(10.81)	(12.38)

Figures under the parenthesis are angular transformed values  
 DAT-Days after transplanting; LDFL – Leaf damage caused by leaf folder

**Table-4.2.6: Relative incidence of green leaf hopper (*Nephtotettix species*) in some rice cultivars/varieties**

SN.	Cultivar	No. of GLH / 10 hill AT 70 DAT			No. of GLH / 10 hill AT 85 DAT			Overall Mean		
		2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean
T1	CR Dhan - 303	8.94 (3.02)	12.83 (3.54)	10.89 (3.28)	10.48 (3.23)	14.76 (3.76)	12.62 (3.49)	9.71 (3.13)	13.80 (3.65)	11.76 (3.39)
T2	IR-20	18.80 (4.32)	24.70 (4.95)	21.75 (4.64)	22.33 (4.70)	26.40 (5.12)	24.37 (4.91)	20.57 (4.51)	25.55 (5.04)	23.06 (4.77)
T3	MTU-1010	18.09 (4.25)	21.53 (4.61)	19.81 (4.43)	19.43 (4.40)	23.37 (4.80)	21.40 (4.60)	18.76 (4.32)	22.45 (4.70)	20.60 (4.51)
T4	IR-64 Drt.	19.67 (4.42)	25.54 (5.03)	22.60 (4.72)	22.97 (4.78)	28.00 (5.28)	25.49 (5.03)	21.32 (4.62)	26.77 (5.17)	24.04 (4.89)
T5	Naveen	11.76 (3.40)	16.42 (3.98)	14.09 (3.69)	14.46 (3.81)	18.55 (4.28)	16.50 (4.04)	13.11 (3.61)	17.48 (4.15)	15.30 (3.88)
T6	Sahbhagi	12.43 (3.50)	18.00 (4.19)	15.22 (3.85)	15.30 (3.86)	20.53 (4.44)	17.92 (4.15)	13.86 (3.68)	19.27 (4.32)	16.57 (4.00)
T7	Pusa-1176	15.56 (3.89)	20.37 (4.49)	17.96 (4.19)	18.52 (4.25)	22.52 (4.73)	20.52 (4.49)	17.04 (4.07)	21.44 (4.61)	19.24 (4.34)
T8	Abhisek	16.56 (4.01)	21.86 (4.66)	19.21 (4.33)	19.16 (4.33)	23.39 (4.80)	21.28 (4.56)	17.86 (4.17)	22.63 (4.75)	20.24 (4.46)
T9	IR-36	8.83 (2.99)	12.78 (3.52)	10.81 (3.26)	10.37 (3.20)	15.44 (3.83)	12.91 (3.51)	9.60 (3.10)	14.11 (3.68)	11.86 (3.39)
T10	CR Dhan - 304	7.76 (2.79)	12.52 (3.51)	10.14 (3.15)	9.36 (3.06)	16.82 (3.99)	13.09 (3.52)	8.56 (2.93)	14.67 (3.76)	11.62 (3.34)
T11	Achhay Dhan	12.96 (3.59)	17.43 (4.10)	15.20 (3.85)	14.56 (3.84)	20.50 (4.53)	17.53 (4.19)	13.76 (3.72)	18.96 (4.33)	16.36 (4.03)
T12	IR-64 Sub-1	15.36 (3.90)	18.98 (4.30)	17.17 (4.10)	16.56 (4.07)	21.62 (4.65)	19.09 (4.36)	15.96 (4.00)	20.30 (4.50)	18.13 (4.25)
T13	CR Dhan -205	9.07 (3.04)	13.70 (3.63)	11.38 (3.34)	10.53 (3.21)	15.33 (3.90)	12.93 (3.56)	9.80 (3.13)	14.52 (3.77)	12.16 (3.45)
T14	DRR-44	7.85 (2.81)	12.88 (3.52)	10.36 (3.17)	9.35 (3.03)	15.45 (3.94)	12.40 (3.49)	8.60 (2.92)	14.16 (3.75)	11.38 (3.33)
T15	BVS-1	16.61 (4.04)	20.51 (4.49)	18.56 (4.27)	18.71 (4.33)	23.33 (4.80)	21.02 (4.56)	17.66 (4.20)	21.92 (4.65)	19.79 (4.43)
T16	Kavya	10.27 (3.19)	15.79 (3.91)	13.03 (3.55)	12.27 (3.44)	17.46 (4.16)	14.86 (3.80)	11.27 (3.32)	16.62 (4.04)	13.95 (3.68)
T17	Lalat	10.06 (3.16)	15.23 (3.83)	12.65 (3.49)	12.06 (3.41)	16.76 (4.08)	14.41 (3.74)	11.06 (3.29)	15.99 (3.96)	13.53 (3.62)
T18	Advanta-801 <sup>+</sup>	13.56 (3.69)	18.33 (4.25)	15.94 (3.97)	15.59 (3.92)	20.49 (4.54)	18.04 (4.23)	14.58 (3.82)	19.41 (4.41)	16.99 (4.12)
T19	Suraksha	7.69 (2.80)	13.46 (3.65)	10.58 (3.22)	9.65 (3.09)	16.56 (4.04)	13.11 (3.57)	8.67 (2.96)	15.01 (3.85)	11.84 (3.41)
T20	TN-1	40.33 (6.25)	51.04 (7.03)	45.68 (6.64)	42.33 (6.40)	52.10 (7.13)	47.21 (6.77)	41.33 (6.33)	51.57 (7.08)	46.45 (6.71)
	<b>SEm±</b>	(0.28)	(0.31)	(0.19)	(0.28)	(0.30)	(0.19)	(0.25)	(0.26)	(0.16)
	<b>CD 5%</b>	(0.80)	(0.88)	(0.53)	(0.81)	(0.87)	(0.53)	(0.71)	(0.75)	(0.46)
	<b>CV %</b>	(13.19)	(12.46)	(12.81)	(12.58)	(11.59)	(12.06)	(11.34)	(10.29)	(10.78)

Figures under the parenthesis are square root transformed values. DAT-Days after transplanting; GLH-Green leaf hopper

**Table-4.2.7: Relative incidence of gundhi bug (*Leptocorsia species*) in some rice cultivars/varieties**

SN.	Cultivar	No. of gundhi bug per 10 hills recorded at Milking stage of the crop		
		2016	2017	Pooled Mean
T1	CR Dhan - 303	5.29 (2.35)	3.30 (1.89)	4.29 (2.12)
T2	IR-20	10.36 (3.26)	8.73 (2.92)	9.55 (3.09)
T3	MTU- 1010	12.59 (3.57)	11.53 (3.42)	12.06 (3.50)
T4	IR-64 Drt.	15.56 (3.92)	14.54 (3.81)	15.05 (3.86)
T5	Naveen	10.57 (3.31)	11.55 (3.45)	11.06 (3.38)
T6	Sahbhagi	7.11 (2.68)	4.50 (2.20)	5.80 (2.44)
T7	Pusa- 1176	13.06 (3.64)	13.53 (3.66)	13.30 (3.65)
T8	Abhisek	8.99 (2.95)	7.43 (2.72)	8.21 (2.84)
T9	IR-36	5.47 (2.39)	4.58 (2.21)	5.03 (2.30)
T10	CR Dhan - 304	12.43 (3.53)	10.52 (3.26)	11.48 (3.40)
T11	Achhay Dhan	14.00 (3.74)	11.50 (3.43)	12.75 (3.58)
T12	IR-64 Sub-1	9.33 (3.06)	7.52 (2.73)	8.43 (2.90)
T13	CR Dhan -205	5.40 (2.38)	4.30 (2.15)	4.85 (2.26)
T14	DRR-44	9.19 (3.06)	7.45 (2.79)	8.32 (2.92)
T15	BVS-1	7.67 (2.80)	5.50 (2.43)	6.58 (2.61)
T16	Kavya	2.33 (1.67)	2.02 (1.56)	2.18 (1.61)
T17	Lalat	6.49 (2.60)	5.53 (2.41)	6.01 (2.50)
T18	Advanta-801+	9.77 (3.15)	7.36 (2.74)	8.57 (2.95)
T19	Suraksha	2.38 (1.69)	1.79 (1.48)	2.09 (1.59)
T20	TN-1	18.37 (4.22)	16.61 (4.05)	17.49 (4.14)
	<b>SEm±</b>	(0.22)	(0.22)	(0.14)
	<b>CD 5%</b>	(0.62)	(0.63)	(0.40)
	<b>CV %</b>	(12.53)	(13.69)	(13.08)

Figures under the parenthesis are square root transformed values. DAT-Days after transplanting; GB-Gundhi bug

**Table-4.2.8: Yield of rice grain in some rice cultivars/varieties**

SN.	Cultivar	Yield of rice grain (q/ha)		
		2016	2017	Pooled Mean
T1	CR Dhan - 303	50.27	52.12	51.19
T2	IR-20	39.53	40.72	40.13
T3	MTU- 1010	47.57	48.92	48.24
T4	IR-64 Drt.	41.70	42.68	42.19
T5	Naveen	40.77	42.16	41.47
T6	Sahbhagi	47.42	48.78	48.10
T7	Pusa- 1176	27.53	28.73	28.13
T8	Abhisek	49.35	50.22	49.78
T9	IR-36	49.77	50.92	50.34
T10	CR Dhan - 304	43.60	44.87	44.23
T11	Achhay Dhan	60.47	61.83	61.15
T12	IR-64 Sub-1	43.70	44.73	44.22
T13	CR Dhan -205	51.87	53.30	52.58
T14	DRR-44	45.67	47.07	46.37
T15	BVS-1	34.52	35.78	35.15
T16	Kavya	45.30	46.73	46.02
T17	Lalat	50.23	51.67	50.95
T18	Advanta-801+	58.57	60.03	59.30
T19	Suraksha	30.37	31.90	31.14
T20	TN-1	21.03	22.43	21.73
	<b>SEm±</b>	2.40	2.45	1.54
	<b>CD 5%</b>	6.87	7.03	4.31
	<b>CV %</b>	9.46	9.39	9.42

**Table-4.3.1: Effect of date of transplanting on the incidence of rice hispa (*Diuraphis armigera* Olivier) in terms of leaf damage (LDH %)**

Treatment	Percentage of leaf damage caused by rice hispa (LDH)								
	25 DAT			40 DAT			Overall Mean		
	2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean
Date of transplanting									
D <sub>1</sub> (Early planting) 01.07.2016 & 01.07.2017	3.03 (9.91)	3.27 (10.28)	3.15 (10.09)	4.58 (12.23)	4.72 (12.39)	4.65 (12.31)	3.81 (11.17)	3.99 (11.43)	3.90 (11.30)
D <sub>2</sub> (Normal planting) 21.07.2016 & 21.07.2017	5.20 (13.03)	5.44 (13.41)	5.32 (13.22)	7.80 (16.14)	7.88 (16.25)	7.84 (16.19)	6.50 (14.68)	6.66 (14.91)	6.58 (14.80)
D <sub>3</sub> (Delayed planting) 12.08.2016 & 12.08.2017	7.29 (15.59)	7.65 (15.99)	7.47 (15.79)	10.91 (19.24)	11.08 (19.38)	11.00 (19.31)	9.10 (17.51)	9.36 (17.77)	9.23 (17.64)
SEm. (±)	(0.54)	(0.51)	(0.37)	(0.60)	(0.58)	(0.42)	(0.51)	(0.46)	(0.34)
C.D. (P=0.05)	(1.60)	(1.51)	(1.06)	(1.78)	(1.73)	(1.20)	(1.51)	(1.36)	(0.98)
C.V. (%)	(13.27)	(12.13)	(12.70)	(11.93)	(11.51)	(11.72)	(11.09)	(9.84)	(10.48)

Figure under the parentheses are angular transformed values.

DAT – Days after transplanting. LDH- Leaf damage caused by hispa

**Table-4.3.2: Effect of date of transplanting on the incidence of yellow stem borer (*Scirpophaga incertulas* Walker) in terms of dead heart (DH %)**

Treatments	Percentage of DH caused by yellow stem borer											
	30 DAT			45 DAT			60 DAT			Overall Mean		
	2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean
Date of transplanting												
D <sub>1</sub> (Early planting) 01.07.2016 & 01.07.2017	1.57 (7.11)	1.61 (7.17)	1.59 (7.14)	3.96 (11.32)	4.51 (12.16)	4.24 (11.74)	2.02 (8.09)	2.25 (8.42)	2.14 (8.26)	2.52 (9.09)	2.79 (9.57)	2.65 (9.33)
D <sub>2</sub> (Normal planting) 21.07.2016 & 21.07.2017	4.99 (12.83)	5.44 (13.42)	5.21 (13.12)	7.16 (15.40)	7.41 (15.64)	7.28 (15.52)	3.64 (10.90)	3.96 (11.28)	3.80 (11.09)	5.26 (13.23)	5.60 (13.67)	5.43 (13.45)
D <sub>3</sub> (Delayed planting) 12.08.2016 & 12.08.2017	8.09 (16.45)	8.50 (16.89)	8.29 (16.67)	9.54 (17.93)	10.06 (18.39)	9.80 (18.16)	5.58 (13.61)	5.77 (13.82)	5.68 (13.71)	7.73 (16.12)	8.11 (16.52)	7.92 (16.32)
SEm. (±)	(0.53)	(0.55)	(0.38)	(0.62)	(0.53)	(0.41)	(0.45)	(0.51)	(0.34)	(0.32)	(0.29)	(0.22)
C.D. (P=0.05)	(1.58)	(1.62)	(1.09)	(1.83)	(1.58)	(1.17)	(1.34)	(1.52)	(0.98)	(0.96)	(0.85)	(0.62)
C.V. (%)	(13.90)	(13.82)	(13.86)	(13.11)	(10.95)	(12.04)	(13.12)	(14.47)	(13.83)	(7.95)	(6.85)	(7.40)

Figures under the parentheses are angular transformed values.

DAT – Days after transplanting; DH-Dead heart caused by yellow stem borer.

**Table-4.3.3: Effect of date of transplanting on the incidence yellow stem borer (*Scirpophaga incertulas* Walker) in terms of white ear (WE %)**

Treatment	Percentage of white ear (WE) recorded		
	Pre-maturity stage		
	2016	2017	Pooled Mean
Date of transplanting			
D <sub>1</sub> (Early planting) 01.07.2016 & 01.07.2017	3.21 (10.14)	3.40 (10.52)	3.31 (10.33)
D <sub>2</sub> (Normal planting) 21.07.2016 & 21.07.2017	6.52 (14.70)	7.07 (15.28)	6.79 (14.99)
D <sub>3</sub> (Delayed planting) 12.08.2016 & 12.08.2017	10.17 (18.52)	10.70 (19.05)	10.44 (18.79)
SEm. (±)	(0.66)	(0.55)	(0.43)
C.D. (P=0.05)	(1.96)	(1.63)	(1.23)
C.V. (%)	(14.47)	(11.63)	(13.08)

Figures parentheses are angular transformed values,  
WE-White ear caused by yellow stem borer

**Table-4.3.4: Effect of date of transplanting on the incidence gall midge (*Orseolia oryzae* Wood mason) in terms of silver shoots (SS %)**

Treatment	Silver shoot (SS%) caused by gall midge								
	30 DAT			45 DAT			Overall Mean		
	2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean
Date of transplanting									
D <sub>1</sub> (Early planting) 01.07.2016 & 01.07.2017	1.63 (7.12)	2.16 (8.36)	1.90 (7.74)	3.48 (10.57)	5.07 (12.73)	4.28 (11.65)	2.55 (9.13)	3.62 (10.85)	3.09 (9.99)
D <sub>2</sub> (Normal planting) 21.07.2016 & 21.07.2017	8.20 (16.59)	9.95 (18.35)	9.07 (17.47)	10.18 (18.52)	11.47 (19.75)	10.82 (19.13)	9.19 (17.60)	10.71 (19.06)	9.95 (18.33)
D <sub>3</sub> (Delayed planting) 12.08.2016 & 12.08.2017	13.61 (21.61)	15.31 (22.96)	14.46 (22.28)	17.03 (24.33)	18.51 (25.46)	17.77 (24.90)	15.32 (23.02)	16.91 (24.25)	16.11 (23.64)
SEm. (±)	(0.51)	(0.52)	(0.36)	(0.56)	(0.63)	(0.42)	(0.38)	(0.47)	(0.30)
C.D. (P=0.05)	(1.52)	(1.55)	(1.05)	(1.67)	(1.87)	(1.21)	(1.13)	(1.40)	(0.87)
C.V. (%)	(10.68)	(9.94)	(10.29)	(10.00)	(10.31)	(10.18)	(7.24)	(8.27)	(7.82)

Figure under the parentheses are angular transformed values.

