# INCIDENCE AND MANAGEMENT OF RICE YELLOW STEM BORER AND RICE HISPA ON RICE VARIETY BRRI dhan43

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## CERTIFICATE

This is to certify that the thesis entitled **'Incidence and Management of Rice Yellow Stem Borer and Rice Hispa on Rice Variety BRRI dhan43'** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of Master of Science in Entomology, embodies the result of a piece of *bonafide* research work carried out by **Md. Mahmudul Hassan**, Registration number: **09-03321** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has duly been acknowledged.

Dated: June, 2016
Dhaka, Bangladesh

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DEDICATED

TO

MY BELOVED PARENTS

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**INCIDENCE AND MANAGEMENT OF RICE YELLOW STEM BORER AND RICE HISPA ON RICE VARIETY BRRI dhan43**

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## ABSTRACT

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from April to August, 2016 to incidence and management of rice yellow stem borer and rice hispa on rice variety BRRI dhan43. The experiment comprised of the following control measure as treatment- $T_1$: Marshall 20 EC @ 3.0 ml/L of water at 7 days interval; $T_2$: Malathion 57 EC @ 2.0 ml/L of water at 7 days interval; $T_3$: Diazinon 60 EC @ 3.5 ml/L of water at 7 days interval; $T_4$: Furadan 5G @ 2.5 g/plot at 7 days interval; $T_5$: Sevin 85 SP @ 3.0 g/plot at 7 days interval; $T_6$:Cartap 50 WP @ 3 g/L of water at 7 days interval and $T_7$: Untreated control. Data was recorded on dead heart and white head infestation, incidence of rice hispa and also yield attributes, yield of BRRI dhan43 and found statistically significant differences for different treatment. At 40 and 47 DAT, the lowest dead heart infestation 2.90% and 3.05% recorded in $T_1$ treatment. At 92, 99, 106 and 113 DAT, the lowest white head infestation 3.43%, 6.73%, 4.24% and 4.90% was observed from $T_1$, while the highest white head infestation was recorded from $T_7$. In vegetative stage, at 40, 47, 54 and 61 DAT, the lowest number of rice hispa/2 sweeps 1.00, 1.20, 1.11 and 2.22 was observed from $T_1$, whereas the highest number of rice hispa/2 sweeps was recorded from $T_7$ treatment. In reproductive stage, 92, 99, 106 and 113 DAT, the lowest number of rice hispa/2 sweeps 1.33, 1.33, 0.67 and no rice hispa/2 sweeps was recorded from $T_1$, whereas the highest number was recorded from $T_7$ treatment. The highest yield/hectare (5.67 ton) was recorded from $T_1$, whereas the lowest yield/hectare (3.35 ton) from $T_7$ treatment. The results of economic analysis of rice cultivation revealed that the highest benefit cost ratio (2.28) was estimated for $T_1$ treatment and the lowest (1.03) for $T_2$ treatment under the trial. Among the different control measures, spraying Marshall 20 EC @ 3.0 ml/L of water at 7 days interval was the better for the of rice yellow stem borer and rice hispa on rice variety BRRI dhan43.

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# Chapter I

# Introduction

# CHAPTER I

# INTRODUCTION

Rice (*Oryza sativa* L.), belongs to the family Gramineae and is regarded as an important food crop in tropical and subtropical regions (Singh *et al*., 2012). It is grown in more than a hundred countries of the world with a total area of about 160 million hectares and producing more than 700 million tons every year and more than three billion people in the world are taking rice as their main food (IRRI, 2013). In Asia, rice has been consumed as more than 90% of all produced (FAO, 2014). Rice is the world's most important food crop and is the staple food for 50% of the global population (Barrion *et al*., 2007). Bangladesh ranks 4$^{th}$ in both area and production and 6$^{th}$ in the production of per hectare yield of rice (Sarkar *et al*., 2016). In Bangladesh 10.4 million hectares of land is used for rice production which is about 84.67% of total cropped area, with annual production of 30.42 million tons (BBS, 2014).

Population growth of at present in Bangladesh demands a continuous increase in rice production and so the highest priority has been given to produce more rice (Bhuiyan, 2004). Rice production has to be increased at least 60% to meet up food requirement of the increasing population of our country by the year 2020 (Masum, 2009). The geographical, climatic and edaphic conditions of Bangladesh are favorable for year round rice production. However, in Bangladesh, the average yield of rice is about 2.92 t ha$^{-1}$ (BBS, 2014) which is very low compared to other rice growing countries of the World, like China (6.30 t ha$^{-1}$), Japan (6.60 t ha$^{-1}$) and Korea (6.30 t ha$^{-1}$) (FAO, 2014). Rice yield can be increased in many ways and among them developing new high yielding variety and by adopting proper agronomic management practices are the important. The possibility of horizontal expansion of rice production area has come to a standstill and, farmers and agricultural scientists are diverting their attention towards vertical expansion of production. Therefore, attempts should be taken to increase per unit yield as vertical expansion.

Rice yields are either stagnating/declining in post green revolution era mainly due to different factors related to crop production (Prakash, 2010). The reasons for low productivity of rice includes various factors like erratic rainfall, drought, weed, insect pest diseases, unavailability of quality seeds, non adoption of recommended production and plant protection technology but the major reason attributed to prevalence of local varieties instead of high yielding rice varieties (Mandira, 2016). Insect pests complex as is the major constraints for the successful rice production. Recently various rice varieties were developed and maximum of them is exceptionally high yielding had larger panicles, heavier seeds, resulting in an average yield increase of 7.27% (Bhuiyan *et al.*, 2014). This variety however, needs further evaluation under different adaptive condition to interact with different environmental conditions and investigation of insect pests' complex and their infestation level is a major one.

Rice is attacked by several insect pests from nursery to harvest, which cause severe yield loss in one region of the country or another (Asghar *et al*., 2009). In Bangladesh, about 175 insect pest species have been reported, which cause damage to the rice plants (Mustafi *et al.*, 2007). The estimated loss of rice in Bangladesh due to insect pests and diseases amounts to 1.5 to 2.0 million tons (Siddique, 1992). In Bangladesh, stem borer, is one of the major pest cause 20% yield loss (Khan *et al.,* 1991). This symptom of stem borer called dead heart and white head and as mode of infestations at tillering stage and at grain filling stage, respectively. Yellow stem borer has emerged as one of the most important pests of rice during post green revolution of country (Bandong and Litsinger, 2005; Krishnaiah *et al*., 2008). The extent of rice yield losses due to YSB has been estimated as 20-70% (Catling *et al*., 1987; Chinniah *et al.*, 1998). Hybrid rice variety found to most susceptible to stem borer and cause yield loss 22.19-27.09% (Rahman *et al.,* 2004). Rice hispa, is another one of the major pests of rice and causing about 35-65% loss in yield by attacking the vegetative stage (Puzari and Hazarika, 1992). Under post flood situation, the late transplanted rice crop suffers 100% loss because of its attack (Hazarika, 1999).

Both biotic and abiotic factors are believed to be responsible for pest population dynamics (Singh *et al*., 2009). Climatic factors such as temperature, rainfall, and relative humidity greatly influence the outbreak of the insect population (Heong *et al*., 2007; Siswanto *et al*., 2008). Population dynamics of insect pests of rice are thus liable to fluctuate according to the dynamic condition of its environment (Khaliq *et al*., 2014). Management of rice insect pests, many options such as chemical, cultural, mechanical, biological etc. are available. Cultural and mechanical control in combination with insecticide reduced insect pests infestation and increased yield with the highest BCR (Alam *et al.*, 2003). Chemical control strategies have been adopted against rice pests and common method being the use of insecticides (Chinniah *et al.*, 1998). Chemical control is still considered as the first line of defense in rice pest control. Application of various insecticidal formulations gives effective control of rice pests (Uthamasamy and Kuruppuchamy, 1988; Dash *et al*., 1996). Various chemical insecticides also have been recommended to control the insect pest of rice (Singh, 1993; Misra, 2003). Application of chemical insecticides is an important approach considered promising but little studied in respect of specific insecticides as concentration and time of application interval.