DAT – Days after transplanting.

SS- Silver shoot

**Table-4.3.5: Effect of date of transplanting on the incidence of leaf folder (*Cnephalocrosis medinalis*) in terms of leaf damage (LDLF %)**

Treatment	Percentage of LDLF recorded											
	60 DAT			70 DAT			80 DAT			Overall Mean		
	2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean
Date of transplanting												
D <sub>1</sub> (Early planting) 01.07.2016 & 01.07.2017	3.30 (10.27)	3.70 (10.88)	3.50 (10.57)	5.30 (13.16)	5.57 (13.56)	5.44 (13.36)	9.24 (17.63)	9.79 (18.16)	9.52 (17.89)	5.95 (14.09)	6.35 (14.56)	6.15 (14.32)
D <sub>2</sub> (Normal planting) 21.07.2016 & 21.07.2017	5.33 (13.24)	5.73 (13.79)	5.53 (13.52)	8.48 (16.86)	9.23 (17.63)	8.86 (17.25)	11.88 (20.11)	12.44 (20.61)	12.16 (20.36)	8.56 (16.98)	9.13 (17.57)	8.85 (17.28)
D <sub>3</sub> (Delayed planting) 12.08.2016 & 12.08.2017	8.18 (16.53)	8.90 (17.30)	8.54 (16.91)	10.59 (18.95)	11.29 (19.59)	10.94 (19.27)	13.57 (21.55)	14.42 (22.27)	13.99 (21.91)	10.78 (19.13)	11.54 (19.83)	11.16 (19.48)
SEm. (±)	(0.57)	(0.52)	(0.39)	(0.56)	(0.54)	(0.39)	(0.57)	(0.55)	(0.40)	(0.37)	(0.31)	(0.24)
C.D. (P=0.05)	(1.69)	(1.55)	(1.11)	(1.66)	(1.60)	(1.12)	(1.71)	(1.64)	(1.14)	(1.11)	(0.92)	(0.69)
C.V. (%)	(13.47)	(11.79)	(12.62)	(10.85)	(10.09)	(10.46)	(9.20)	(8.57)	(8.87)	(7.05)	(5.65)	(6.36)

Figure under the parentheses is angular transformed values.

DAT – Days after transplanting. LDLF-Leaf damage caused by leaf folder

**Table-4.3.6: Effect of date of transplanting on the incidence of green leaf hopper (GLH), *Nephotettix species* infesting rice**

Treatment	Number of GLH per 10 hills recorded											
	40 DAT			60 DAT			80 DAT			Overall Mean		
	2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean
Date of transplanting												
D <sub>1</sub> (Early planting) 01.07.2016 & 01.07.2017	8.7 (3.02)	9.6 (3.17)	9.15 (3.09)	18.8 (4.39)	19.4 (4.45)	19.1 (4.42)	30 (5.52)	30.7 (5.58)	30.35 (5.55)	19.17 (4.43)	19.9 (4.51)	19.53 (4.47)
D <sub>2</sub> (Normal planting) 21.07.2016 & 21.07.2017	10.4 (3.28)	12 (3.51)	11.2 (3.40)	20.9 (4.62)	21.9 (4.73)	21.4 (4.67)	36.8 (6.09)	37.6 (6.16)	37.2 (6.13)	22.7 (4.81)	23.83 (4.93)	23.27 (4.87)
D <sub>3</sub> (Delayed planting) 12.08.2016 & 12.08.2017	16.4 (4.09)	17.8 (4.27)	17.1 (4.18)	29.3 (5.45)	29.9 (5.50)	29.6 (5.47)	49.7 (7.08)	51 (7.17)	50.35 (7.13)	31.8 (5.68)	32.9 (5.78)	32.35 (5.73)
SEm. (±)	(0.09)	(0.09)	(0.07)	(0.10)	(0.12)	(0.08)	(0.12)	(0.12)	(0.08)	(0.07)	(0.07)	(0.05)
C.D. (P=0.05)	(0.28)	(0.28)	(0.19)	(0.31)	(0.35)	(0.23)	(0.35)	(0.35)	(0.24)	(0.20)	(0.21)	(0.12)
C.V. (%)	(8.70)	(8.15)	(8.42)	(6.85)	(7.69)	(7.28)	(5.94)	(5.95)	(5.94)	(4.28)	(4.34)	(4.31)

Figures in the parentheses indicate the square root transformed values ( $\sqrt{x+0.5}$ ),  
 DAT – Days after transplanting. GLH- green leaf hopper

**Table-4.3.7: Effect of date of transplanting on the incidence of ear bug (gundhi bug) *Leptocorsa species* infesting rice**

Treatment	No. of ear bug /10 hills recorded		
	Pre-Maturity stage		
Date of transplanting	2016	2017	Pooled Mean
D <sub>1</sub> (Early planting) 01.07.2016 & 01.07.2017	20.78 (4.60)	23.84 (4.92)	22.31 (4.76)
D <sub>2</sub> (Normal planting) 21.07.2016 & 21.07.2017	16.41 (4.08)	19.61 (4.46)	18.01 (4.27)
D <sub>3</sub> (Delayed planting) 12.08.2016 & 12.08.2017	9.56 (3.11)	12.62 (3.59)	11.09 (3.35)
SEm. (±)	(0.18)	(0.16)	(0.12)
C.D. (P=0.05)	(0.53)	(0.46)	(0.34)
C.V. (%)	(14.38)	(11.44)	(12.87)

Figures in the parentheses indicate the square root transformed values ( $\sqrt{x+0.5}$ ),  
 DAT – Days after transplanting. GB- Gundhi bug

**Table-4.3.8: Effect of dates of planting on grain's yield of rice**

Treatment	Yield recorded q/ha		
	Maturity stage		
	2016	2017	Pooled Mean
Date of transplanting			
D <sub>1</sub> (Early planting) 01.07.2016 & 01.07.2017	47.06	49.70	48.38
D <sub>2</sub> (Normal planting) 21.07.2016 & 21.07.2017	44.12	44.95	44.53
D <sub>3</sub> (Delayed planting) 12.08.2016 & 12.08.2017	38.17	39.87	39.02
SEm. (±)	1.08	1.19	0.80
C.D. (P=0.05)	3.20	3.53	2.30
C.V. (%)	7.89	8.39	8.15

**Table-4.4.1: Effect of botanical insecticides on the incidence of rice hispa (*Dicladispa armigera*) in terms of leaf damage (LDH%)**

S.N	Treatment	Formulations (a.i.) or Aza content %	Dose g or ml/ha	Percentage of damaged leaves (LDH) caused by hispa, recorded after 1 <sup>st</sup> spray* at											
				4 DAA			7 DAA			10 DAA			Overall Mean		
				2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean
<b>T1</b>	Neem Baan	1.00	1000 ml	1.80 (7.53)	2.45 (8.81)	2.13 (8.17)	2.31 (8.27)	3.29 (10.03)	2.80 (9.15)	2.75 (9.05)	3.59 (10.40)	3.17 (9.72)	2.28 (8.36)	3.11 (9.79)	2.70 (9.07)
<b>T2</b>	Neemazal	1.00	1000 ml	2.09 (8.15)	2.75 (9.38)	2.42 (8.77)	2.75 (9.21)	3.62 (10.74)	3.18 (9.97)	3.15 (9.88)	3.92 (11.09)	3.54 (10.48)	2.66 (9.15)	3.43 (10.45)	3.05 (9.80)
<b>T3</b>	Nimbecidine	0.03	2500 ml	2.97 (9.82)	3.67 (10.91)	3.32 (10.36)	3.51 (10.51)	3.95 (11.21)	3.73 (10.86)	3.79 (10.97)	4.25 (11.60)	4.02 (11.28)	3.42 (10.46)	3.96 (11.25)	3.69 (10.86)
<b>T4</b>	Multineem	0.03	2500 ml	3.94 (11.36)	4.68 (12.38)	4.31 (11.87)	4.19 (11.70)	4.45 (12.04)	4.32 (11.87)	4.54 (12.17)	4.80 (12.50)	4.67 (12.34)	4.22 (11.76)	4.65 (12.31)	4.44 (12.04)
<b>T5</b>	Neemoil	-	2500 ml	4.28 11.86	5.03 (12.86)	4.65 (12.36)	4.47 (12.08)	4.72 (12.35)	4.60 (12.22)	4.80 (12.53)	5.09 (12.83)	4.94 (12.68)	4.51 (12.17)	4.95 (12.69)	4.73 (12.43)
<b>T6</b>	Achook	0.03	2500 ml	0.95 (5.55)	1.57 (7.12)	1.26 (6.34)	1.34 (5.50)	1.97 (7.50)	1.66 (6.50)	1.77 (6.69)	2.26 (7.95)	2.01 (7.32)	1.35 (6.17)	1.93 (7.60)	1.64 (6.88)
<b>T7</b>	Pongamia oil (karanj oil)	-	2500 ml	2.49 (8.87)	3.17 (10.05)	2.83 (9.46)	3.24 (10.12)	3.79 (10.97)	3.51 (10.54)	3.57 (10.64)	4.09 (11.37)	3.83 (11.00)	3.10 (9.95)	3.68 (10.82)	3.39 (10.38)
<b>T8</b>	Dinotefuran	20 SG	200 g	1.55 (6.99)	2.20 (8.32)	1.87 (7.66)	2.03 (7.64)	3.02 (9.58)	2.52 (8.61)	2.47 (8.48)	3.32 (9.96)	2.89 (9.22)	2.02 (7.77)	2.84 (9.33)	2.43 (8.55)
<b>T9</b>	Rynaxypyr	20SC	150 ml	1.44 (6.71)	2.08 (8.08)	1.76 (7.39)	1.76 (7.01)	2.78 (9.18)	2.27 (8.10)	2.20 (7.92)	3.08 (9.55)	2.64 (8.73)	1.80 (7.28)	2.65 (8.98)	2.22 (8.13)
<b>T10</b>	Untreated control	Water spray	500 lit.	8.26 (16.08)	9.16 (16.99)	8.71 (16.54)	8.05 (15.76)	8.76 (16.50)	8.40 (16.13)	10.34 (18.09)	10.47 (18.30)	10.41 (18.20)	9.32 (17.15)	9.92 (17.77)	9.62 (17.46)
<b>SEm±</b>				(0.81)	(0.78)	(0.51)	(0.77)	(0.79)	(0.52)	(0.83)	(0.76)	(0.52)	(0.72)	(0.70)	(0.46)
<b>CD 5%</b>				(2.41)	(2.32)	(1.44)	(2.30)	(2.35)	(1.48)	(2.47)	(2.25)	(1.47)	(2.14)	(2.09)	(1.31)
<b>CV %</b>				(15.13)	(12.88)	(13.94)	(13.72)	(12.42)	(13.03)	(13.55)	(11.37)	(12.43)	(12.45)	(10.98)	(11.68)

Figures under the parenthesis are angular transformed values. LDH-Leaf damage due to hispa  
 DAT-Days after transplanting; DAA-Days after application of insecticidal treatment  
 \*1<sup>st</sup> foliar spray of the insecticidal treatments was applied at 25 DAT.

**Table-4.4.2: Effect of botanical insecticides on the incidence of yellow stem borer (*Scirpophaga incertulas* Walker) in terms of dead heart (DH %)**

S.N	Treatment	Formulations (a.i.) or Aza content %	Dose g or ml/ha	Percentage of dead heart (DH) caused by YSB, recorded after 2 <sup>nd</sup> spray* at											
				4 DAA			7 DAA			10 DAA			Overall Mean		
				2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean
<b>T1</b>	Neem Baan	1.00	1000 ml	1.83 (7.40)	2.43 (8.61)	2.13 (8.00)	2.88 (9.22)	3.45 (10.10)	3.17 (9.66)	4.06 (11.42)	4.63 (12.17)	4.34 (11.80)	2.92 (9.53)	3.51 (10.43)	3.22 (9.98)
<b>T2</b>	Neemazal	1.00	1000 ml	2.13 (8.13)	2.75 (9.24)	2.45 (8.68)	3.13 (9.80)	3.78 (10.74)	3.45 (10.27)	4.40 (11.94)	4.97 (12.67)	4.68 (12.30)	3.22 (10.11)	3.83 (11.00)	3.52 (10.55)
<b>T3</b>	Nimbecidine	0.03	2500 ml	2.65 (9.14)	3.27 (10.14)	2.96 (9.64)	3.37 (10.25)	3.94 (11.06)	3.65 (10.66)	5.11 (12.92)	5.68 (13.60)	5.39 (13.26)	3.71 (10.9)	4.29 (11.71)	4.00 (11.31)
<b>T4</b>	Multineem	0.03	2500 ml	3.54 (10.71)	4.16 (11.59)	3.85 (11.15)	3.70 (10.94)	4.27 (11.73)	3.99 (11.34)	5.49 (13.43)	6.06 (14.09)	5.78 (13.76)	4.25 (11.76)	4.83 (12.52)	4.54 (12.14)
<b>T5</b>	Neemoil	-	2500 ml	3.73 (11.00)	4.34 (11.86)	4.04 (11.43)	3.82 (11.11)	4.40 (11.89)	4.11 (11.50)	5.98 (14.04)	6.55 (14.68)	6.27 (14.36)	4.51 (12.13)	5.10 (12.88)	4.80 (12.51)
<b>T6</b>	Achook	0.03	2500 ml	0.97 (4.60)	1.59 (6.72)	1.28 (5.66)	1.91 (7.18)	2.48 (8.29)	2.20 (7.74)	2.86 (9.40)	3.43 (10.27)	3.14 (9.84)	1.91 (7.48)	2.50 (8.59)	2.21 (8.03)
<b>T7</b>	Pongamia oil (karanj oil)	-	2500 ml	2.51 (8.89)	2.99 (9.73)	2.75 (9.31)	3.25 (10.06)	3.85 (10.93)	3.54 (10.50)	4.72 (12.41)	5.29 (13.12)	5.01 (12.76)	3.49 (10.57)	4.04 (11.36)	3.77 (10.97)
<b>T8</b>	Dinotefuran	20 SG	200 g	1.62 (6.84)	2.20 (8.15)	1.91 (7.50)	2.68 (8.85)	3.25 (9.77)	2.97 (9.31)	3.74 (10.89)	4.31 (11.66)	4.02 (11.28)	2.68 (9.04)	3.26 (9.98)	2.97 (9.51)
<b>T9</b>	Rynaxypyr	20SC	150 ml	1.50 (6.55)	2.13 (7.92)	1.82 (7.24)	2.51 (8.51)	3.08 (9.46)	2.80 (8.98)	3.46 (10.40)	4.03 (11.20)	3.75 (10.80)	2.49 (8.66)	3.08 (9.64)	2.79 (9.15)
<b>T10</b>	Untreated control	Water spray	500 lit.	8.14 (16.30)	8.42 (16.36)	8.28 (16.33)	9.44 (17.61)	9.67 (17.62)	9.56 (17.61)	10.99 (18.87)	11.56 (19.36)	11.27 (19.11)	9.52 (17.62)	9.88 (17.82)	9.70 (17.72)
<b>SEm±</b>				(0.48)	(0.55)	(0.35)	(0.58)	(0.64)	(0.39)	(0.67)	(0.65)	(0.42)	(0.50)	(0.58)	(0.35)
<b>CD 5%</b>				(1.43)	(1.63)	(0.99)	(1.71)	(1.90)	(1.11)	(1.99)	(1.92)	(1.19)	(1.48)	(1.73)	(0.99)
<b>CV %</b>				(9.30)	(9.48)	(9.42)	(9.62)	(9.91)	(9.79)	(9.23)	(8.42)	(8.81)	(8.03)	(8.68)	(8.39)

Figures under the parenthesis are angular transformed values.

DAT-Days after transplanting; DH-Dead heart caused by yellow stem borer;

DAA-Days after application of insecticidal treatment \*2<sup>nd</sup> foliar spray of the insecticidal treatments was applied at 40 DAT.

**Table-4.4.3: Effect of botanical insecticides on the incidence of yellow stem borer (*Scirpophaga incertulas* Walker) in terms of white ear (WE %)**

S.N	Treatment	Formulations (a.i.) or Aza content %	Dose g or ml/ha	Percentage of white ear (WE) caused by yellow stem borer recorded after 4 <sup>th</sup> spray* at								
				Dough stage			Pre - Maturity Stage			Overall Mean		
				2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean
<b>T1</b>	Neem Baan	1.00	1000 ml	3.60 (10.64)	4.17 (11.45)	3.89 (11.05)	4.33 (11.72)	5.17 (12.89)	4.75 (12.30)	3.97 (11.19)	4.67 (12.20)	4.32 (11.7)
<b>T2</b>	Neemazal	1.00	1000 ml	3.94 (11.16)	4.51 (11.95)	4.22 (11.56)	4.68 (12.20)	5.51 (13.33)	5.09 (12.77)	4.31 (11.69)	5.01 (12.66)	4.66 (12.18)
<b>T3</b>	Nimbecidine	0.03	2500 ml	4.63 (12.18)	5.20 (12.91)	4.92 (12.54)	5.39 (13.18)	6.23 (14.23)	5.81 (13.70)	5.01 (12.69)	5.71 (13.59)	5.36 (13.14)
<b>T4</b>	Multineem	0.03	2500 ml	4.91 (12.55)	5.48 (13.27)	5.20 (12.91)	5.77 (13.66)	6.60 (14.68)	6.18 (14.17)	5.34 (13.12)	6.04 (13.99)	5.69 (13.56)
<b>T5</b>	Neemoil	-	2500 ml	5.24 (12.95)	5.81 (13.65)	5.52 (13.30)	6.18 (14.18)	7.02 (15.16)	6.60 (14.67)	5.71 (13.58)	6.41 (14.43)	6.06 (14.00)
<b>T6</b>	Achook	0.03	2500 ml	2.51 (8.69)	3.08 (9.64)	2.80 (9.17)	3.26 (10.03)	4.10 (11.39)	3.68 (10.71)	2.89 (9.39)	3.59 (10.56)	3.24 (9.98)
<b>T7</b>	Pongamia oil (karanj oil)	-	2500 ml	4.30 (11.73)	4.87 (12.48)	4.59 (12.11)	5.07 (12.77)	5.90 (13.85)	5.48 (13.31)	4.68 (12.26)	5.39 (13.18)	5.03 (12.72)
<b>T8</b>	Dinotefuran	20 SG	200 g	3.28 (10.09)	3.85 (10.93)	3.57 (10.51)	4.03 (11.25)	4.86 (12.47)	4.44 (11.86)	3.65 (10.69)	4.36 (11.73)	4.00 (11.21)
<b>T9</b>	Rynaxypyr	20SC	150 ml	3.02 (9.61)	3.59 (10.48)	3.30 (10.05)	3.75 (10.81)	4.58 (12.08)	4.17 (11.44)	3.38 (10.23)	4.09 (11.32)	3.73 (10.77)
<b>T10</b>	Untreated control	Water spray	500 lit.	10.74 (18.60)	11.31 (19.10)	11.03 (18.85)	12.32 (20.05)	13.15 (20.81)	12.73 (20.43)	11.53 (19.36)	12.23 (19.99)	11.88 (19.67)
<b>SEm±</b>				(0.64)	(0.62)	(0.40)	(0.75)	(0.73)	(0.47)	(0.66)	(0.64)	(0.41)
<b>CD 5%</b>				(1.91)	(1.85)	(1.14)	(2.23)	(2.16)	(1.34)	(1.97)	(1.90)	(1.18)
<b>CV %</b>				(9.40)	(8.56)	(8.97)	(10.03)	(8.96)	(9.47)	(9.25)	(8.31)	(8.76)

Figures under the parenthesis are angular transformed values. WE-White ear by yellow stem borer

DAT-Days after transplanting; DAA-Days after application of insecticidal treatment, \*4<sup>th</sup> foliar spray of the insecticidal treatments was applied at 95 DAT.

**Table-4.4.4: Effect of botanical insecticides on the incidence of gall midge (*Orseolia oryzae* Wood mason) in terms of silver shoots (SS %)**

S.N	Treatment	Formulations (a.i.) or Aza content %	Dose g or ml/ha	Silver shoot (SS) caused by gall midge, recorded after 2 <sup>nd</sup> spray* at											
				4 DAA			7 DAA			10 DAA			Overall Mean		
				2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean
<b>T1</b>	Neem Baan	1.00	1000 ml	2.21 (8.32)	2.62 (9.11)	2.42 (8.72)	2.98 (9.25)	3.35 (9.95)	3.16 (9.60)	4.24 (11.6)7	6.71 (14.72)	5.48 (13.19)	3.14 (9.91)	4.23 (11.55)	3.68 (10.73)
<b>T2</b>	Neemazal	1.00	1000 ml	2.63 (9.18)	3.06 (9.93)	2.84 (9.55)	3.32 (10.08)	3.70 (10.72)	3.51 (10.40)	4.72 (12.37)	7.20 (15.32)	5.96 (13.84)	3.55 (10.67)	4.65 (12.23)	4.10 (11.45)
<b>T3</b>	Nimbecidine	0.03	2500 ml	3.36 (10.40)	3.82 (11.11)	3.59 (10.76)	3.65 (10.68)	4.05 (11.30)	3.85 (10.99)	5.71 (13.68)	8.23 (16.46)	6.97 (15.07)	4.24 (11.70)	5.37 (13.18)	4.81 (12.44)
<b>T4</b>	Multineem	0.03	2500 ml	4.62 (12.30)	5.12 (12.97)	4.87 (12.64)	4.13 (11.58)	4.54 (12.17)	4.33 (11.88)	6.25 (14.35)	8.79 (17.05)	7.52 (15.70)	5.00 (12.80)	6.15 (14.21)	5.57 (13.50)
<b>T5</b>	Neemoil	-	2500 ml	4.87 (12.65)	5.38 (13.31)	5.12 (12.98)	4.29 (11.80)	4.71 (12.39)	4.50 (12.09)	6.93 (15.16)	9.50 (17.78)	8.22 (16.47)	5.36 (13.27)	6.53 (14.66)	5.95 (13.97)
<b>T6</b>	Achook	0.03	2500 ml	1.01 (5.51)	1.39 (6.56)	1.20 (6.04)	1.70 (6.61)	1.94 (7.07)	1.82 (6.84)	2.56 (8.76)	4.97 (12.41)	3.77 (10.58)	1.76 (7.17)	2.77 (9.13)	2.26 (8.15)
<b>T7</b>	Pongamia oil (karanj oil)	-	2500 ml	3.17 (10.10)	3.62 (10.81)	3.39 (10.46)	3.49 (10.43)	3.88 (11.05)	3.68 (10.74)	5.17 (13.00)	7.67 (15.86)	6.42 (14.43)	3.94 (11.27)	5.06 (12.78)	4.50 (12.02)
<b>T8</b>	Dinotefuran	20 SG	200 g	1.90 (7.68)	2.31 (8.51)	2.10 (8.10)	2.70 (8.72)	3.06 (9.46)	2.88 (9.09)	3.79 (10.9)3	6.24 (14.10)	5.02 (12.52)	2.80 (9.27)	3.87 (10.98)	3.33 (10.13)
<b>T9</b>	Rynaxypyr	20SC	150 ml	1.76 (7.35)	2.16 (8.21)	1.96 (7.78)	2.45 (8.19)	2.81 (8.99)	2.63 (8.59)	3.41 (10.24)	5.84 (13.54)	4.63 (11.89)	2.54 (8.76)	3.60 (10.54)	3.07 (9.65)
<b>T10</b>	Untreated control	Water spray	500 lit.	10.11 (18.10)	10.81 (18.76)	10.46 (18.43)	11.69 (19.92)	12.90 (20.98)	12.29 (20.45)	12.57 (20.33)	14.24 (21.48)	13.41 (20.90)	11.46 (19.51)	12.65 (20.49)	12.05 (20.00)
<b>SEm±</b>				(0.59)	(0.59)	(0.37)	(0.71)	(0.68)	(0.44)	(0.70)	(0.84)	(0.51)	(0.46)	(0.51)	(0.31)
<b>CD 5%</b>				(1.74)	(1.76)	(1.06)	(2.11)	(2.01)	(1.25)	(2.07)	(2.51)	(1.46)	(1.35)	(1.51)	(0.89)
<b>CV %</b>				(9.99)	(9.38)	(9.67)	(11.47)	(10.29)	(10.86)	(9.23)	(9.22)	(9.27)	(6.91)	(6.77)	(6.85)

Figures under the parenthesis are angular transformed values. SS- Silver shoot caused by gall midge

DAT-Days after transplanting; DAA-Days after application of insecticidal treatment

\*2<sup>nd</sup> foliar spray of the insecticidal treatments was applied at 40 DAT.

**Table-4.4.5: Effect of botanical insecticides on the incidence of leaf folder (*Cnephalocrosis medinalis*) in terms of leaf damage (LDLF %)**

S.N	Treatment	Formulations (a.i.) or Aza content %	Dose g or ml/ha	Percentage of leaf damage caused by the leaf folder (LDLF), recorded after 3 <sup>rd</sup> spray* at											
				4 DAA			7 DAA			10 DAA			Overall Mean		
				2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean
<b>T1</b>	Neem Baan	1.00	1000 ml	3.36 (10.33)	4.02 (11.38)	3.69 (10.86)	4.69 (12.43)	5.62 (13.63)	5.16 (13.03)	6.04 (14.19)	6.88 (15.13)	6.46 (14.66)	4.70 (12.43)	5.51 (13.47)	5.10 (12.95)
<b>T2</b>	Neemazal	1.00	1000 ml	3.89 (11.19)	4.67 (12.35)	4.28 (11.77)	5.22 (13.14)	6.24 (14.40)	5.73 (13.77)	6.57 (14.82)	7.43 (15.75)	7.00 (15.29)	5.22 (13.14)	6.11 (14.24)	5.67 (13.69)
<b>T3</b>	Nimbecidine	0.03	2500 ml	4.74 (12.43)	5.80 (13.78)	5.27 (13.10)	6.07 (14.20)	7.32 (15.61)	6.70 (14.91)	7.42 (15.77)	8.33 (16.71)	7.88 (16.24)	6.08 (14.21)	7.15 (15.42)	6.61 (14.81)
<b>T4</b>	Multineem	0.03	2500 ml	6.14 (14.17)	7.72 (16.04)	6.93 (15.10)	7.47 (15.79)	9.15 (17.55)	8.31 (16.67)	8.82 (17.22)	9.80 (18.16)	9.31 (17.69)	7.48 (15.78)	8.89 (17.27)	8.18 (16.53)
<b>T5</b>	Neemoil	-	2500 ml	6.50 (14.60)	8.11 (16.45)	7.30 (15.53)	7.83 (16.18)	9.52 (17.91)	8.68 (17.05)	9.18 (17.58)	10.18 (18.52)	9.68 (18.05)	7.84 (16.17)	9.27 (17.65)	8.55 (16.91)
<b>T6</b>	Achook	0.03	2500 ml	2.22 (8.22)	2.19 (8.37)	2.20 (8.29)	3.55 (10.74)	3.87 (11.31)	3.71 (11.02)	4.90 (12.74)	5.68 (13.70)	5.29 (13.22)	3.56 (10.76)	3.91 (11.33)	3.74 (11.04)
<b>T7</b>	Pongamia oil (karanj oil)	-	2500 ml	4.39 (11.94)	5.50 (13.42)	4.95 (12.68)	5.73 (13.79)	7.03 (15.30)	6.38 (14.54)	7.07 (15.39)	7.97 (16.33)	7.52 (15.86)	5.73 (13.79)	6.83 (15.07)	6.28 (14.43)
<b>T8</b>	Dinotefuran	20 SG	200 g	3.05 (9.76)	3.55 (10.67)	3.30 (10.22)	4.38 (11.98)	5.17 (13.06)	4.78 (12.52)	5.73 (13.80)	6.55 (14.74)	6.14 (14.27)	4.38 (11.98)	5.09 (12.93)	4.74 (12.46)
<b>T9</b>	Rynaxypyr	20SC	150 ml	2.78 (9.30)	3.33 (10.31)	3.06 (9.81)	4.11 (11.60)	4.97 (12.79)	4.54 (12.20)	5.46 (13.47)	6.27 (14.42)	5.87 (13.94)	4.12 (11.61)	4.86 (12.62)	4.49 (12.12)
<b>T10</b>	Untreated control	Water spray	500 lit.	13.84 (21.06)	16.40 (23.18)	(15.12 22.12)	18.51 (24.98)	16.51 (23.34)	17.51 (24.16)	19.85 (26.04)	20.69 (26.52)	20.27 (26.28)	17.40 (24.12)	17.86 (24.39)	17.63 (24.25)
<b>SEm±</b>				(1.03)	(1.10)	(0.69)	(1.06)	(1.12)	(0.72)	(1.07)	(1.14)	(0.70)	(1.05)	(1.11)	(0.69)
<b>CD 5%</b>				(3.06)	(3.26)	(1.95)	(3.14)	(3.34)	(2.06)	(3.18)	(3.37)	(1.99)	(3.12)	(3.30)	(1.96)
<b>CV %</b>				(14.52)	(13.99)	(14.25)	(12.63)	(12.58)	(12.61)	(11.51)	(11.58)	(11.55)	(12.64)	(12.46)	(12.56)

Figures under the parenthesis are angular transformed values. LDLF-Leaf damage due to leaf folder

DAT-Days after transplanting; DAA-Days after application of insecticidal treatment

\*3<sup>rd</sup> foliar spray of the insecticidal treatments was applied at 80 DAT.

**Table-4.4.6: Effect of botanical insecticides on the incidence of green leaf hopper, (GLH) (*Nephtottetix species*), infesting rice**

S.N	Treatment	Formulations (a.i.) or Aza content %	Dose g or ml/ha	No of GLH/10 hills recorded after 3 <sup>rd</sup> spray* at											
				4 DAA			7 DAA			10 DAA			Overall Mean		
				2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean
<b>T1</b>	Neem Baan	1.00	1000 ml	9.58 (3.14)	9.68 (3.16)	9.63 (3.15)	11.02 (3.38)	11.45 (3.44)	11.24 (3.41)	12.93 (3.65)	13.36 (3.71)	13.15 (3.68)	11.18 (3.40)	11.50 (3.44)	11.34 (3.42)
<b>T2</b>	Neemazal	1.00	1000 ml	12.14 (3.52)	12.19 (3.53)	12.16 (3.53)	12.88 (3.64)	13.31 (3.70)	13.10 (3.67)	14.09 (3.81)	14.52 (3.86)	14.30 (3.83)	13.03 (3.66)	13.34 (3.70)	13.19 (3.68)
<b>T3</b>	Nimbecidine	0.03	2500 ml	13.94 (3.78)	14.06 (3.79)	14.00 (3.79)	15.07 (3.93)	15.50 (3.99)	15.29 (3.96)	15.89 (4.04)	16.32 (4.09)	16.11 (4.06)	14.97 (3.92)	15.29 (3.96)	15.13 (3.94)
<b>T4</b>	Multineem	0.03	2500 ml	15.02 (3.92)	15.15 (3.94)	15.08 (3.93)	15.99 (4.05)	16.62 (4.10)	16.21 (4.08)	18.08 (4.30)	18.51 (4.35)	18.29 (4.33)	16.36 (4.09)	16.69 (4.13)	16.53 (4.11)
<b>T5</b>	Neemoil	-	2500 ml	15.89 (4.03)	16.03 (4.05)	15.96 (4.04)	17.21 (4.20)	17.64 (4.25)	17.42 (4.22)	19.33 (4.44)	19.76 (4.49)	19.55 (4.47)	17.47 (4.23)	17.81 (4.27)	17.64 (4.25)
<b>T6</b>	Achook	0.03	2500 ml	8.66 (2.99)	8.84 (3.02)	8.75 (3.00)	9.23 (3.10)	9.66 (3.17)	9.44 (3.13)	11.22 (3.40)	11.65 (3.47)	11.44 (3.44)	9.70 (3.17)	10.05 (3.22)	9.87 (3.20)
<b>T7</b>	Pongamia oil (karanj oil)	-	2500 ml	12.73 (3.61)	12.88 (3.63)	12.80 (3.62)	14.05 (3.80)	14.48 (3.86)	14.26 (3.83)	15.18 (3.95)	15.61 (4.00)	15.39 (3.98)	13.98 (3.79)	14.32 (3.84)	14.15 (3.81)
<b>T8</b>	Dinotefuran	20 SG	200 g	5.41 (2.36)	5.54 (2.38)	5.47 (2.37)	6.98 (2.70)	7.41 (2.78)	7.20 (2.74)	9.01 (3.06)	9.44 (3.13)	9.23 (3.09)	7.13 (2.72)	7.46 (2.78)	7.30 (2.75)
<b>T9</b>	Rynaxypyr	20SC	150 ml	4.27 (2.09)	4.36 (2.1)	4.32 (2.10)	5.92 (2.49)	6.35 (2.58)	6.14 (2.53)	8.22 (2.92)	8.65 (3.00)	8.43 (2.96)	6.14 (2.53)	6.45 (2.59)	6.30 (2.56)
<b>T10</b>	Untreated control	Water spray	500 lit.	26.78 (5.08)	27.11 (5.12)	26.95 (5.10)	27.94 (5.21)	28.37 (5.25)	28.15 (5.23)	31.57 (5.52)	32.00 (5.56)	31.78 (5.54)	28.76 (5.28)	29.16 (5.31)	28.96 (5.30)
<b>SEm±</b>				(0.18)	(0.18)	(0.12)	(0.19)	(0.19)	(0.12)	(0.21)	(0.21)	(0.13)	(0.19)	(0.19)	(0.12)
<b>CD 5%</b>				(0.55)	(0.55)	(0.33)	(0.57)	(0.57)	(0.35)	(0.63)	(0.62)	(0.38)	(0.57)	(0.57)	(0.35)
<b>CV %</b>				(9.26)	(9.19)	(9.22)	(9.17)	(8.95)	(9.06)	(9.32)	(9.17)	(9.25)	(9.08)	(8.95)	(9.01)

Figures under the parentheses are square root transformed values. GLH-Green leaf hopper

DAT-Days after transplanting; DAA-Days after application of insecticidal treatment, \*3<sup>rd</sup> foliar spray of the insecticidal treatments was applied at 80 DAT.