Under the above situation and context the present study has been undertaken with fulfilling the following objectives.

- To study the incidence of rice yellow stem borer and rice hispa on rice variety BRRI dhan43;
- To assess the level of infestation caused by rice yellow stem borer, rice hispa on rice; and
- To find out the most effective insecticides applied against these insect pests.

# Chapter II

# Review of Literature

# CHAPTER II

# REVIEW OF LITERATURE

The increased of rice production in Bangladesh is an immediate requirement due to its rapidly growing population. Yield and yield contributing characteristics of rice are considerably depended on manipulation of basic ingredients as varieties of rice, environment, agronomic practices (planting time & density, fertilizer, irrigation etc.), and insect pest management etc. The yielding ability of rice is determined by plant growth behavior, which again depends on the crop protection against insect pests infestation and their management practices. Rice suffers heavy losses every year due to attack of many pests, among those, Yellow stem borer (YSB) and rice hispa is most important. They cause huge damage of leaf, stem, plant and ultimately yield. But research works related to these pests and their management so far done in Bangladesh and elsewhere is not adequate and conclusive. Nevertheless, some of the important and informative works and research findings related to the infestation level and their management of so far been done at home and abroad have been reviewed in this chapter under the following headings-

## 2.1 Rice yellow stem borer

### 2.1.1 Common species of stem borer

Different kinds of stem borer species are found in Asia and even in Bangladesh. They are yellow stem borer-YSB (*Scirpophaga incertulas*), dark headed stem borer-DHB (*Chilo polychrysus*), pink stem borer-PSB (*Sesamia inferens*), stripped stem borer-SSB (*Chilo suppressalis*) and white stem borer-WSB (*Scirpophaga innotata*). Among the above mention species, the YSB, DHB and PSB are considered as important based on their abundance and nature of damage. Their life cycle and mode of infestations causing dead heart at tillering stage and white head at grain filling stage are more or less same. Yellow stem borer is a chromic pest and one of the most serious and descriptive insect pests among the stem borer species in rice field (Pathak and Khan, 1994).

### 2.1.2 Systematic Position of YSB

Phylum: Arthropoda

Class: Insecta

Division: Endopterygota

Order:Lepidoptera

Family: Crambidae

Genus: Scirpophaga

Species: *Scirpophaga incertulas*

### 2.1.3 Geographic distribution

Rice stem borer is distributed primarily in tropical Asia. It also occurs in temperate areas where the temperature remains above $10^0$C and annual rainfall is >1000 mm (Pathak and Khan, 1994). The stem borer is found in all the districts of Bangladesh in different cropping seasons. The prevalence of stem borer is greater in the southern coastal belt of Bangladesh. Distribution of stem borer larvae of all species was non-random and approximated to the negative binomial series. Clustering was greatest in *Chilo suppressalis*, and was attributed to lack of dispersal from the hatching sites. Infestation of the rice crop was usually high prior to the flowering phase. During the off-season there was evidence of diapauses and quiescence in mature larvae of *Tryporyza innotata* and *T. incertulas*, respectively, but small breeding populations of these species, as well as of *Chilo suppressalis* and *Sesamia*, were present on volunteer and ratoon rice plants (Rothschild, 1971).

### 2.1.4 Life cycle

Hugar *et al*. (2010) reported that the biology of yellow stem borer, showed that eggs were oval, flattened and creamy white in both aerobic and transplanted rice reported by. However, average length and breadth varied slightly. It was 0.7+or-0.03 mm and 0.43+or-0.02 mm in transplanted paddy and 0.6+or-0.03 mm and 0.38+or-0.02 mm in aerobic paddy, respectively. The eggs were laid in masses having an average length and breadth of 5.9+or-1.41 mm and 3.41+or-0.36 mm, respectively on transplanted paddy and 5.6+or-1.36 mm and 3.37+or-0.0 mm, respectively on aerobic paddy. The newly hatched larva was yellowish green with dark head. It passed through five instars. The full grown larva was dirty white with the length of 20.3+or-1.21 mm on transplanted paddy and 19.9+or-0.30 mm on aerobic paddy. The average length of prepupa was 12.61+or-1.30 mm on transplanted paddy and 11.5+or-0.93 mm on aerobic paddy. The pupa was pale to dark brown and was longer and broader on transplanted paddy than on aerobic paddy. Fore-wings of the adult female were yellow in colour with a distinct black spot in the centre at each fore-wing. The fore-wings of the adult male were brown with numerous small light brown spots on them. Average length and breadth of the female and male moth and their longevity were higher on transplanted paddy than on aerobic paddy. Fecundity of the female was 159.3+or-39.8 eggs on transplanted paddy and 152.2+or-33.29 on aerobic paddy. Total life cycle of the pest was 42.8+or-1.73 and 43.8+or-0.67 days, respectively on transplanted paddy and aerobic paddy.

### 2.1.5 Nature of damage

Rangini *et al.* (2005) conducted a survey to evaluate the seasonal occurrence and relative abundance of 3 rice stem borer species, i.e the yellow stem borer (YSB, *Scirpophaga incertulas) i*s, the pink stem borer (PSB, *Sesamia inferens*) and the dark headed borer (DHB, *Chilo polychrysus*). YSB was the most predominant species in June- September (60.0%) and October -January (48.43%). PSB was as abundant as YSB in October-January (48.43%). YSB infestation was predominant from early tillering to maximum tillering stage and decreased gradually with increasing PSB infestation from the flowering stage.

The rice stem borers are generally considered as the most serious pest of rice. They occur regularly and attack plants from seedling to maturity stages. About 16 different stem borer species are found in rice fields and among them the yellow stem borer, dark headed striped borer and pink borer are of major borer and have great economic significance (Rao and Israel, 2004).

Srinavasa *et al*. (2000) monitored 3 insect pests of rice viz. Nephotettix spp., *Nilaparvata lugens* and *Scirpophaga incertulas*. They reported spp. and *Nilaparvata lugens* were present throughout the year but showed peaks of abundance in November and May: *S. incertulas* was also present throughout the year with low incidence in March, and had peaks in November and June.

*Scirpophaga incertulas* could attack most of the growing stages of rice plant, begin Scanning with seedling through tillering and up to car setting (Ranasinghe, 1992). The larvae of *Scirpophaga incertulas* attack the young as well as the grown up stages of rice. The larvae enter into the stern and feed on the inner-tissues of the plant. Such feeding separates the apical parts of the plant from the base. When this occurs during the vegetative phase of the plant, the central leaf turns brownish and dries off. This condition is known dead heart and the affected tillers dry out without bearing panicles. After panicle initiation, growing plant parts from base dries the panicles, which may not emerge; panicles that have emerged do not produce grains. Being empty, they remain straight and are whitish. They are usually called white head.

Rai *et al.* (1989) conducted a field survey to determine the relative abundance of stem borers infesting the deepwater rice and to study the population dynamics of these species. The stem borer species were *Scirpophaga incertulas*, *Chilo polychrysus* and *C. suppressalis,* and the Noctuid *Sesamia inferens*. The relative composition of the different species as a percentage of the total stem borer population during the growing and no growing seasons were 3-89,12-81,2-28 and 8 for the 4 species respectively in Bihar. Populations of *C. suppressalis* were highest during the first 2 weeks of November and remained high until July. *S incertulas* and *S. inferens* were predominant during the wet season.