**Table-4.4.7: Effect of botanical insecticides on the incidence of gundhi /ear bug (*Leptocorsia species*), infesting rice**

S.N	Treatment	Formulations (a.i.) or Aza content %	Dose g or ml/ha	Number of ear bug per 10 hills recorded after 4 <sup>th</sup> spray* at											
				4 DAA			7 DAA			10 DAA			Overall Mean		
				2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean
<b>T1</b>	Neem Baan	1.00	1000 ml	4.87 (2.30)	5.09 (2.35)	4.98 (2.33)	6.57 (2.64)	7.09 (2.74)	6.83 (2.69)	7.36 (2.78)	7.57 (2.82)	7.47 (2.80)	6.26 (2.58)	6.58 (2.66)	6.42 (2.62)
<b>T2</b>	Neemazal	1.00	1000 ml	5.77 (2.49)	6.09 (2.55)	5.93 (2.52)	7.51 (2.81)	8.13 (2.92)	7.82 (2.87)	7.91 (2.88)	8.04 (2.91)	7.97 (2.90)	7.06 (2.73)	7.42 (2.81)	7.24 (2.77)
<b>T3</b>	Nimbecidine	0.03	2500 ml	7.78 (2.87)	8.10 (2.92)	7.94 (2.90)	9.44 (3.14)	9.96 (3.22)	9.70 (3.18)	9.88 (3.21)	9.98 (3.23)	9.93 (3.22)	9.03 (3.08)	9.35 (3.14)	9.19 (3.11)
<b>T4</b>	Multineem	0.03	2500 ml	9.55 (3.16)	9.87 (3.21)	9.71 (3.19)	10.88 (3.36)	11.40 (3.44)	11.14 (3.40)	11.45 (3.45)	11.49 (3.46)	11.47 (3.45)	10.62 (3.32)	10.92 (3.38)	10.77 (3.35)
<b>T5</b>	Neemoil	-	2500 ml	10.44 (3.30)	10.75 (3.35)	10.59 (3.32)	11.77 (3.49)	12.37 (3.58)	12.07 (3.54)	12.25 (3.56)	12.40 (3.59)	12.33 (3.58)	11.49 (3.45)	11.84 (3.51)	11.66 (3.48)
<b>T6</b>	Achook	0.03	2500 ml	3.81 (2.05)	4.15 (2.14)	3.98 (2.10)	5.14 (2.35)	5.68 (2.46)	5.41 (2.40)	5.68 (2.46)	5.95 (2.53)	5.81 (2.50)	4.88 (2.29)	5.26 (2.39)	5.07 (2.34)
<b>T7</b>	Pongamia oil (karanj oil)	-	2500 ml	6.46 (2.62)	6.82 (2.69)	6.64 (2.66)	8.13 (2.92)	8.68 (3.01)	8.41 (2.97)	8.63 (3.00)	9.45 (3.14)	9.04 (3.07)	7.74 (2.85)	8.32 (2.97)	8.03 (2.91)
<b>T8</b>	Dinotefuran	20 SG	200 g	2.26 (1.60)	2.72 (1.75)	2.49 (1.68)	3.09 (1.85)	3.49 (1.96)	3.29 (1.90)	3.44 (1.95)	3.60 (2.02)	3.52 (1.98)	2.93 (1.81)	3.27 (1.93)	3.10 (1.87)
<b>T9</b>	Rynaxypyr	20SC	150 ml	1.77 (1.47)	2.14 (1.59)	1.96 (1.53)	2.57 (1.71)	3.05 (1.85)	2.81 (1.78)	2.90 (1.81)	2.97 (1.86)	2.94 (1.84)	2.41 (1.67)	2.72 (1.78)	2.57 (1.73)
<b>T10</b>	Untreated control	Water spray	500 lit.	14.61 (3.79)	14.73 (3.81)	14.67 (3.80)	16.94 (4.10)	17.54 (4.17)	17.24 (4.13)	17.34 (4.15)	18.44 (4.29)	17.89 (4.22)	16.30 (4.02)	16.90 (4.14)	16.60 (4.08)
<b>SEm±</b>				(0.15)	(0.15)	(0.10)	(0.15)	(0.15)	(0.10)	(0.15)	(0.16)	(0.10)	(0.15)	(0.10)	(0.08)
<b>CD 5%</b>				(0.45)	(0.45)	(0.27)	(0.45)	(0.45)	(0.27)	(0.45)	(0.47)	(0.28)	(0.44)	(0.30)	(0.23)
<b>CV %</b>				(10.21)	(9.91)	(9.03)	(9.26)	(8.97)	(8.16)	(9.03)	(9.13)	(8.16)	(9.30)	(6.19)	(7.04)

Figures under the parentheses are square root transformed values. GB-Gundhi bug

DAT-Days after transplanting; DAA-Days after application of insecticidal treatment, \*4<sup>th</sup> foliar spray of the insecticidal treatments was applied at 95 DAT.

**Table-4.4.8: Effect of botanical insecticides on grain's yield of rice**

S.N	Treatment	Formulations (a.i.)	Dose g or ml/ha	Yield of rice grains (q/ha)		
				2016	2017	Pooled Mean
<b>T1</b>	Neem Baan	1.00	1000 ml	45.80	47.00	46.40
<b>T2</b>	Neemazal	1.00	1000 ml	45.03	46.30	45.67
<b>T3</b>	Nimbecidine	0.03	2500 ml	43.33	44.63	43.98
<b>T4</b>	Multineem	0.03	2500 ml	41.20	42.40	41.80
<b>T5</b>	Neemoil	-	2500 ml	40.33	41.50	40.92
<b>T6</b>	Achook	0.03	2500 ml	49.00	50.40	49.70
<b>T7</b>	Pongamia oil (karanj oil)	-	2500 ml	44.10	45.33	44.72
<b>T8</b>	Dinotefuran	20 SG	200 g	47.10	48.40	47.75
<b>T9</b>	Rynaxypyr	20SC	150 ml	47.83	49.17	48.50
<b>T10</b>	Untreated control	Water spray	500 lit.	34.40	35.57	34.98
<b>SEm±</b>				1.72	1.76	1.10
<b>CD 5%</b>				5.11	5.23	3.13
<b>CV %</b>				6.80	6.76	6.78

**Table-4.4.9: Economics of botanical insecticidal treatments used against major insect pest of rice (var. IR-64Drt)  
(Based on pooled mean yield of 2016 and 2017)**

S.N	Insecticidal treatment				Additional gain in yield over control		Money value of the extra yield of grains @ Rs.1750/q	Straw yield (q/ha)	Additional straw in yield over control		Money value of the extra yield of rice straw @ Rs.200/q	Price (Rs./lit. or Kg)	Quantity of the insecticides for four spray (litre/ha)	Cost of insecticides (Rs/ha) for 4 spray	Cost of protection** (Rs/ha)	Total income (Rs/ha)	Net profit (Rs/ha)	Benefit cost ratio
	Insecticides	Formulations Aza. % EC	Dose g or ml/ha	Yield of rice grains (q/ha)	(q/ha)	(%)			(q/ha)	(%)								
T1	Neem Baan	1.00	1000 ml	46.40	<b>11.42</b>	32.65	19985	60.32	<b>14.85</b>	32.65	2969.20	1020	4	4080	<b>4988</b>	22954.2	<b>17966.2</b>	3.60:1
T2	Neemazal	1.00	1000 ml	45.67	<b>10.69</b>	30.56	18707.5	59.37	<b>13.90</b>	30.56	2779.40	950	4	3800	<b>4708</b>	21486.9	<b>16778.9</b>	3.56:1
T3	Nimbecidine	0.03	2500 ml	43.98	<b>9</b>	25.73	15750	57.17	<b>11.70</b>	25.73	2340.00	650	10	6500	<b>7408</b>	18090	<b>10682</b>	1.44:1
T4	Multineem	0.03	2500 ml	41.80	<b>6.82</b>	19.50	11935	54.34	<b>8.87</b>	19.50	1773.20	450	10	4500	<b>5408</b>	13708.2	<b>8300.2</b>	1.53:1
T5	Neem oil	-	2500 ml	40.92	<b>5.94</b>	16.98	10395	53.19	<b>7.72</b>	16.98	1544.40	350	10	3500	<b>4408</b>	11939.4	<b>7531.4</b>	1.71:1
T6	Achook	0.03	2500 ml	49.70	<b>14.72</b>	42.08	25760	64.61	<b>19.14</b>	42.08	3827.20	600	10	6000	<b>6908</b>	29587.2	<b>22679.2</b>	3.28:1
T7	Pongamia oil (karanj oil)	-	2500 ml	44.72	<b>9.74</b>	27.84	17045	58.13	<b>12.66</b>	27.84	2532.40	250	10	2500	<b>3408</b>	19577.4	<b>16169.4</b>	4.74:1
T8	Dinotefuran*	20 SG	200 g	47.75	<b>12.77</b>	36.51	22347.5	62.07	<b>16.60</b>	36.51	3320.20	1350	0.8	1080	<b>1988</b>	25667.7	<b>23679.7</b>	11.91:1
T9	Rynaxypyr*	20SC	150 ml	48.50	<b>13.52</b>	38.65	23660	63.05	<b>17.58</b>	38.65	3515.20	8500	0.6	5100	<b>6008</b>	27175.2	<b>21167.2</b>	3.52:1
T10	Untreated control plot	Water spray	500 lit.	39.98				45.47										

\*Chemical insecticides (kept as check)

\*\*Cost of protection comprising of money value of the total quantity of the respective insecticide use in 04 application and cost of labourer @ Rs 227 per labourer per day. Four labourers were used in four rounds of foliar sprays.

**Table-4.5.1: Effect of chemical insecticides on the incidence of rice hispa (*Dicladispa armigera*) in terms of leaf damage (LDH%)**

S.N	Treatment	Formulations (a.i.) or	Dose (ml or g /ha)	Percentage of damaged leaves (LDH) caused by hispa , recorded after 1 <sup>st</sup> spray* at											
				4 DAA			7 DAA			10 DAA			Overall Mean		
				2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean
<b>T1</b>	Spinetoram 6SC plus methoxyfenozide 30SC	36 SC	375 ml	0.50 (4.04)	0.78 (5.04)	0.64 (4.54)	0.64 (4.43)	1.00 (5.58)	0.82 (5.01)	0.83 (5.12)	1.29 (6.43)	1.06 (5.78)	0.66 (4.56)	1.02 (5.72)	0.84 (5.14)
<b>T2</b>	Spinetoram 6SC plus methoxyfenozide 30SC	36 SC	400 ml	0.44 (3.80)	0.72 (4.85)	0.58 (4.33)	0.56 (4.12)	0.92 (5.34)	0.74 (4.73)	0.74 (4.80)	1.19 (6.17)	0.97 (5.48)	0.58 (4.27)	0.94 (5.49)	0.76 (4.88)
<b>T3</b>	Triflumezopyrim	106 SC	238 ml	1.01 (5.71)	1.29 (6.45)	1.15 (6.08)	1.22 (6.06)	1.58 (6.96)	1.40 (6.51)	1.53 (7.05)	1.99 (8.05)	1.76 (7.55)	1.26 (6.32)	1.62 (7.20)	1.44 (6.76)
<b>T4</b>	Flubendiamide	48SC	50 ml	0.60 (4.43)	0.88 (5.35)	0.74 (4.89)	0.74 (4.81)	1.10 (5.89)	0.92 (5.35)	0.92 (5.37)	1.37 (6.63)	1.15 (6.00)	0.75 (4.89)	1.12 (5.98)	0.94 (5.44)
<b>T5</b>	Rynaxypyr	20SC	150 ml	1.11 (5.90)	1.39 (6.64)	1.25 (6.27)	1.35 (6.51)	1.71 (7.35)	1.53 (6.93)	1.68 (7.24)	2.14 (8.23)	1.91 (7.73)	1.38 (6.58)	1.75 (7.44)	1.57 (7.01)
<b>T6</b>	Acephate	95SG	526 g	0.87 (5.35)	1.15 (6.14)	1.01 (5.75)	0.94 (5.49)	1.30 (6.45)	1.12 (5.97)	1.24 (6.27)	1.70 (7.38)	1.47 (6.83)	1.02 (5.73)	1.38 (6.69)	1.20 (6.21)
<b>T7</b>	Dinotefurain	20 SG	200 g	1.19 (6.16)	1.47 (6.87)	1.33 (6.51)	1.55 (6.93)	1.91 (7.72)	1.73 (7.32)	1.86 (7.54)	2.32 (8.50)	2.09 (8.02)	1.53 (6.91)	1.90 (7.73)	1.72 (7.32)
<b>T8</b>	Triazophos	40 EC	1500 ml	0.92 (5.35)	1.20 (6.15)	1.06 (5.75)	1.11 (5.71)	1.47 (6.67)	1.29 (6.19)	1.41 (6.74)	1.87 (7.77)	1.64 (7.25)	1.15 (5.99)	1.51 (6.91)	1.33 (6.45)
<b>T9</b>	Carbofuran followed by triazophos	3G & 40 EC	30 kg & 1500 ml	0.73 (4.64)	1.01 (5.55)	0.87 (5.09)	0.85 (5.22)	1.21 (6.23)	1.03 (5.72)	1.11 (5.96)	1.56 (7.11)	1.34 (6.53)	0.89 (5.32)	1.26 (6.34)	1.08 (5.83)
<b>T10</b>	Untreated control	Water spray	500 lit.	5.57 (13.58)	5.85 (13.92)	5.71 (13.75)	7.20 (15.35)	7.56 (15.74)	7.38 (15.54)	8.11 (16.34)	8.56 (16.82)	8.34 (16.58)	6.96 (15.14)	7.33 (15.54)	7.14 (15.34)
<b>SEm±</b>				(0.42)	(0.37)	(0.25)	(0.47)	(0.43)	(0.29)	(0.46)	(0.44)	(0.29)	(0.39)	(0.36)	(0.24)
<b>CD 5%</b>				(1.25)	(1.08)	(0.72)	(1.40)	(1.28)	(0.83)	(1.38)	(1.32)	(0.83)	(1.15)	(1.07)	(0.69)
<b>CV %</b>				(12.39)	(9.45)	(10.86)	(12.64)	(10.07)	(11.28)	(11.09)	(9.23)	(10.10)	(10.20)	(8.29)	(9.18)

Figures under the parenthesis are angular transformed values. LDH-Leaf damage due to hispa  
 DAT-Days after transplanting; DAA-Days after application of insecticidal treatment  
 \*1<sup>st</sup> foliar spray of the insecticidal treatments was applied at 25 DAT.