### 2.1.6 Management of stem borer

Mondal and Chakraborty (2016) conducted a field experiment to assess the relative efficacy of three selected plant extracts *i.e* neem, tobacco, akando and two selected chemical insecticides *i.e* Dursban 20 EC and Fipronil against the incidence of yellow rice stem borer (YSB), *Scirpophaga incertulas* (Walk.) at Murshidabad, West Bengal, India, during three consecutive *kharif* crop seasons. Plant extracts significantly control *S. incertulas* population that is comparable with chemical insecticides. Fipronil showed the reduction of 56.28% dead hearts (DH) and 65.27% white head (WH) over control after 35 days of spraying. While the result for dursban was 30.01% DH and 40.27% WH. Neem extract reduced DH and WH by 38.33% and 48.14% respectively. The results from tobacco (22.18% DH and 24.30% WH), akando (15.33% DH and 16.89% WH) are appreciable. Fipronil and Dursban treated plot showed yield of 3.18 and 3.04 t/ha respectively. While in neem, tobacco and akando extracts treated plot the yield was 3.07, 2.86 and 2.68 t/ha respectively. The result indicates that out of the insecticides of plant origin, application of neem formulation effectively reduces *S. incertulas* infestation in consideration to chemical insecticides.

Eleven insecticides including new insecticide sulfoxaflor and check insecticide monocrotophos were evaluated by Rath (2015) in field condition against yellow stem borer and rice gundhi bug during dry season**.** 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% @  375g/ha, 4.96 t/ha, Thiamethoxam 25% @ 100 g/ha, 4.9 t/ha and triazophus 40% @ 625 g/ha, 4.78 t/ha. All the tested insecticides significantly reduce damage due to yellow stem borer. The grain yield of treatment imidacloprid17.8% @ 300 g/ha was highest (5.28 and 5.21 t/ha) significantly superior to check insecticide monocrotophus 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 damage.

The effect of three commonly available botanical extracts and two insecticides with different concentrations was determined by Islam *et al*. (2013) in the field against yellow stem borer. The treatments include three botanical extracts viz., Tobacco extracts, Neem extracts, and Karonja extracts at 15ml/L concentration and two insecticides named Acephate 75 SP at 2 g/L and Fipronil (Nema 50 SC) at 2 ml/L. 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 the reduction of 51.89% dead heart and 65.05% white head over control.

A field experiment was conducted by Hugar *et al*. (2009) at Shimoga, Karnataka, India, during the kharif season to evaluate the efficacy of monocrotophos 36 SL (500 g a.i./ha), imidacloprid 17.8 SL (20 g a.i./ha), lambda -cyhalothrin 2.5 EC (12.5 g a.i./ha), beta-cyfluthrin 25 EC (12.5 g a.i./ha), imidacloprid 70 WS (5 ml/kg of seeds), flubendiamide 500 SC (24 g a.i./ha), indoxacarb 14.5 SC (30 g a.i./ha), carbofuran 3G (750 g a.i./ha; control), carbosulfan 6G (1000 g a.i./ha), cartap hydrochloride 4 G (1000 g a.i./ha) and fipronil 0.3 G (7.5 g a.i./ha) against S. incertulas on rice (cv. Rasi). At 50 and 75 days after sowing (DAS), fipronil 0.3 G resulted in the lowest percentages of dead heart (DH) damage (3.40 and 2.43%, respectively). This treatment also resulted in the lowest white ear head incidence (2.59%), and highest grain (42.97 kg/ha) and cost:benefit ratio (1:7.86).

MoA (2008) reported in bio-control program with collaboration of Andaman and Nicobar that the adoption of modern technology, comprising of introduction of high yielding varieties, use of chemical fertilizers and improved agronomic practices during late sixties and seventies has enabled the farmers in increasing the crop production two to three folds. Such intensive cropping systems have also paved the way for emergence of pests, diseases and weed problems.

A study was conducted by Sherawat *et al*. (2007) in Sheikhupura, Pakistan, to determine the economic threshold level (ETL) for the chemical control of rice stem borers, *Scirpophaga incertulas* and *S. innotata*. Infestation levels of 0.0, 2.5, 5.0, 7.5, 10.0, 12.5 and 15.0% were induced artificially by clipping off tillers at 55 days after transplanting. The cost of application of Padan (cartap 4.G) below 7.5% infestation level was higher compared to the value of reduced grain yield due to borer infestation. At 7.5% infestation level, the cost of chemical control was equal to or less than the cost of yield reduction; thus, this level can be considered as the ETL for rice stem borers.

Mishra *et al*. (2007) conducted a field experiment in Uttar Pradesh, India during kharif seasons to evaluate the effect of certain granular insecticides against leaf roller and stem borer on rice. The treatments were Cartap 4G, Carbofuran 3G, Phorate 10G, Fenthion 5G and Fenitrothion 5G. Maximum grain yield was obtained using cartap at 1.0 kg/ha, which was statistically at par with that of carbofuran and phorate at 1.0 kg/ha.

Roshan (2006) were conducted a trials on the novel use of cartap hydrochloride 40 against stem borers at CCS Haryana Agricultural University, Rice Research Station, Kaul for two consecutive kharif seasons and reported that rice stem borers, *S. incertulas, Scirpophaga innotata and Sesamia inferens* pose a serious threat to scented rice in Haryana, India trials were conducted on the novel use of cartap hydrochloride 40 against stem borers at CCS Haryana Agricultural University, Rice Research Station, Kaul for two consecutive kharif seasons. Cartap hydrochloride 40 at 1.0 and 0.75 kg a.i./ha were applied at 30, 50; 30, 70; 50, 70 and 30, 50 and 70 days after transplanting (DAT) and were compared with monocrotophos 36 WSC at 0.45 kg a.i/ha applied at 30, 50 and 70 L)AT. Cartap hydrochloride at 1.0 and 0.75 kg a.i./ha applied at 30, 50 and 70 DAT proved most effective in managing the incidence of stem borers and realizing higher rice grain yield. Application of cartap hydrochloride initiated at 50 and 70 DAT could not suppress the incidence of stem borers. Two applications of cartap hydrochloride at 30, 50 and 30, 70 DAT were equally effective to three applications of monocrotophos in managing the incidence of stem borers and realizing higher yield. The effect of cartap hydrochloride was observed more than 30 days when applied at 30 DAT and observation recorded up to 70 days. All the treatments increased yield over the control.

A field study was conducted by Chakroborti (2003) wet seasons to assess the effects of some integrated management approaches (involving neem [*Azadirachta indica*] oil, neem cake, neem seed kernel extract, azadirachtin, phosphamidon and triazophos) on the insect pests (*Scirpophaga incertulas*, *Dicladispa armigera* and *Nymphula depunctalis* [*Parapoynx stagnalis*]) in deep water rice at the University Farm in Mohanpur, West Bengal, India. Integrated treatments with neem components plus one or two synthetic chemical applications were very effective in controlling the pest population build up and kept the damages by insect pests at significantly low levels notably superior to the chemical controls. Integrated neem treatments also performed reasonably well. Neem treatments were quite safe, and integrated neem plus synthetic chemical treatments were moderately safe to natural enemies. However, the contribution of the natural enemies in controlling the pest population build up appeared only marginal.

The efficacy of fipronil and other insecticides against rice stem borer in (*Scirpophaga incertulas)* were studied by Saijoqi *et al*. (2002) in a field trial. The results showed that all insecticides gave significantly better control of rice stem borer than the untreated check. Padan 4G (cartap) at 22.23 kg/ha was found to be the most effective in reducing rice stem borer infestation, followed by Regent 300 EC (fipronil) at 197.6 mi/ha, Regent 300 EC mixed with fertilizer at 197.6 ml/ha and Furadan 3G at 19.76 kg/ha, respectively. The highest yield was obtained from Padan 4G treated plots, followed by Regent 300 EC; Regent 300 EC mixed with fertilizer and Furadan 3G compared to untreated plots.

The efficacy of some granular and sprayable insecticides, a neem product and a Bt (*Bacillus thuringiensis*) formulation studied by Rath (2001) against stem borer revealed that thiocyclam hydrogen oxalate, chlorpyriphos and thiomethoxam were proved best and recorded more than 80% yield increase over control. The performance of granular fipronil (75 g.a.i/ha) was on par with carbofuran granule (1 kg.a.i./ha) against the pest. The efficacy of other insecticides was slightly inferior and registered 52.00-66.50% yield increase over control.

Field trials were conducted by Gururaj *et al*. (2001) in Andhra Pradesh, India during kharif to study the effects of integrating pheromone mass trapping and biological control for the management of rice yellow stem borer (*Scirpophaga incertulas*) and rice leaf folder (*C. medinalis*). The first treatment involved mass trapping with the use of 20 pheromone traps per ha and the inundative release of *T. chilonis* at 1,000,000 adults/ha. The second treatment consisted of granular and spray applications of insecticides once during rabi 1997 (farmers' practice). In 1995, lower stem borer (8.9%) and leaf folder (8.5%) damage, and higher grain yield (4747 kg/ha), were obtained with mass trapping, compared with the stem borer (28%) and leaf folder (22%) damage, and grain yield (3421 kg/ha), obtained with the farmers' practice. In 1997, lower stem borer (1.5%) and leaf folder (7.0%) damage were recorded for the mass trapping treatment compared with the farmers' practice (7.6 and 53.9%, respectively).

The efficacy of carbosulfan (1000 g a.i./ha) against *S. incertulas* on rice cv. Red Triveni was studied by Karthikeyan and Purushothaman (2000) in Pattambi, Kerala, India. In all years, carbosulfan effectively controlled *S. incertulas*. Carbosulfan gave a higher yield (3492 kg/ha) than the control insecticide 1000 g a.i. carbofuran/ha (3444 kg/ha) and the untreated control (2658 kg/ha).

Results of field experiments carried out by Korat *et al*. (1999) during kharif at the Main Rice Research Station, Nawagam, Gujarat, revealed that among the treatments evaluated, the smallest (2.72 to 3.73 hoppers/hill) number of the white backed plant hopper *Sogatella furcifera* were observed following treatment with buprofizin 25 W1 (0.5 kg a.i./ha) followed by acephate 75 sp. (0.75 kg a.i./ha). A relatively low (3.9 1%) incidence of the leaf folder, *C. medinalis* Guen, was Ibund in the plots treated with monocrotophos 36=WSC (0.75 kg a. i./ha), acepbate 75 sp (4.38%) and triazophos 40 EC (5.03%) compared with 9.30% in untreated check plots. The minimum incidence (120.67 white ear heads/plot of 27.6 rn2) of the stem borer *S. incertulas* (Walker) was recorded following triazophos 40 EC (0.50 kg a.i./ha) treatment. The greatest (2625 kg/ha) grain yield was obtained from the plots treated with buprofezin followed by acephate (2618 kg/ha), carbofuran 30 (2572 kg/ha) and monocrotophos (2499 kg/ha).

A field trial for the integrated management of stem borer *(Scirpophaga Incertulas*) and neck blast *(Pyricularia grisea [Magnaporthe grisea*]) in scented rice (cv. Taraori basmati) was carried out by Dodan and Roshan (1999) during kharif in Kaul (Haryana, India). The following treatments were tested: burnt rice husk (BRH) incorporated pre-transplanting at 10 tlha; Nimbecidine [a neem-based pesticide] at 20 ml/litre; BRH+Nimbecidine + *Trichogramma japonicum*; carbendazim (Bavistin at 0.1%) + monocrotophos (Nuvacron at 0.25%); and an untreated control. In both years, all treatments reduced neck blast incidence and stem borer damage compared to the control. BRH alone and in combination with Nimbecidine and *T. japonicum* were as effective as the pesticide combination for neck blast control (28.1, 27.2 and 26.1% neck blast incidence, respectively). Under conditions of low stem borer infestation in 1996. BRH, Nimbecidine and BRH + Nimbecidine + *T. japonicum* provided superior stem borer control, compared to the pesticide combination (3.8, 3.6, 3.1 and 4.3% stem borer damage, respectively). Under high infestation, the pesticide combination was most effective. The mean yields were 29.7, 29.6, 31.4, 31.2 and 28.6 q/ha for

BkH, Nimbecidine, BRH + Nimbecidine + 7: japonlcum, carbendazim + monocrotophos and the control, respectively.

Control of *S. incertulas* in rice was attempted by Cork *et al*. (1998) as mating disruption using the natural ratio of pheromone components, a 1:3 blend of (Z)-9 and (Z)-11-hexadecenal, in replicated trials by at three locations in Andhra Pradesh, India. The pheromone was formulated in Selibate and applied by hand at a rate of 40 g a.i./ha. In Medchal and Nellore, pheromone-mediated communication was reduced by at least 94% for the first 50 and 64 days after application, respectively, as measured by pheromone trap catch suppression. Compared with adjacent farmers' practice plots, subsequent dead heart and white head damage were reduced by 74 and 63% and 83 and 40% in Medchal and Nellore, respectively. In Medchal, average rice yields were increased compared to the farmers' practice plots, 4108 and 3835 kg/ha respectively, but in Nellore, they were the same as those obtained in the farmers' practice plots, 6400 and 6733 kg/ha. In Warangal, the level of communication disruption over the first 70 nights after pheromone application was less than obtained in either Medchal or Nellore and averaged between 50 and 87%. The maximum dead heart and white head damage recorded in the pheromone-treated plots in Warangal was 2.8 and 15.7%, respectively, compared to 7.0 and 20.9% in the farmers' practice plots. Differences in *S. incertulas* larval damage estimates obtained from the pheromone-treated and farmers' practice plots in Warangal were reflected in grain yields, 4036 and 3715 kg/ha, respectively. Surveys of insecticide use indicated that 92% of smallholders in Medchal applied insecticide at least once per season while in Warangal over 60% applied insecticide on two or more occasions.

Harish (1995) conducted the studies in the Philippines, the flight activity of the yellow stem borer peaked in the months of April-May, May-June, August-September and October. The number of egg masses and the number of adults attracted to light sources were used as indicators of *S. incertulas* flight activity.

All varieties except 1R66 were susceptible to dead heart damage by *S. incertulas*. When the rice varieties TKM6, BPLRi2, BPJRi4, 1R22, 1R36, 1R60, 1R66 and 1R74 were treated with carbofuran insecticide at the time of peak oviposition by *S. incertulas* in the field, the dead heart damage on all the varieties was significantly reduced in comparison to the untreated plots. Indiscriminate routine insecticidal treatments (fixed schedule) can be replaced by schedule based on the dynamics of *S. incertulas.*

## 2.2 Rice hispa

The rice hispa (*Dicladispa armigera*) (Coleoptera, Chrysomelidae) is an increasingly important outbreak pest in rice cropping systems in Bangladesh and one which appears to be associated with intensification of production. An understanding of its population dynamics, natural mortality factors and socioeconomic aspects of control options will allow the development and adoption appropriate sustainable control measures within the context of an integrated rice pest management strategy in Bangladesh (Karim, 1986).