**Table-4.5.2:Effect of chemical insecticides on the incidence of yellow stem borer (*Scirpophaga incertulas* Walker) in terms of dead heart (DH %)**

S.N	Treatment	Formulation s (a.i.)	Dose (ml or g /ha)	Percentage of dead heart (DH) caused by YSB, recorded after 2 <sup>nd</sup> spray* at											
				4 DAA			7 DAA			10 DAA			Overall Mean		
				2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean
<b>T1</b>	Spinetoram 6SC plus methoxyfenozide 30SC	36 SC	375 ml	0.93 (5.38)	1.36 (6.63)	1.15 (6.00)	1.26 (6.22)	1.70 (7.31)	1.48 (6.76)	1.63 (7.25)	2.07 (8.19)	1.85 (7.72)	1.27 (6.34)	1.71 (7.41)	1.49 (6.87)
<b>T2</b>	Spinetoram 6SC plus methoxyfenozide 30SC	36 SC	400 ml	0.86 (5.19)	1.29 (6.47)	1.07 (5.82)	1.06 (5.81)	1.50 (6.95)	1.28 (6.38)	1.40 (6.70)	1.84 (7.71)	1.62 (7.21)	1.11 (5.94)	1.54 (7.06)	1.33 (6.50)
<b>T3</b>	Triflumezopyrim	106 SC	238 ml	1.44 (6.77)	1.88 (7.79)	1.66 (7.27)	2.22 (8.43)	2.66 (9.26)	2.44 (8.84)	3.17 (9.85)	3.60 (10.59)	3.39 (10.22)	2.28 (8.45)	2.71 (9.30)	2.50 (8.88)
<b>T4</b>	Flubendiamide	48SC	50 ml	1.07 (5.67)	1.51 (6.91)	1.29 (6.28)	1.43 (6.75)	1.87 (7.75)	1.65 (7.25)	2.04 (8.03)	2.48 (8.90)	2.26 (8.47)	1.51 (6.89)	1.95 (7.90)	1.73 (7.39)
<b>T5</b>	Rynaxypyr	20SC	150 ml	1.56 (6.82)	2.00 (7.91)	1.78 (7.36)	2.53 (8.70)	2.97 (9.54)	2.75 (9.12)	3.46 (10.38)	3.90 (11.08)	3.68 (10.73)	2.52 (8.76)	2.96 (9.60)	2.74 (9.18)
<b>T6</b>	Acephate	95SG	526 g	1.21 (6.27)	1.65 (7.35)	1.43 (6.80)	1.81 (7.68)	2.25 (8.57)	2.03 (8.13)	2.66 (9.24)	3.10 (10.00)	2.88 (9.62)	1.90 (7.83)	2.33 (8.71)	2.12 (8.27)
<b>T7</b>	Dinotefurain	20 SG	200 g	1.62 (6.90)	2.05 (8.00)	1.84 (7.43)	2.69 (9.11)	3.13 (9.90)	2.91 (9.50)	3.75 (10.87)	4.19 (11.54)	3.97 (11.21)	2.69 (9.12)	3.13 (9.92)	2.91 (9.52)
<b>T8</b>	Triazophos	40 EC	1500 ml	1.31 (6.31)	1.74 (7.45)	1.52 (6.87)	1.97 (7.84)	2.41 (8.73)	2.19 (8.29)	2.94 (9.77)	3.38 (10.49)	3.16 (10.13)	2.07 (8.11)	2.51 (8.98)	2.29 (8.55)
<b>T9</b>	Carbofuran followed by triazophos	3G & 40 EC	30 kg & 1500 ml	1.16 (6.00)	1.59 (7.15)	1.38 (6.57)	1.62 (6.98)	2.06 (7.98)	1.84 (7.48)	2.30 (8.53)	2.74 (9.35)	2.52 (8.94)	1.69 (7.25)	2.13 (8.22)	1.91 (7.73)
<b>T10</b>	Untreated control	Water spray	500 lit.	6.07 (14.18)	6.51 (14.53)	6.29 (14.33)	7.79 (16.06)	8.23 (16.41)	8.01 (16.24)	10.24 (18.33)	10.68 (18.63)	10.46 (18.48)	8.04 (16.29)	8.47 (16.61)	8.25 (16.45)
	<b>SEm±</b>			(0.42)	(0.47)	(0.29)	(0.49)	(0.57)	(0.34)	(0.60)	(0.70)	(0.42)	(0.40)	(0.54)	(0.30)
	<b>CD 5%</b>			(1.24)	(1.39)	(0.82)	(1.45)	(1.68)	(0.96)	(1.80)	(2.08)	(1.18)	(1.18)	(1.59)	(0.86)
	<b>CV %</b>			(10.44)	(10.10)	(10.27)	(10.12)	(10.63)	(10.41)	(10.59)	(11.39)	(11.03)	(8.08)	(9.91)	(9.13)

Figures under the parenthesis are angular transformed values. DH-Dead heart caused by yellow stem borer

DAT-Days after transplanting; DAA-Days after application of insecticidal treatment

\*2<sup>nd</sup> foliar spray of the insecticidal treatments was applied at 40 DAT.

**Table-4.5.3: Effect of chemical insecticides on the incidence of yellow stem borer (*Scirpophaga incertulas* Walker) in terms of white ear (WE %)**

S.N	Treatment	Formulations (a.i.)	Dose (ml or g /ha)	Percentage of white ear (WE) caused by yellow stem borer recorded after 4 <sup>th</sup> spray* at								
				Dough stage			Pre - Maturity Stage			Overall Mean		
				2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean
<b>T1</b>	Spinetoram 6SC plus methoxyfenozide 30SC	36 SC	375 ml	1.68 (7.40)	2.11 (8.30)	1.89 (7.85)	1.93 (7.82)	2.38 (8.74)	2.16 (8.28)	1.80 (7.62)	2.25 (8.53)	2.02 (8.07)
<b>T2</b>	Spinetoram 6SC plus methoxyfenozide 30SC	36 SC	400 ml	1.44 (6.80)	1.87 (7.78)	1.65 (7.29)	1.76 (7.56)	2.22 (8.49)	1.99 (8.03)	1.60 (7.19)	2.04 (8.15)	1.82 (7.67)
<b>T3</b>	Triflumezopyrim	106 SC	238 ml	2.81 (9.51)	3.24 (10.24)	3.03 (9.87)	2.93 (9.74)	3.38 (10.50)	3.16 (10.12)	2.87 (9.63)	3.31 (10.37)	3.09 (10.00)
<b>T4</b>	Flubendiamide	48SC	50 ml	1.84 (7.74)	2.27 (8.61)	2.05 (8.18)	2.11 (8.18)	2.56 (9.06)	2.34 (8.62)	1.97 (7.97)	2.42 (8.84)	2.19 (8.41)
<b>T5</b>	Rynaxypyr	20SC	150 ml	3.06 (9.70)	3.50 (10.43)	3.28 (10.06)	3.18 (9.91)	3.64 (10.67)	3.41 (10.29)	3.12 (9.81)	3.57 (10.55)	3.34 (10.18)
<b>T6</b>	Acephate	95SG	526 g	2.35 (8.60)	2.78 (9.40)	2.57 (9.00)	2.58 (8.98)	3.04 (9.80)	2.81 (9.39)	2.47 (8.79)	2.91 (9.60)	2.69 (9.20)
<b>T7</b>	Dinotefurain	20 SG	200 g	3.28 (10.11)	3.71 (10.81)	3.50 (10.46)	3.45 (10.41)	3.91 (11.13)	3.68 (10.77)	3.37 (10.26)	3.81 (10.97)	3.59 (10.62)
<b>T8</b>	Triazophos	40 EC	1500 ml	2.54 (9.01)	2.97 (9.78)	2.76 (9.39)	2.76 (9.40)	3.22 (10.18)	2.99 (9.79)	2.65 (9.21)	3.10 (9.98)	2.87 (9.59)
<b>T9</b>	Carbofuran followed by triazophos	3G & 40 EC	30 kg & 1500 ml	2.08 (8.12)	2.52 (8.96)	2.30 (8.54)	2.25 (8.50)	2.71 (9.35)	2.48 (8.92)	2.17 (8.31)	2.61 (9.16)	2.39 (8.74)
<b>T10</b>	Untreated control	Water spray	500 lit.	9.72 (17.83)	10.16 (18.25)	9.94 (18.04)	11.80 (19.66)	12.26 (20.07)	12.03 (19.87)	10.76 (18.77)	11.21 (19.19)	10.99 (18.98)
	<b>SEm±</b>			(0.73)	(0.70)	(0.46)	(0.75)	(0.73)	(0.47)	(0.71)	(0.69)	(0.44)
	<b>CD 5%</b>			(2.18)	(2.09)	(1.30)	(2.22)	(2.17)	(1.34)	(2.11)	(2.05)	(1.27)
	<b>CV %</b>			(13.39)	(11.88)	(12.61)	(12.93)	(11.73)	(12.30)	(12.63)	(11.37)	(11.98)

Figures under the parenthesis are angular transformed values. WE-White ear by yellow stem borer  
 DAT-Days after transplanting; DAA-Days after application of insecticidal treatment  
 \*4<sup>th</sup> foliar spray of the insecticidal treatments was applied at 95 DAT.

**Table-4.5.4: Effect of chemical insecticides on the incidence of gall midge (*Orseolia oryzae* Wood mason) in terms of silver shoots (SS %)**

S.N	Treatment	Formulations (a.i.)	Dose (ml or g /ha)	Silver shoot (SS) caused by gall midge, recorded after 2 <sup>nd</sup> spray* at											
				4 DAA			7 DAA			10 DAA			Overall Mean		
				2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean
T1	Spinetoram 6SC plus methoxyfenozide 30SC	36 SC	375 ml	0.35 (3.32)	0.57 (4.16)	0.46 (3.74)	0.85 (5.19)	1.17 (6.14)	1.01 (5.66)	1.34 (6.49)	1.81 (7.63)	1.58 (7.06)	0.85 (5.18)	1.18 (6.15)	1.01 (5.67)
T2	Spinetoram 6SC plus methoxyfenozide 30SC	36 SC	400 ml	0.25 (2.80)	0.44 (3.76)	0.35 (3.28)	0.68 (4.54)	1.00 (5.63)	0.84 (5.08)	1.19 (6.09)	1.66 (7.30)	1.43 (6.69)	0.71 (4.68)	1.04 (5.76)	0.87 (5.22)
T3	Triflumezopyrim	106 SC	238 ml	1.14 (5.88)	1.36 (6.43)	1.25 (6.16)	1.58 (7.03)	1.91 (7.78)	1.75 (7.41)	2.35 (8.61)	2.82 (9.51)	2.58 (9.06)	1.69 (7.26)	2.02 (8.01)	1.86 (7.63)
T4	Flubendiamide	48SC	50 ml	0.48 (3.95)	0.66 (4.70)	0.57 (4.33)	1.01 (5.47)	1.34 (6.44)	1.18 (5.95)	1.55 (6.97)	2.02 (8.05)	1.79 (7.51)	1.02 (5.62)	1.35 (6.55)	1.18 (6.08)
T5	Rynaxypyr	20SC	150 ml	1.23 (6.13)	1.44 (6.64)	1.33 (6.38)	1.75 (7.37)	2.08 (8.09)	1.92 (7.73)	2.45 (8.76)	2.92 (9.65)	2.69 (9.20)	1.81 (7.51)	2.14 (8.23)	1.98 (7.87)
T6	Acephate	95SG	526 g	0.88 (5.20)	1.10 (5.82)	0.99 (5.51)	1.23 (6.10)	1.55 (6.97)	1.39 (6.54)	1.92 (7.74)	2.39 (8.74)	2.16 (8.24)	1.34 (6.44)	1.68 (7.27)	1.51 (6.86)
T7	Dinotefurain	20 SG	200 g	1.36 (6.49)	1.55 (6.96)	1.46 (6.72)	1.92 (7.68)	2.25 (8.38)	2.09 (8.03)	2.70 (9.25)	3.18 (10.09)	2.94 (9.67)	1.99 (7.90)	2.33 (8.58)	2.16 (8.24)
T8	Triazophos	40 EC	1500 ml	1.08 (5.70)	1.26 (6.28)	1.17 (5.99)	1.39 (6.54)	1.72 (7.35)	1.56 (6.95)	2.15 (8.28)	2.62 (9.20)	2.39 (8.74)	1.54 (6.93)	1.87 (7.71)	1.71 (7.32)
T9	Carbofuran followed by triazophos	3G & 40 EC	30 kg & 1500 ml	0.63 (4.42)	0.84 (5.12)	0.73 (4.77)	1.15 (5.95)	1.47 (6.82)	1.31 (6.38)	1.80 (7.60)	2.28 (8.59)	2.04 (8.09)	1.20 (6.13)	1.53 (6.99)	1.36 (6.56)
T10	Untreated control	Water spray	500 lit.	5.64 (13.66)	5.87 (13.90)	5.75 (13.78)	6.08 (14.16)	6.74 (14.87)	6.41 (14.51)	7.26 (15.47)	7.73 (16.01)	7.50 (15.74)	6.33 (14.53)	6.77 (15.03)	6.55 (14.78)
<b>SEM±</b>				(0.46)	(0.42)	(0.28)	(0.44)	(0.44)	(0.28)	(0.58)	(0.57)	(0.37)	(0.26)	(0.25)	(0.17)
<b>CD 5%</b>				(1.36)	(1.25)	(0.80)	(1.31)	(1.30)	(0.80)	(1.72)	(1.70)	(1.04)	(0.79)	(0.73)	(0.47)
<b>CV %</b>				(13.80)	(11.43)	(12.57)	(10.93)	(9.67)	(10.27)	(11.78)	(10.47)	(11.09)	(6.36)	(5.29)	(5.80)

Figures under the parenthesis are angular transformed values. SS- Silver shoot caused by gall midge

DAT-Days after transplanting; DAA-Days after application of insecticidal treatment

\*2<sup>nd</sup> foliar spray of the insecticidal treatments was applied at 40 DAT.

**Table-4.5.5: Effect of chemical insecticides on the incidence of leaf folder (*Cnephalocrosis medinalis*) in terms of leaf damage (LDLF %)**

S.N	Treatment	Formulations (a.i.) or	Dose (ml or g /ha)	Percentage of leaf damage caused by the leaf folder (LDLF) , recorded after 3 <sup>rd</sup> spray* at											
				4 DAA			7 DAA			10 DAA			Overall Mean		
				2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean
<b>T1</b>	Spinetoram 6SC plus methoxyfenozide 30SC	36 SC	375 ml	0.52 (4.04)	0.95 (5.52)	0.74 (4.78)	1.15 (5.94)	1.62 (7.14)	1.38 (6.54)	1.82 (7.45)	2.27 (8.40)	2.05 (7.93)	1.17 (5.97)	1.61 (7.12)	1.39 (6.55)
<b>T2</b>	Spinetoram 6SC plus methoxyfenozide 30SC	36 SC	400 ml	0.44 (3.70)	0.87 (5.27)	0.65 (4.48)	1.00 (5.50)	1.46 (6.78)	1.23 (6.14)	1.59 (6.95)	2.03 (7.96)	1.81 (7.45)	1.01 (5.54)	1.45 (6.76)	1.23 (6.15)
<b>T3</b>	Triflumezopyrim	106 SC	238 ml	1.23 (6.08)	1.66 (7.18)	1.44 (6.63)	1.90 (7.79)	2.37 (8.73)	2.14 (8.26)	2.60 (9.09)	3.04 (9.87)	2.82 (9.48)	1.91 (7.76)	2.36 (8.67)	2.13 (8.21)
<b>T4</b>	Flubendiamide	48SC	50 ml	0.65 (4.59)	1.07 (5.91)	0.86 (5.25)	1.32 (6.39)	1.79 (7.52)	1.56 (6.96)	2.03 (8.06)	2.48 (8.93)	2.26 (8.49)	1.33 (6.51)	1.78 (7.56)	1.56 (7.03)
<b>T5</b>	Rynaxypyr	20SC	150 ml	1.39 (6.55)	1.81 (7.56)	1.60 (7.06)	2.05 (8.00)	2.52 (8.93)	2.28 (8.46)	2.73 (9.47)	3.18 (10.22)	2.96 (9.85)	2.06 (8.12)	2.50 (8.98)	2.28 (8.55)
<b>T6</b>	Acephate	95SG	526 g	1.03 (5.59)	1.45 (6.75)	1.24 (6.17)	1.61 (7.11)	2.08 (8.13)	1.85 (7.62)	2.32 (8.66)	2.77 (9.47)	2.55 (9.07)	1.65 (7.24)	2.10 (8.20)	1.88 (7.72)
<b>T7</b>	Dinotefurain	20 SG	200 g	1.51 (6.84)	1.94 (7.82)	1.73 (7.33)	2.19 (8.30)	2.66 (9.19)	2.42 (8.75)	2.86 (9.64)	3.30 (10.38)	3.08 (10.01)	2.19 (8.35)	2.63 (9.19)	2.41 (8.77)
<b>T8</b>	Triazophos	40 EC	1500 ml	1.14 (5.81)	1.57 (6.95)	1.35 (6.38)	1.74 (7.38)	2.21 (8.37)	1.98 (7.87)	2.45 (8.93)	2.90 (9.72)	2.68 (9.32)	1.78 (7.50)	2.22 (8.43)	2.00 (7.97)
<b>T9</b>	Carbofuran followed by triazophos	3G & 40 EC	30 kg & 1500 ml	0.90 (5.35)	1.33 (6.53)	1.11 (5.94)	1.47 (6.87)	1.94 (7.91)	1.71 (7.39)	2.16 (8.34)	2.61 (9.18)	2.39 (8.76)	1.51 (6.96)	1.96 (7.95)	1.74 (7.45)
<b>T10</b>	Untreated control	Water spray	500 lit.	7.58 (15.88)	8.01 (16.33)	7.79 (16.11)	8.85 (17.14)	9.31 (17.61)	9.08 (17.38)	9.88 (18.01)	10.33 (18.44)	10.11 (18.23)	8.77 (17.06)	9.22 (17.51)	8.99 (17.28)
<b>SEM±</b>				(0.40)	(0.36)	(0.25)	(0.50)	(0.48)	(0.31)	(0.57)	(0.55)	(0.36)	(0.33)	(0.33)	(0.21)
<b>CD 5%</b>				(1.19)	(1.07)	(0.71)	(1.48)	(1.41)	(0.89)	(1.69)	(1.63)	(1.01)	(0.99)	(0.97)	(0.61)
<b>CV %</b>				(10.79)	(8.24)	(9.43)	(10.72)	(9.11)	(9.87)	(10.43)	(9.28)	(9.84)	(7.15)	(6.24)	(6.67)

Figures under the parenthesis are angular transformed values. LDLF-Leaf damage due to leaf folder  
 DAT-Days after transplanting; DAA-Days after application of insecticidal treatment, \*3<sup>rd</sup> foliar spray of the insecticidal treatments was applied at 80 DAT.