### 2.2.1 Common species of rice hispa

The most common of rice hispa is the *Dicladispa armigera* and there are no specific and defined species were identified.

### 2.2.2 Systematic Position of YSB

Phylum: Arthropoda

Class: Insecta

Order: Coleoptera

Family: Chrysomelidae

Genus: Dicladispa

Species: *Dicladispa armigera*

### 2.2.3 Geographic distribution

Surveys by BRRI in the early 2000s revealed that the rice hispa can appear at any time in any part of Bangladesh; currently the north eastern part is more prone to rice hispa incidence while southern districts have been relatively unaffected. There is a general notion, reflected in the literature (Karim, 1986; Johnsen *et al.*, 1997) that the rice hispa has an endemic winter range on ratoons, wild rice etc. in the southern Districts of Bangladesh; but Johnsen *et al*. (1997) found no evidence that the rice hispa retreats to overwinter on wild rice and other plants in the Sunderbans.

### 2.2.4 Life cycle

Several authors (Karim, 1986, Islam, 1997) have summarized the basic information that has been collected on the life cycle, life history and phenology of the rice hispa. The rice hispa passes through four stages: egg, larva (four instars), pupa and adult. Adult rice hispa feed externally on leaf tissue and the larvae mine into the leaf. Both the adult beetle and larvae damage a rice plant by eating the green tissue of the leaf and severely infested leaves dry up. From a distance, severely damaged fields look burnt. In the intensive rice-cropping areas of Bangladesh and India, the rice hispa can have 6-7 generations. During the crop-free period, the rice hispa can breed on rice ratoons or wild grasses, or diapauses as adults. Rice hispa is a highly dispersive species and hispa attacks all four rice crops: aus (summer rice), transplanted aman (monsoon rice), deepwater rice, and boro (winter rice) in Bangladesh. After emergence, adults mate and often disperse in large numbers. Adult beetles can fly long distances from one crop to another. The flight capacity of the rice hispa has not been determined but there is speculation that it may fly more than 25 km/day (Islam, 1999).

Johnsen *et al.* (1997), using historical data on hispa abundance could find no correlation between hispa numbers and major abiotic parameters such as rainfall but the analysis was very basic. Grasses and weed hosts play a role in the survival of the rice hispa in low numbers during the off-season, and in their initial multiplication at the beginning of the crop season but crops raised early in the season may escape or suffer negligible damage. Continuous, heavy rain has a negative effect on adult feeding and egg laying. Egg hatching and the survival of larvae are greatly affected by moisture and they suffer heavy mortality in dry conditions but on the other hand, high temperatures and high humidity are conductive to the build-up of rice hispa populations (Islam, 1999). Karim (1986) suggested the warmer winter conditions of the south are a principal factor driving outbreaks.

### 2.2.5 Nature of damage

The rice hispa is a major pest of rice in Bangladesh and parts of India, Nepal, Myanmar and southern China. It has a long record of sporadic outbreaks in Bangladesh and India. Damage caused by the rice hispa reduces plant height, tiller number, grain per panicle, and ultimately, grain yield. Affected deep-water rice plants become vulnerable to rising flood water level (Karim 1986; Islam 1999). More recent studies by Haque *et al.* (2000) indicate that under high densities of rice hispa, the leaf growth of younger plants (with greater than 20% leaf damage) is severely retarded. Under such conditions, grain yields in the t. aman are affected but not in the aus. Estimates suggest a wide variation in yield losses between 10 and 65%; with an average of 20% in affected areas (Karim 1986; Islam 1999). The intensity of outbreaks seems to increase following the large-scale adoption of high-yielding rice varieties and their associated production technologies.

Rice hispa attacks all four rice crops: aus (summer rice), transplanted aman (monsoon rice), deepwater rice, and boro (winter rice) in Bangladesh. Sporadic outbreaks of rice hispa occur almost throughout Bangladesh, but large areas have been affected by outbreaks of a higher intensity in the south-western parts of the country in the past. In India, both rice crops, kharif and rabi, are subjected to sporadic outbreaks of *D. armigera* and may be severely attacked (Karim, 1986).

Resistance by rice plants has been found at useful but not decisive levels, and has tended to favour traditional varieties rather than the modern hybrids which, as higher yielders, have often been promoted to replace them. Dhaliwal *et al*., 1980; found numbers of damaged leaves per plant significantly less in Basmati and PR476 varieties (respectively 7 and 10) than in PR484, PR274 and PR437 (respectively 13, 13 an6 16).

Sontakke and Rath (1998) found leaf damage of 15.9% in a local variety and 32.4% in a hybrid. Budhraja *et al*. (1980) found varieties differed in their ability to recover from hispa attack after "rescue" by insecticides as (in yield in MT/Ha, respectively unprotected/"rescued"): Anupama 0.9/2.0; Chatri 1.5/2.0; Numgi 1.2/1.8; Ratna 0.7/5.0.

Dutta and Hazarika (1994) screened 50 varieties and found none suffered less than 10% damaged leaves (the best being 13% and the worst 100%). Dhaliwal *et al*. (1980) found none resistant among 334 cultivars tested. Chand and Tomar (1984) screened 64 cultivars and found none with less than 20% damage and most over 50%.

### 2.2.6 Management of Rice Hispa

Puzari *et al*. (2015) reported that as such in search of alternative to chemical insecticides against insect pest of rice resulted in identifying white muscardine fungus, *Beauveria bassiana* an entomopathogen out of several entomogenous fungi prevalent in rice ecosystem as the potential mycoinsecticides. The fungus has 78-87% virulence against rice hispa with LC50 value of 90.16. Under field situations it is required that the effectiveness of the bioagents is enhanced by combining them with compatible pesticides. A sublethal dose of a pesticide would make the insect physiologically weak which makes it much more susceptible to the attack of the entomogenous organisms. In view of this, compatibility test was conducted with 14 different commonly applied insecticides at two different doses i.e., recommended and half of the recommended dose. In small scale field trial chloropyriphos at half of the recommended dose along with *B. bassiana* was the best treatment in controlling the pest along with increased yield of the crop consecutively for two years. Similarly, in multilocational field demonstration trial conducted in hispa endemic areas of Assam *viz*., Sibsagar and Jorhat covering six different localities *B. bassiana* (@ 10 million spore/ml dilution) and half of the recommended dose of chlorpyriphos proved superiority then the commonly applied insecticides in decreasing the pest population with increased yield of crop.

Currently rice hispa is principally controlled principally with insecticides. However, a range of cultural control methods have been developed for hispa which address different life stages. Early planting can avoid peaks of oviposition, and the avoidance of early-season fertilizer applications slows population growth. Mechanical removal of the egg stage is possible by cutting off the leaf tips where eggs are laid (Rawat *et al*., 1980; Karim, 1986; Khan, 1989). Trapping adults in sweep nets have been shown to reduce damage at high outbreak levels if it is done correctly (CABI, 1999).

Chemical insecticides have been widely and successfully evaluated against hispa. Budhraja *et al.* (1980) found all granular insecticides obtained positive economic returns in controlling hispa, with Carbofuran (obtaining a yield of 2.3MT/ha), Thiodemeton (obtaining 2.2MT/ha), Quinalphos (2.0MT/ha), Phorate (2.0) and Disulfoton (1.9) all obtaining significantly higher yields than an unprotected crop (1.4).

From the above cited literature, it is observed that rice yellow stem borer and rice hispa have a significant influence on rice yield. Different infestation level was identified based on their nature of damage and life cycle. The literature suggests, the use of different chemical control measures for the control of rice yellow stem borer and rice hispa.

Chapter III

# Materials and Methods

# CHAPTER III

# MATERIALS AND METHODS

The experiment was conducted to incidence and management of rice yellow stem borer and rice hispa on rice variety BRRI dhan43. The details of the materials and methods i.e. experimental period, location, soil and climatic condition of the experimental area, materials that were used for the experiment, treatment and design of the experiment, growing of crops, data collection procedure and procedure of data analysis that followed in this experiment has been presented under the following headings-

## 3.1 Description of the experimental site

### 3.1.1 Experimental period

The experiment was conducted during the period from April to August, 2016.

### 3.1.2 Experimental location

The present research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is $23^{0}74^{/}$N latitude and $90^{0}35^{/}$E longitude with an elevation of 8.2 meter from sea level. Experimental location presented in Appendix I.

### 3.1.3 Characteristics of soil

The general soil type of the experimental field was Shallow Red Brown Terrace soil and the soil belongs to the Tejgaon series under the Agroecological Zone, Madhupur Tract (AEZ-28). A composite sample of the experimental field was made by collecting soil from several spots of the field at a depth of 0-15 cm before initiation of the experiment. The collected soil was air-dried, grind and passed through 2 mm sieve and analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka for some important physical and chemical properties. The soil was having a texture of silty clay with pH and organic matter 5.7 and 1.13%, respectively. The results showed that the soil composed of 27% sand, 43% silt and 30% clay, details have been presented in Appendix II.

### 3.1.4 Climatic condition

The climatic condition of experimental site is subtropical and characterized by three distinct seasons, the Rabi from November to February and the Kharif-I, pre-monsoon period or hot season from March to April and the Kharif-II monsoon period from May to October. The monthly average temperature, relative humidity and rainfall during the crop growing period were collected from Weather Yard, Bangladesh Meteorological Department, and presented in Appendix III. During the experimental period the maximum temperature (36.2$^0$C), highest relative humidity (83%) and highest rainfall (553 mm) was recorded in the month of July, 2016, whereas the minimum temperature (23.4$^0$C), minimum relative humidity (61%) and total rainfall (128 mm) was recorded for the month of April, 2016.

## 3.2 Experimental details

### 3.2.1 Planting material

BRRI dhan43 were used as the test crop in this experiment.

### 3.2.2 Treatment of the experiment

The experiment comprised of the following control measure as treatment

$T_1$: Marshall 20 EC @ 3.0 ml/L of water at 7 days interval

$T_2$: Malathion 57 EC @ 2.0 ml/L of water at 7 days interval

$T_3$: Diazinon 60 EC @ 3.5 ml/L of water at 7 days interval

$T_4$: Furadan 5G @ 2.5 g/plot at 7 days interval

$T_5$: Sevin 85 SP @ 3.0 g/plot at 7 days interval

$T_6$: Cartap 50 WP @ 3 g/L of water at 7 days interval

$T_7$: Untreated control

### 3.2.3 Experimental design and layout

The experiment was laid out in a randomized complete block design (RCBD) with three replications, where the experimental area was divided into three blocks representing the replications to reduce soil heterogenetic effects. Each block was divided into 7 unit plots as treatments demarked with raised bunds. Thus the total numbers of plots were 21. The unit plot size was 3.0 m × 2.5 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.

## 3.3 Growing of crops

### 3.3.1 Seed collection and sprouting

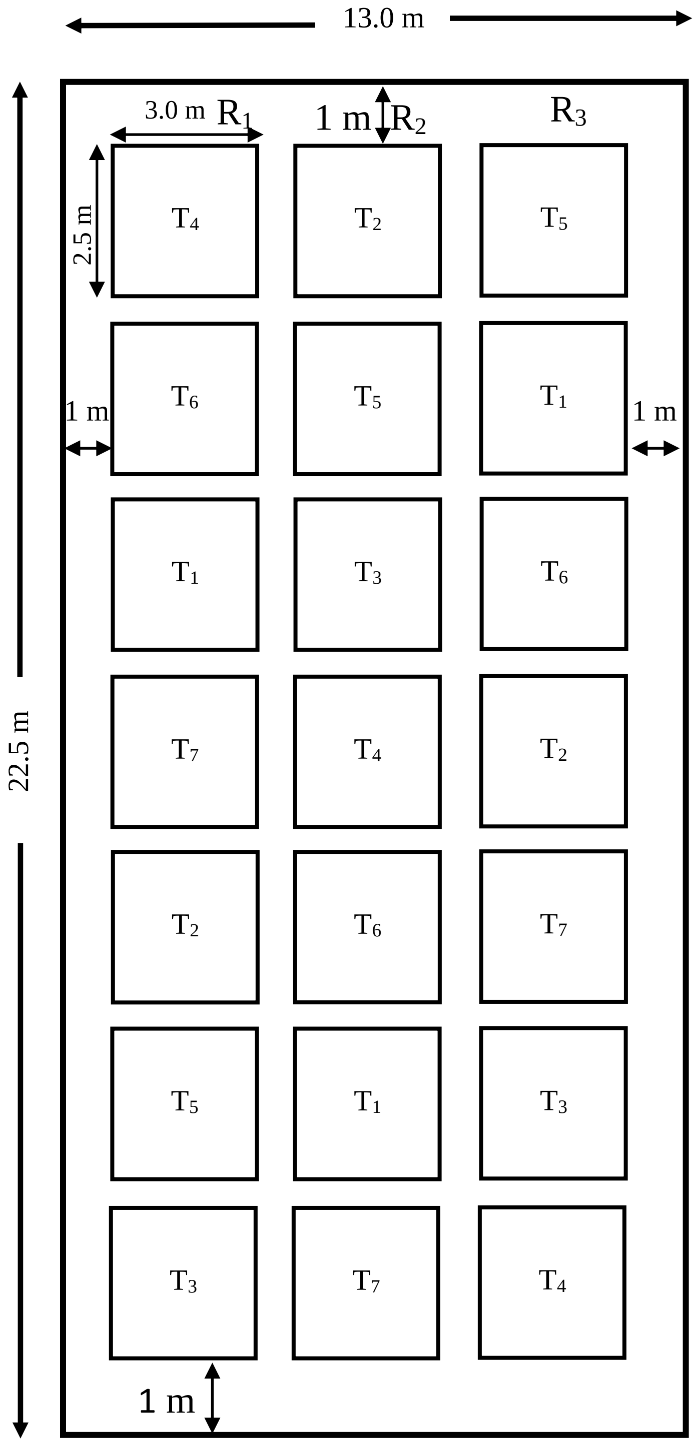
Seeds were collected from BRRI (Bangladesh Rice Research Institute), Gazipur just 20 days ahead of the sowing of seeds in seed bed. Seeds were immersed in water in a bucket for 24 hours. The imbibed seeds were then taken out of water and kept in gunny bags. The seeds started sprouting after 48 hours which were suitable for sowing in 72 hours.

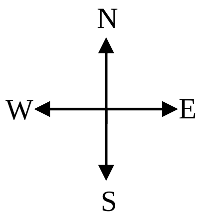
### 3.3.2 Raising of seedlings

The nursery bed was prepared by puddling with repeated ploughing followed by laddering. The sprouted seeds were sown on beds as uniformly as possible at 13$^{th}$ April, 2016. Irrigation was gently provided to the bed as and when needed. No fertilizer was used in the nursery bed.

### 3.3.3 Land preparation

The plot selected for conducting the experiment was opened in the last week of April, 2016 with a power tiller, and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good puddle condition. Weeds and stubbles were removed. The experimental plot was partitioned into unit plots in accordance with the experimental design. Organic and inorganic manures as indicated below were mixed with the soil of each unit plot.