**Table-4.5.6: Effect of chemical insecticides on the incidence of green leaf hopper (GLH) (*Nephtottetix nigropictus*), infesting rice**

S.N	Treatment	Formulations (a.i.) or	Dose (ml or g /ha)	No of GLH/10 hills, recorded after 3 <sup>rd</sup> spray* at											
				4 DAA			7 DAA			10 DAA			Overall Mean		
				2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean
<b>T1</b>	Spinetoram 6SC plus methoxyfenozide 30SC	36 SC	375 ml	3.57 (1.98)	4.19 (2.13)	3.88 (2.05)	4.67 (2.23)	5.33 (2.37)	5.00 (2.30)	6.42 (2.57)	7.16 (2.71)	6.79 (2.64)	4.89 (2.27)	5.56 (2.41)	5.22 (2.34)
<b>T2</b>	Spinetoram 6SC plus methoxyfenozide 30SC	36 SC	400 ml	3.24 (1.88)	3.86 (2.04)	3.55 (1.96)	4.49 (2.19)	5.15 (2.33)	4.82 (2.26)	6.02 (2.50)	6.76 (2.64)	6.39 (2.57)	4.58 (2.20)	5.26 (2.35)	4.92 (2.28)
<b>T3</b>	Triflumezopyrim	106 SC	238 ml	4.55 (2.21)	5.17 (2.34)	4.86 (2.28)	5.88 (2.48)	9.80 (2.60)	6.21 (2.54)	8.08 (2.88)	8.82 (3.00)	8.45 (2.94)	6.17 (2.54)	6.84 (2.66)	6.51 (2.60)
<b>T4</b>	Flubendiamide	48SC	50 ml	3.81 (2.05)	4.43 (2.20)	4.12 (2.12)	4.90 (2.28)	5.56 (2.42)	5.23 (2.35)	6.79 (2.65)	7.53 (2.78)	7.16 (2.72)	5.17 (2.34)	5.84 (2.48)	5.50 (2.41)
<b>T5</b>	Rynaxypyr	20SC	150 ml	4.97 (2.30)	5.59 (2.43)	5.28 (2.36)	6.23 (2.55)	6.89 (2.68)	6.56 (2.62)	8.40 (2.93)	9.13 (3.05)	8.77 (2.99)	6.53 (2.61)	7.21 (2.73)	6.87 (2.67)
<b>T6</b>	Acephate	95SG	526 g	4.25 (2.14)	4.87 (2.28)	4.56 (2.21)	5.32 (2.38)	5.98 (2.51)	5.65 (2.45)	7.30 (2.73)	8.03 (2.86)	7.67 (2.80)	5.62 (2.43)	6.30 (2.56)	5.96 (2.50)
<b>T7</b>	Dinotefurain	20 SG	200 g	5.43 (2.39)	6.05 (2.52)	5.74 (2.45)	7.06 (2.69)	7.72 (2.81)	7.39 (2.75)	9.04 (3.03)	9.77 (3.15)	9.41 (3.09)	7.17 (2.72)	7.85 (2.84)	7.51 (2.78)
<b>T8</b>	Triazophos	40 EC	1500 ml	4.34 (2.16)	4.96 (2.30)	4.65 (2.23)	5.55 (2.43)	6.20 (2.55)	5.88 (2.49)	7.61 (2.79)	8.34 (2.92)	7.98 (2.86)	5.83 (2.47)	6.50 (2.61)	6.17 (2.54)
<b>T9</b>	Carbofuran followed by triazophos	3G & 40 EC	30 kg & 1500 ml	4.02 (2.09)	4.65 (2.23)	4.34 (2.16)	5.20 (2.36)	5.85 (2.49)	5.53 (2.43)	7.04 (2.68)	7.78 (2.81)	7.41 (2.75)	5.42 (2.39)	6.09 (2.52)	5.76 (2.46)
<b>T10</b>	Untreated control	Water spray	500 lit.	17.64 (4.22)	18.26 (4.29)	17.95 (4.26)	21.71 (4.63)	22.37 (4.71)	22.04 (4.67)	25.87 (5.07)	26.60 (5.14)	26.24 (5.10)	21.74 (4.66)	22.41 (4.73)	22.08 (4.69)
<b>SEm±</b>				(0.15)	(0.14)	(0.09)	(0.22)	(0.21)	(0.14)	(0.18)	(0.18)	(0.11)	(0.18)	(0.17)	(0.11)
<b>CD 5%</b>				(0.44)	(0.42)	(0.26)	(0.65)	(0.63)	(0.39)	(0.54)	(0.52)	(0.32)	(0.53)	(0.52)	(0.32)
<b>CV %</b>				(10.94)	(10.01)	(10.46)	(14.48)	(13.48)	(13.96)	(10.48)	(9.80)	(10.13)	(11.69)	(10.86)	(11.26)

Figures under the parentheses are square root transformed values. GLH-Green leaf hopper

DAT-Days after transplanting; DAA-Days after application of insecticidal treatment

\*3<sup>rd</sup> foliar spray of the insecticidal treatments was applied at 80 DAT.

**Table-4.5.7: Effect of chemical insecticides on the incidence of gundhi bug /ear bug (*Leptocorsia oratorius*), infesting rice**

S.N	Treatment	Formulations (a.i.)	Dose (ml or g /ha)	Number of ear bug per 10 hills, recorded after 4 <sup>th</sup> spray* at											
				4 DAA			7 DAA			10 DAA			Overall Mean		
				2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean
<b>T1</b>	Spinetoram 6SC plus methoxyfenozide 30SC	36 SC	375 ml	0.98 (1.20)	1.31 (1.33)	1.14 (1.26)	1.46 (1.34)	1.84 (1.48)	1.65 (1.41)	1.61 (1.43)	2.14 (1.60)	1.88 (1.51)	1.35 (1.33)	1.77 (1.47)	1.56 (1.40)
<b>T2</b>	Spinetoram 6SC plus methoxyfenozide 30SC	36 SC	400 ml	0.85 (1.15)	1.18 (1.29)	1.02 (1.22)	1.22 (1.29)	1.60 (1.43)	1.41 (1.36)	1.42 (1.38)	1.95 (1.55)	1.69 (1.46)	1.16 (1.28)	1.58 (1.43)	1.37 (1.35)
<b>T3</b>	Triflumezopyrim	106 SC	238 ml	1.75 (1.47)	2.08 (1.58)	1.92 (1.52)	2.32 (1.66)	2.70 (1.77)	2.51 (1.71)	2.66 (1.74)	3.19 (1.89)	2.93 (1.81)	2.24 (1.63)	2.66 (1.75)	2.45 (1.69)
<b>T4</b>	Flubendiamide	48SC	50 ml	1.13 (1.26)	1.47 (1.38)	1.30 (1.32)	1.64 (1.44)	2.02 (1.56)	1.83 (1.50)	1.81 (1.49)	2.34 (1.65)	2.08 (1.57)	1.53 (1.40)	1.94 (1.54)	1.74 (1.47)
<b>T5</b>	Rynaxypyr	20SC	150 ml	1.96 (1.53)	2.30 (1.64)	2.13 (1.59)	2.68 (1.76)	3.06 (1.86)	2.87 (1.81)	2.92 (1.80)	3.45 (1.94)	3.19 (1.87)	2.52 (1.71)	2.94 (1.83)	2.73 (1.77)
<b>T6</b>	Acephate	95SG	526 g	1.33 (1.33)	1.66 (1.45)	1.50 (1.39)	1.99 (1.55)	2.37 (1.67)	2.18 (1.61)	2.23 (1.62)	2.76 (1.78)	2.50 (1.70)	1.85 (1.51)	2.27 (1.64)	2.06 (1.57)
<b>T7</b>	Dinotefurain	20 SG	200 g	2.22 (1.62)	2.55 (1.72)	2.38 (1.67)	3.00 (1.85)	3.38 (1.95)	3.19 (1.90)	3.45 (1.94)	3.98 (2.07)	3.72 (2.00)	2.89 (1.81)	3.30 (1.92)	3.10 (1.87)
<b>T8</b>	Triazophos	40 EC	1500 ml	1.54 (1.41)	1.87 (1.52)	1.71 (1.47)	2.16 (1.60)	2.54 (1.72)	2.35 (1.66)	2.41 (1.68)	2.94 (1.82)	2.68 (1.75)	2.04 (1.58)	2.45 (1.70)	2.24 (1.64)
<b>T9</b>	Carbofuran followed by triazophos	3G & 40 EC	30 kg & 1500 ml	1.23 (1.30)	1.57 (1.42)	1.40 (1.36)	1.79 (1.49)	2.17 (1.61)	1.98 (1.55)	1.99 (1.55)	2.52 (1.71)	2.25 (1.63)	1.67 (1.45)	2.08 (1.59)	1.88 (1.52)
<b>T10</b>	Untreated control	Water spray	500 lit.	9.28 (3.07)	9.61 (3.12)	9.45 (3.09)	11.53 (3.43)	11.91 (3.49)	11.72 (3.46)	12.97 (3.65)	13.50 (3.72)	13.24 (3.68)	11.26 (3.39)	11.67 (3.45)	11.47 (3.42)
<b>SEm±</b>				(0.12)	(0.12)	(0.07)	(0.12)	(0.11)	(0.07)	(0.12)	(0.12)	(0.08)	(0.10)	(0.10)	(0.06)
<b>CD 5%</b>				(0.35)	(0.34)	(0.21)	(0.35)	(0.34)	(0.21)	(0.36)	(0.34)	(0.21)	(0.29)	(0.28)	(0.18)
<b>CV %</b>				(13.30)	(12.13)	(12.70)	(11.87)	(10.58)	(11.20)	(11.48)	(10.15)	(10.79)	(9.95)	(9.01)	(9.47)

Figures under the parentheses are square root transformed values. GB-Gundhi bug  
 DAT-Days after transplanting; DAA-Days after application of insecticidal treatment  
 \*4<sup>th</sup> foliar spray of the insecticidal treatments was applied at 95 DAT.

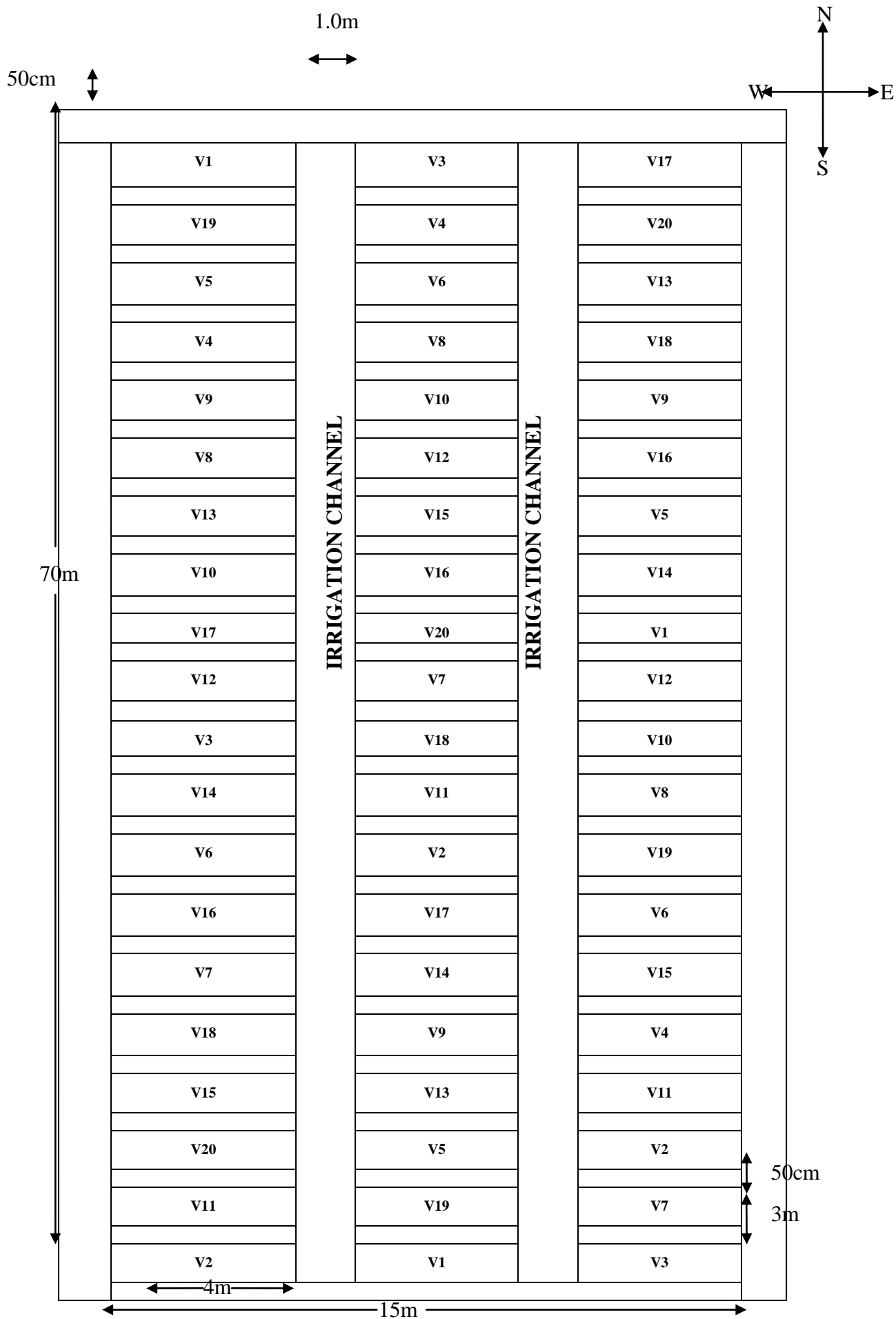
**Table-4.5.8: Effect of chemical insecticides on grain's yield of rice**

S.N	Treatment	Formulations (a.i.)	Dose (ml or g /ha)	Grains' yield of rice q/ha		
				2016	2017	Pooled Mean
T1	Spinetoram 6SC plus methoxyfenozide 30SC	36 SC	375 ml	47.23	48.13	47.68
T2	Spinetoram 6SC plus methoxyfenozide 30SC	36 SC	400 ml	47.95	48.85	48.40
T3	Triflumezopyrim	106 SC	238 ml	42.97	43.87	43.42
T4	Flubendiamide	48SC	50 ml	46.27	47.17	46.72
T5	Rynaxypyr	20SC	150 ml	42.25	43.15	42.70
T6	Acephate	95SG	526 g	44.03	44.93	44.48
T7	Dinotefurain	20 SG	200 g	41.60	42.50	42.05
T8	Triazophos	40 EC	1500 ml	43.50	44.40	43.95
T9	Carbofuran followed by triazophos	3G & 40 EC	30 kg & 1500 ml	45.10	46.00	45.55
T10	Untreated control	Water spray	500 lit.	35.73	36.63	36.18
<b>SEm±</b>				1.72	1.72	1.09
<b>CD 5%</b>				5.12	5.12	3.10
<b>CV %</b>				6.83	6.69	6.76

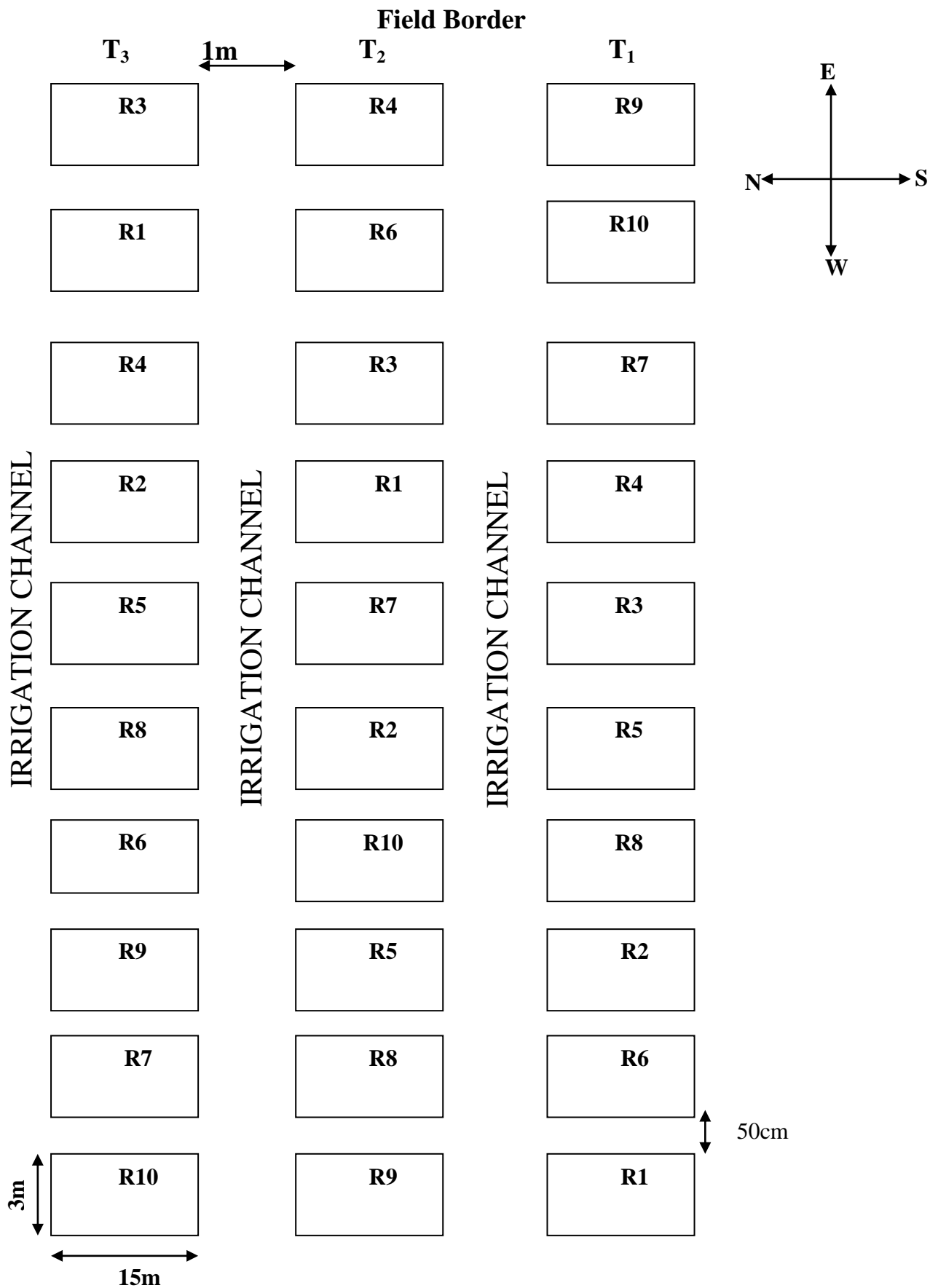
**Table-4.5.9: Economics of chemical insecticidal treatments used against major insect pest of rice (var. Naveen)  
(Based on pooled mean yield of 2016 and 2017)**

S.N	Insecticidal treatments				Additional gain in yield over control		Money value of the extra yield of grains @ Rs.1750/q	Straw yield (q/ha)	Additional straw in yield over control		Money value of the extra yield of straw @ Rs.200/q	Price (Rs./lit. or Kg)	Quantity of the insecticides for four spray (litre/ha)	Cost of insecticides (Rs/ha) for 4 spray	Cost of protection* (Rs/ha)	Total income (Rs/ha)	Net profit (Rs/ha)	Benefit cost ratio
	Treatment	Formulations (a.i.)	Dose g or ml/ha	Yield of rice grains (q/ha)	(q/ha)	(%)			(q/ha)	(%)								
T1	Spinetoram 6SC plus methoxyfenozide 30SC	36 SC	375 ml	47.68	<b>11.5</b>	31.79	20125	61.98	<b>14.95</b>	31.79	2990	2500	1.5	3750	<b>4658</b>	23115	<b>18457</b>	3.96:1
T2	Spinetoram 6SC plus methoxyfenozide 30SC	36 SC	400 ml	48.40	<b>12.22</b>	33.78	21385	62.92	<b>15.89</b>	33.78	3177.2	2500	1.6	4000	<b>4908</b>	24562.2	<b>19654.2</b>	4.00:1
T3	Triflumezopyrim	106 SC	238 ml	43.42	<b>7.24</b>	20.01	12670	56.45	<b>9.41</b>	20.01	1882.4	2500	0.952	2380	<b>3288</b>	14552.4	<b>11264.4</b>	3.43:1
T4	Flubendiamide	48SC	50 ml	46.72	<b>10.54</b>	29.13	18445	60.74	<b>13.70</b>	29.13	2740.4	14000	0.2	2800	<b>3708</b>	21185.4	<b>17477.4</b>	4.71:1
T5	Rynaxypyr	20SC	150 ml	42.70	<b>6.52</b>	18.02	11410	55.51	<b>8.48</b>	18.02	1695.2	8500	0.6	5100	<b>6008</b>	13105.2	<b>7097.2</b>	1.18:1
T6	Acephate	95SG	526 g	44.48	<b>8.3</b>	22.94	14525	57.82	<b>10.79</b>	22.94	2158	900	2.104	1893.6	<b>2801.6</b>	16683	<b>13881.4</b>	4.95:1
T7	Dinotefurain	20 SG	200 g	42.05	<b>5.87</b>	16.22	10272.5	54.67	<b>7.63</b>	16.22	1526.2	1350	0.8	1080	<b>1988</b>	11798.7	<b>9810.7</b>	4.93:1
T8	Triazophos	40 EC	1500 ml	43.95	<b>7.77</b>	21.48	13597.5	57.14	<b>10.10</b>	21.48	2020.2	450	06	2700	<b>3608</b>	15617.7	<b>12009.7</b>	3.33:1
T9	Carbofuran followed by triazophos	3G&40 EC	30 kg & 1500 ml	45.55	<b>9.37</b>	25.90	16397.5	59.22	<b>12.18</b>	25.90	2436.2	65 /450	30kg+3lit	3300	<b>3981</b>	18833.7	<b>14852.7</b>	3.73:1
T10	Untreated control	Water spray	500 lit.	41.18				47.03										

\*Cost of protection comprising of money value of the total quantity of the respective insecticide use in 04 application and cost of labourer @ Rs 227 per labourer per day. Four labourers were used in four rounds of foliar sprays.



**Fig-1: Layout plan of varietal screening experiment against major insect pests of rice**



**Fig-2: Layout plan for the experiment on the effect of three dates of transplanting against major insect pests of rice.**

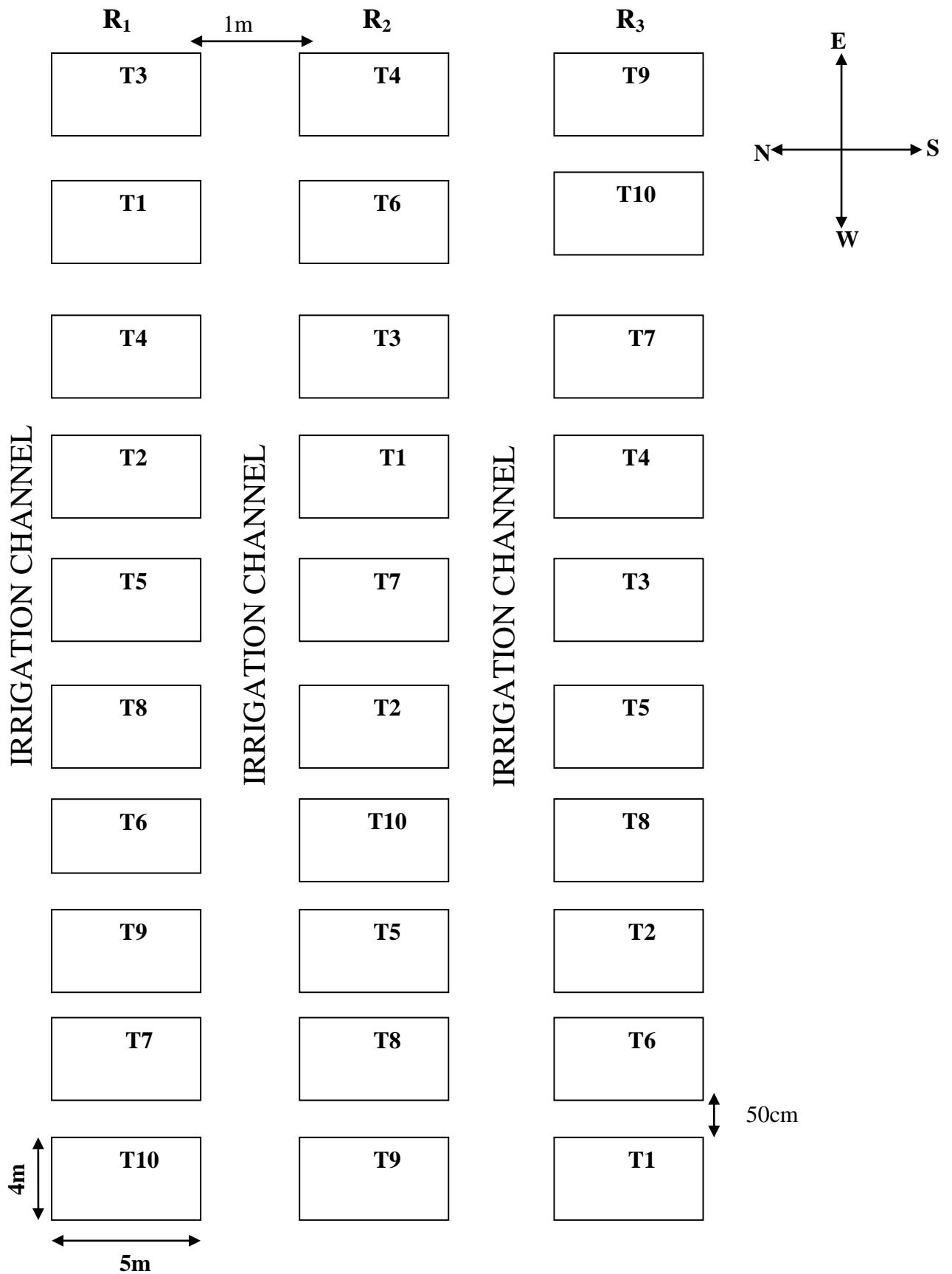


Fig-3: Layout plan for the experiment on the efficacy evaluation of the test botanical insecticides against major insect pests of rice.

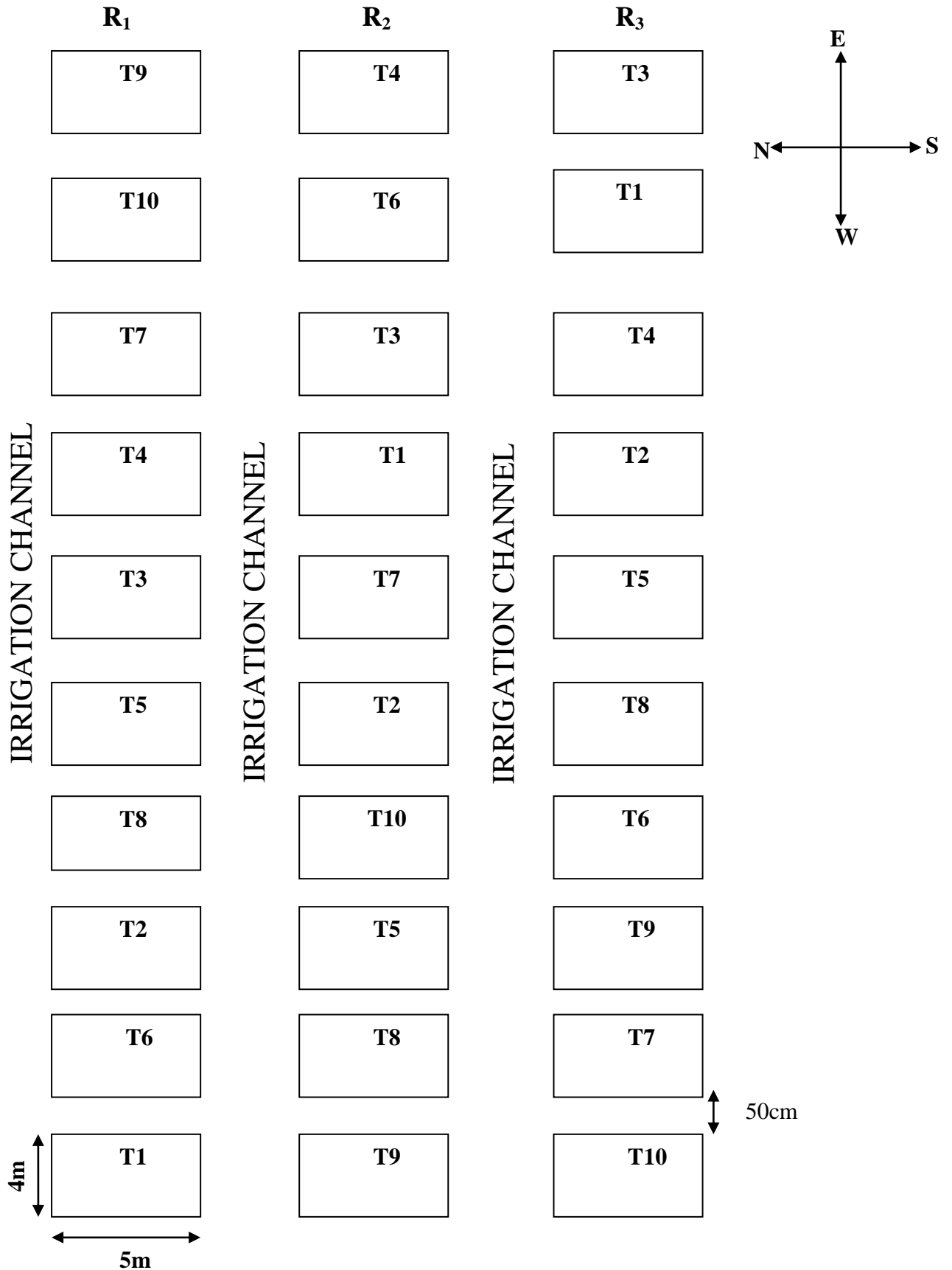


Fig-4: Layout plan for the experiment on the efficacy evaluation of the test chemical insecticides against major insect pests of rice.