Plot size: 3.0 m × 2.5 m

Plot spacing: 50 cm

Between replication: 1.0 m

**<u>Treatment</u>**

$T_1$: Marshall 20 EC @ 3.0 ml/L of water at 7 days interval

$T_2$: Malathion 57 EC @ 2.0 ml/L of water at 7 days interval

$T_3$: Diazinon 60 EC @ 3.5 ml/L of water at 7 days interval

$T_4$: Furadan 5G @ 2.5 g/plot at 7 days interval

$T_5$: Sevin 85 SP @ 3.0 g/plot at 7 days interval

$T_6$: Cartap 50 WP @ 3 g/L of water at 7 days interval

Figure 1. Layout of the experimental plot

Plate 01: Experimental rice field

### 3.3.4 Fertilizers and manure application

The fertilizers N, P, K, S, Zn and B in the form of urea, TSP, MoP, Gypsum, zinc sulphate and borax, respectively were applied @ 80 kg, 60 kg, 90 kg, 12 kg, 2.0 kg and 10 kg (BRRI, 2013). The entire amount of TSP, MoP, gypsum, zinc sulphate and borax were applied during the final preparation of land. Urea was applied in two equal installments at tillering and panicle initiation stages.

### 3.3.5 Transplanting of seedling

Twenty four days old seedlings were carefully uprooted from the seedling nursery and transplanted on 6 May, 2016 in well puddled plot. Three seedlings hill$^{-1}$ were used following spacing as per treatment. After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings of the same source whenever required.

#### 3.3.6 Intercultural operations

Intercultural operations were done to ensure normal growth of the crop. The following intercultural operations were done.

##### 3.3.6.1 Irrigation and drainage

Irrigation was provided to maintain a constant level of standing water upto 6 cm in the early stages to establishment of the seedlings and then maintained the amount drying and wetting system throughout the entire vegetative phase. No water stress was encountered in reproductive and ripening phase. The plot was finally dried out at 15 days before harvesting.

##### 3.3.6.2 Weeding

Weedings were done to keep the plots free from weeds, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully at 30 DAT and 60 DAT by mechanical means.

### 3.4 Harvesting, threshing and cleaning

The crop was harvested at full maturity at $12^{th}$ August, 2016 when 80-90% of the grains were turned into straw colored. The harvested crop was bundled separately, properly tagged and brought to threshing floor. Enough care was taken during threshing and cleaning of rice grain. The grains were dried, cleaned and weighed for individual plot and adjusted to a moisture content of 14%.

### 3.5 Data collection and calculation

The infestation was expressed as percent dead hearts, white head by yellow rice stem borer and rice hispa incidence were calculated by using the formula as suggested by Shafiq *et al.* (2000).

#### 3.5.1 Infestation level

Five hills were selected at random from each plot. The dead hearts and white heads were counted. In case of dead heart, it was counted at 40, 47, 54 and 61 DAT and converted into per plot. On the other hand, white head infected tillers was counted at 92, 99, 106 and 113 DAT and converted into per plot.

#### 3.5.1.1 Percent dead heart infestation

Number of dead heart infested tillers were counted at 40, 47, 54 and 61 DAT from total tillers per five hills and converted into per plot and percent dead heart was calculated by using the following formula:

$$\% \text{ Dead heart tillers} = \frac{\text{No. of dead heart infested plant}}{\text{Total no. of plant per five hills}} \times 100$$

#### 3.5.1.2 Percent white head infestation

Number of whitehead infested tillers were counted at 92, 99, 106 and 113 DAT from total tillers per five hills and converted into per plot and percent whitehead was calculated by using the following formula:

$$\% \text{ White head tillers} = \frac{\text{No. of white head infested plant}}{\text{Total no. of plants per five hills}} \times 100$$

Plate 02: Rice Hispa infested rice leaf blade

Plate 03. Dead heart symptom of rice in experimental field

Plate 04. White head symptom of rice in experimental field

#### 3.5.1.3 Treatment effects on infestation

The percent dead heart and white head reduction, over control was calculated by using the following formula (Khosla, 1997)-

$$\text{Percent population reduction over control} = \frac{X_2 - X_1}{X_2} \times 100$$

Where, $X_1$ = the mean value of treated plots

$X_2$ = the mean value of untreated plots

### 3.5.2 Yield contributing characters and yield of rice

#### 3.5.2.1 Filled and unfilled grains/panicle

The total numbers of filled and unfilled grains were collected randomly from selected 10 panicle of a plot and then average numbers of filled an unfilled grains/panicle was recorded.

#### 3.5.2.2 Panicle length

The length of panicle was measured with a meter scale from5 selected panicle and the average length was recorded as per panicle in cm.

#### 3.5.2.3 Weight of 1000-grains

The total 1000 weight of grains was counted and weighted and express in gram.

#### 3.5.2.4 Grain yield

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains from yield/plot was taken and converted to ton/hectare.

### 3.6 Statistical analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the treatments. The mean values of all the characters were calculated and analysis of variance was performed by using MSTAT-C software. The significance of the difference among the treatments means was estimated by the by the Duncan Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

# Chapter IV

# Results and Discussion

# CHAPTER IV

# RESULTS AND DISCUSSION

The experiment was conducted to find out the incidence and management of rice yellow stem borer and rice hispa on rice variety BRRI dhan43. Data was recorded on dead heart and white head infestation, incidence of rice hispa and also yield attributes and yield of BRRI dhan43. The results have been discussed and presented under the following headings:

## 4.1 Infestation by rice yellow stem borer

### 4.1.1 Dead heart infestation

Statistically significant variation was recorded for dead heart infestation of rice at 40, 47, 54 and 61 DAT (days after transplanting) as 1$^{st}$, 2$^{nd}$, 3$^{rd}$ and 4$^{th}$ observation due to different chemical insecticides (Appendix IV).

As 1$^{st}$ observation at 40 DAT, data revealed that the lowest dead heart infestation (2.90%) was observed from $T_1$ (Marshall 20 EC @ 3.0 ml/L of water at 7 days interval) which was statically similar (3.80%) to $T_3$ (Diazinon 60 EC @ 3.5 ml/L of water at 7 days interval), while the highest dead heart infestation (7.50%) was recorded from $T_7$ (Untreated control) which was similar (4.92%, 4.82%, 4.69% and 4.62%) to $T_2$ (Malathion 57 EC @ 2.0 ml/L of water at 7 days interval), $T_5$ (Sevin 85 SP @ 3.0 g/plot at 7 days interval), $T_4$ (Furadan 5G @ 2.5 g/plot at 7 days interval) and $T_6$ (Cartap 50 WP @ 3 g/L of water at 7 days interval) treatment (Table 1). In case of reduction over control the highest value (61.33%) was found from $T_1$ and the lowest value (34.40%) from $T_2$ treatment.

At 47 DAT, the lowest dead heart infestation (3.05%) was recorded from $T_1$ which was closely followed (4.98% and 5.11%) by $T_6$ and $T_3$, whereas the highest dead heart infestation (9.71%) was found from $T_7$ which was similar (6.39%, 6.12% and 5.88%) to $T_2$, $T_4$ and $T_5$ (Table 1). In case of reduction over control the highest value (67.93%) was recorded from $T_1$ and the lowest value (32.81%) was obtained from $T_2$ treatment.