**Plate : -1. Field view of the varietal screening experiment against major insect pests of rice**



**Plate : -2. Field view of the effect of three dates of transplanting against major insect pests of rice**



**Plate :- 3. Field view of the botanical insecticides against major insect pests of rice**



**Plate :- 4. Field view of the chemical insecticides against major insect pests of rice**



**Plate :- 5. Glimpses of BAU Scientists and Ph.D (Ag.) / M.Sc (Ag.) students, during field visit of some rice growing area of Jharkhand during field survey.**



**Plate:- 6. Close observation of BPH affected rice field during field survey.**



**Plate :- 7. BPH adult and nymph**



**Plate :- 8. Hopper burn caused by BPH in the pest affected rice field.**



**Plate :- 9. Termite attack in upland rice**



**Plate: - 10. Pheromone trap used against YSB**



**Plate :- 11. Yellow hairy caterpillar in *Tanr III* land rice**



**Plate :- 12. Rice plant damaged by case worm**



**Plate :-15. Dead heart caused by yellow stem borer**



**Plate :-16. White ear caused by yellow stem borer**



**Plate:-17. Rice stem damage by yellow stem borer**



**Plate:-18. Adults' of yellow stem borer**



**Plate : -19. Silver shoot caused by gall midge**



**Plate : -20. Silver shoot caused by gall midge**



**Plate : -21. Adult of leaf folder**



**Plate : -22. Folded leaf by leaf folder larva**



**Plate : -23. Damage leaf by leaf folder**



**Plate : -24. Folded leaf by leaf folder larva**



**Plate 25 : GLH**



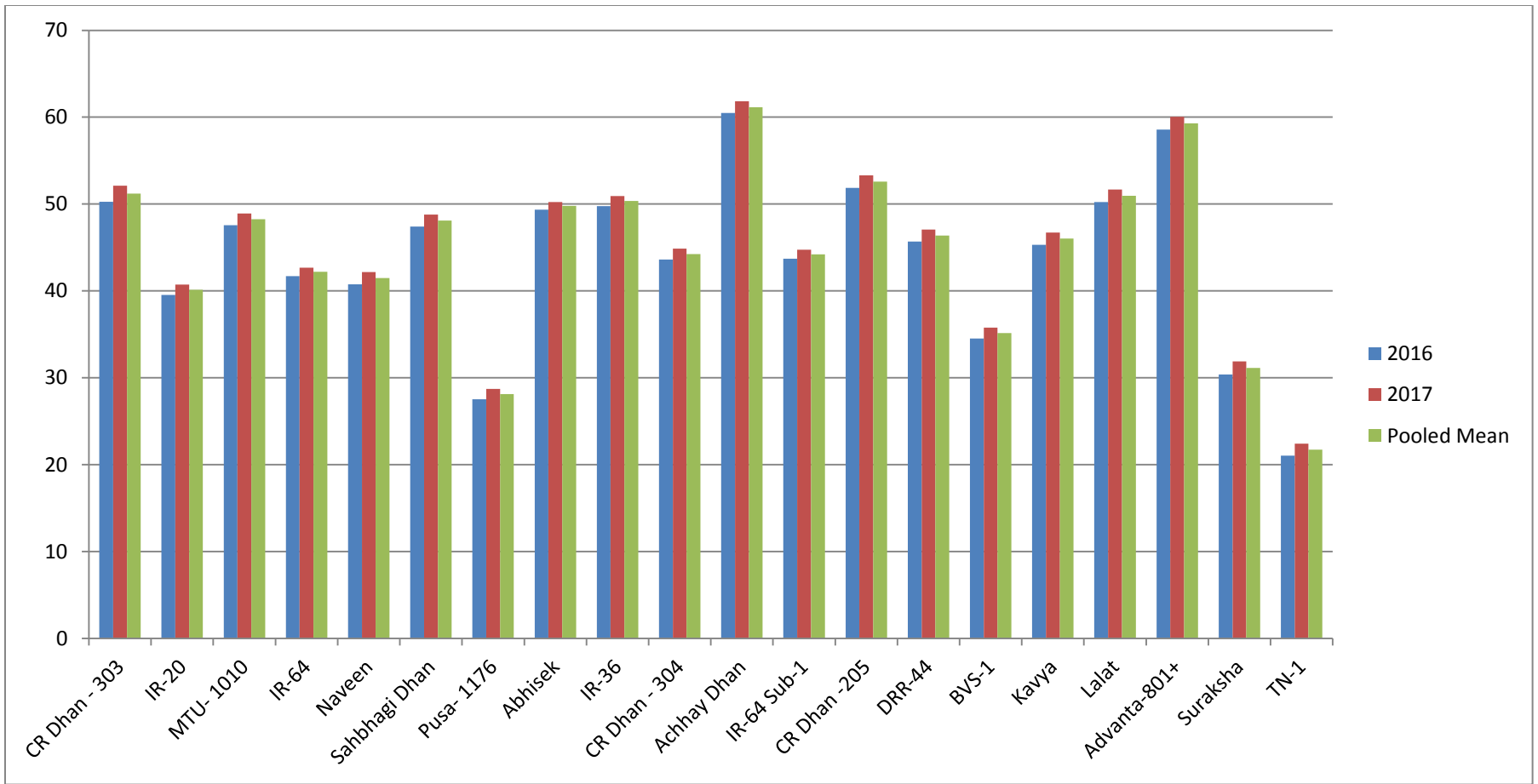
**Plate 26 : Gundhi bug**



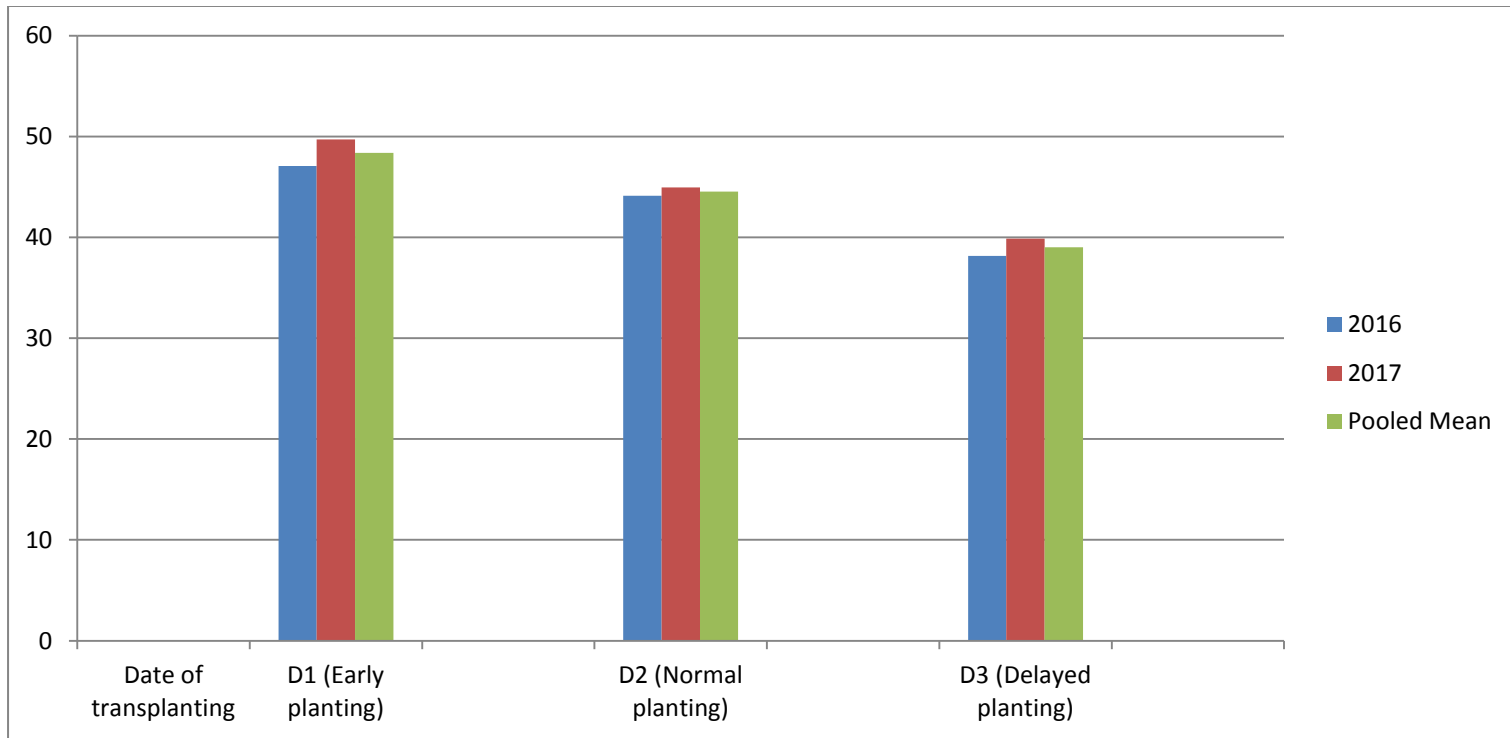
**Plate :-13. Predatory spider in rice ecology**



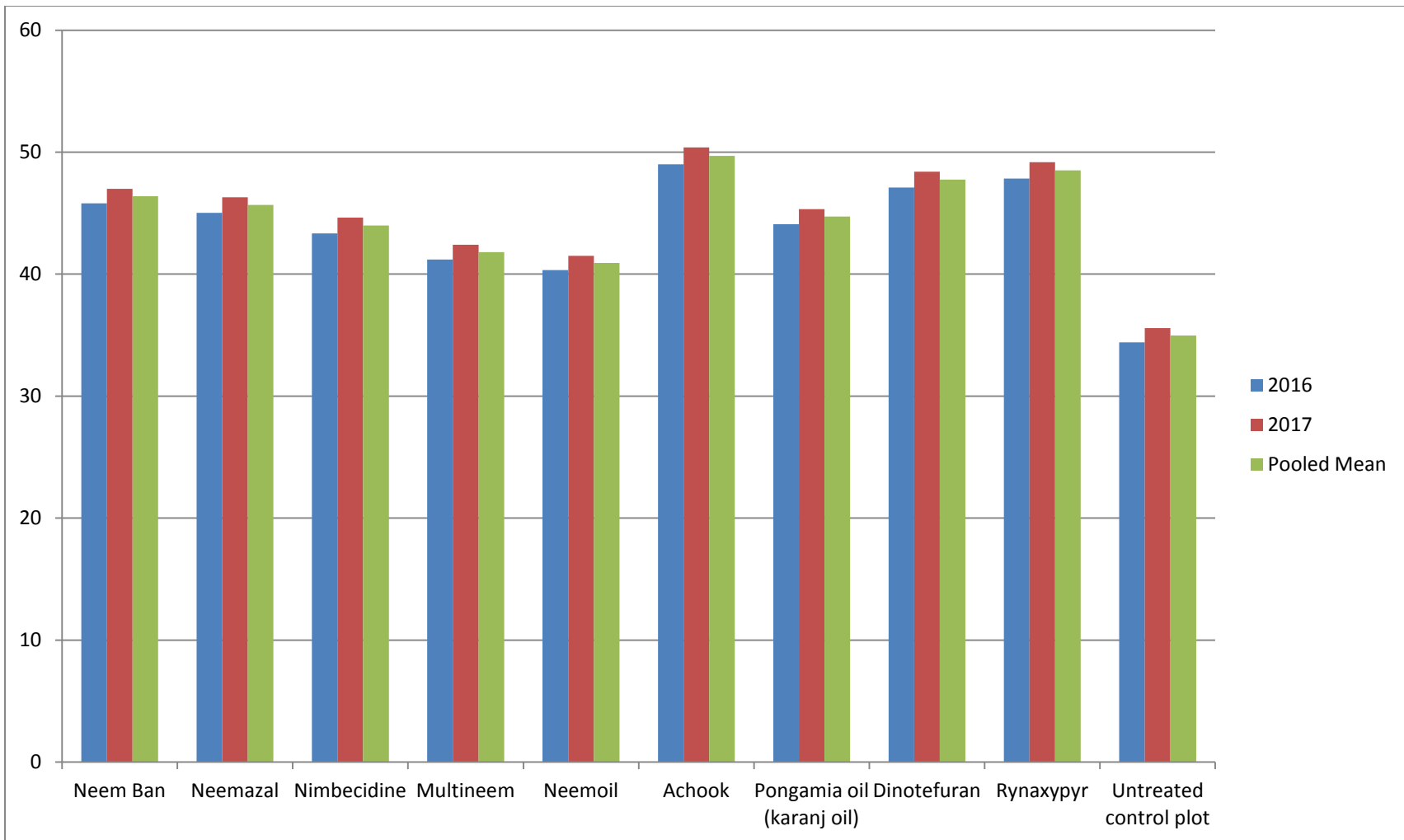
**Plate :-14. Predatory dragonfly in rice ecology**



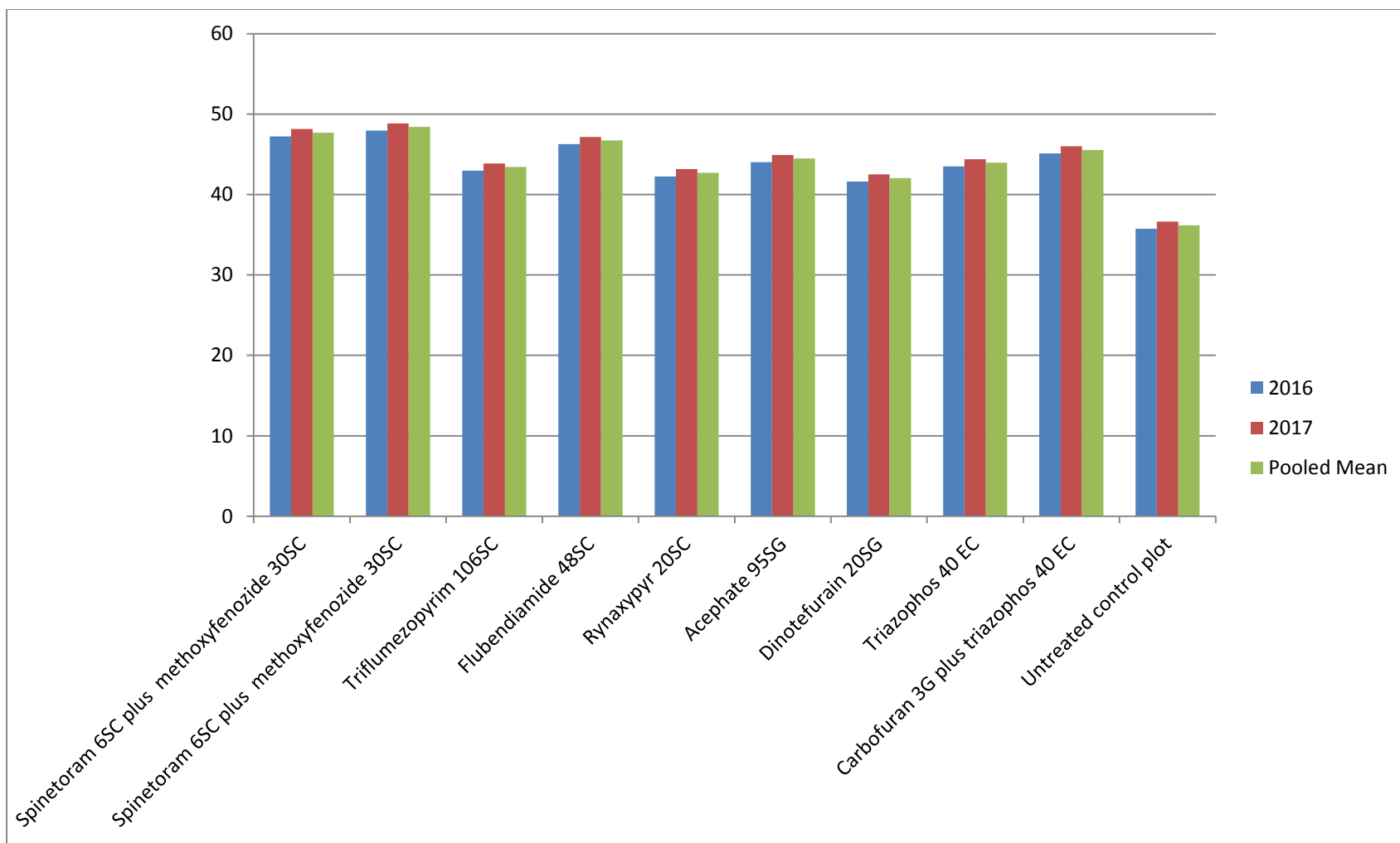
**Fig. 5: Yield of rice grain in some rice cultivars**



**Fig. 6: Effect of dates of planting on grain's yield of rice**



**Fig. 7: Effect of botanical insecticides on grain's yield of rice**



**Fig. 8: Effect of chemical insecticides on grain's yield of rice**