**Table 1. Effect of some promising chemical insecticides on the rice yellow stem borer (dead heart) infestation**

| Treatments | Rice yellow stem borer infestation (dead heart/plot) by number at different days after transplanting (DAT) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1st observation (40 DAT) | | 2nd observation (47 DAT) | | 3rd observation (54 DAT) | | 4th observation (61 DAT) | |
| | Dead heart (%) | Reduction over control (%) | Dead heart (%) | Reduction over control (%) | Dead heart (%) | Reduction over control (%) | Dead heart (%) | Reduction over control (%) |
| $T_1$ | 2.90 c | 61.33 | 3.05 c | 67.93 | 0.00 b | 100 | 0.00 b | 100 |
| $T_2$ | 4.92 ab | 34.40 | 6.39 a | 32.81 | 0.00 b | 100 | 0.00 b | 100 |
| $T_3$ | 3.80 bc | 49.33 | 5.11 b | 46.27 | 0.00 b | 100 | 0.00 b | 100 |
| $T_4$ | 4.69 ab | 37.47 | 6.12 ab | 35.65 | 0.00 b | 100 | 0.00 b | 100 |
| $T_5$ | 4.82 ab | 35.73 | 5.88 ab | 38.17 | 0.00 b | 100 | 0.00 b | 100 |
| $T_6$ | 4.65 ab | 38.00 | 4.98 b | 47.63 | 0.00 b | 100 | 0.00 b | 100 |
| $T_7$ | 7.50 a | -- | 9.51 a | -- | 4.74 a | -- | 3.90 a | -- |
| $LSD_{(0.05)}$ | 1.329 | -- | 1.091 | -- | 0.482 | -- | 0.391 | -- |
| CV(%) | 17.70 | -- | 11.97 | -- | 7.33 | -- | 8.34 | -- |

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 10 hills per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$T_1$: Marshall 20 EC @ 3.0 ml/L of water at 7 days interval

$T_2$: Malathion 57 EC @ 2.0 ml/L of water at 7 days interval

$T_3$: Diazinon 60 EC @ 3.5 ml/L of water at 7 days interval

$T_4$: Furadan 5G @ 2.5 g/plot at 7 days interval

$T_5$: Sevin 85 SP @ 3.0 g/plot at 7 days interval

$T_6$: Cartap 50 WP @ 3 g/L of water at 7 days interval

$T_7$: Untreated control

As 3rd observation at 54 DAT, the dead heart infestation was found only for $T_7$ treatment and it was 4.74%. In case of reduction over control the highest value (100%) was found from all the treatment compare to the control (Table 1).

From the observed data it was found that the dead heart infestation only 3.90% was observed from $T_7$ treatment and it was 4.74% and in case of reduction over control the highest value (100%) was found from all the treatment compare to the control (Table 1).

### 4.1.2 White head infestation

Different chemical insecticides showed statistically significant differences in terms of white head infestation of rice at 92, 99, 106 and 113 DAT as 1st, 2nd, 3rd and 4th observation (Appendix V).

As 1st observation at 92 DAT, data revealed that the lowest white head infestation (3.43%) was observed from $T_1$ which was followed (5.61%) by $T_3$, whereas the highest white head infestation (6.73%) was recorded from $T_7$ which was similar (6.37%, 6.25%, 6.08% and 5.80%) to $T_2$, $T_5$, $T_4$ and $T_6$ (Table 2). In case of reduction over control the highest value (49.03%) was found from $T_1$ and the lowest value (5.35%) was observed from $T_2$ treatment.

At 99 DAT as 2nd observation, the lowest white head infestation (4.24%) was observed from $T_1$ which was statistically different from all other treatment, while the highest white head infestation (8.55%) was recorded from $T_7$ which was similar (8.13%, 7.90% and 7.62%) to $T_5$, $T_2$ and $T_4$ (Table 2). In case of reduction over control the highest value (50.41%) was found from $T_1$ and the lowest value (4.91%) from $T_5$ treatment.

Data revealed that at 106 DAT as 3rd observation, the lowest white head infestation (4.90%) was observed from $T_1$ which was statistically similar (7.28% and 7.46%) to $T_6$ and $T_3$, while the highest white head infestation (9.05%) was recorded from $T_7$ which was similar (8.87%, 8.59% and 8.24%) to $T_4$, $T_2$ and $T_5$ (Table 2). In case of reduction over control the highest value (45.86%) was found from $T_1$ and the lowest value (1.99%) was observed from $T_4$ treatment.

**Table 2. Effect of some promising chemical insecticides on the rice yellow stem borer (white head) infestation**

| Treatments | Rice yellow stem borer infestation (white head/plot) by number at different days after transplanting (DAT) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1st observation (92 DAT) | | 2nd observation (99 DAT) | | 3rd observation (106 DAT) | | 4th observation (113 DAT) | |
| | White head (%) | Reduction over control (%) | White head (%) | Reduction over control (%) | White head (%) | Reduction over control (%) | White head (%) | Reduction over control (%) |
| $T_1$ | 3.43 c | 49.03 | 4.24 d | 50.41 | 4.90 c | 45.86 | 5.56 c | 47.65 |
| $T_2$ | 6.37 ab | 5.35 | 7.90 a | 7.60 | 8.59 ab | 5.08 | 8.67 bc | 18.36 |
| $T_3$ | 5.61 b | 16.64 | 6.96 bc | 18.60 | 7.46 bc | 17.57 | 9.30 ab | 12.43 |
| $T_4$ | 6.08 ab | 9.66 | 7.62 ab | 10.88 | 8.87 a | 1.99 | 8.74 bc | 17.70 |
| $T_5$ | 6.25 ab | 7.13 | 8.13 a | 4.91 | 8.24 ab | 8.95 | 9.62 ab | 9.42 |
| $T_6$ | 5.80 ab | 13.82 | 6.48 c | 24.21 | 7.28 bc | 19.56 | 8.70 bc | 18.08 |
| $T_7$ | 6.73 a | -- | 8.55 a | -- | 9.05 a | -- | 10.62 a | -- |
| $LSD_{(0.05)}$ | 1.009 | -- | 0.870 | -- | 1.232 | -- | 1.564 | -- |
| CV(%) | 10.33 | -- | 7.22 | -- | 9.28 | -- | 10.44 | -- |

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 10 hills per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$T_1$: Marshall 20 EC @ 3.0 ml/L of water at 7 days interval

$T_2$: Malathion 57 EC @ 2.0 ml/L of water at 7 days interval

$T_3$: Diazinon 60 EC @ 3.5 ml/L of water at 7 days interval

$T_4$: Furadan 5G @ 2.5 g/plot at 7 days interval

$T_5$: Sevin 85 SP @ 3.0 g/plot at 7 days interval

$T_6$: Cartap 50 WP @ 3 g/L of water at 7 days interval

$T_7$: Untreated control

As 4th observation at 113 DAT, data revealed that the lowest white head infestation (5.56%) was observed from $T_1$ which was closely followed (8.74%, 8.70% and 8.67%) by $T_4$, $T_6$ and $T_2$ treatment and they were statistically similar, whereas the highest white head infestation (10.62%) was recorded from $T_7$ which was similar (9.62% and 9.30%) to $T_5$ and $T_3$ (Table 2). In case of reduction over control the highest value (47.65%) was found from $T_1$ and the lowest value (9.42%) was observed from $T_5$ treatment.

This symptom of stem borer is known as dead heart and white head and the infestations period at tillering and at grain filling stage, respectively. In Bangladesh, stem borer, is one of the major pest generally causes 20% yield loss (Khan *et al.*, 1991). The extent of rice yield losses due to YSB has been estimated as 20-70% (Catling *et al*., 1987; Chinniah *et al.*, 1998). Hybrid rice variety found to most susceptible to stem borer and cause yield loss 22.19-27.09% (Rahman *et al.*, 2004). Saijoqi *et al*. (2002) reported that insecticides gave significantly better control of rice stem borer than the untreated check. Padan 4G (cartap) at 22.23 kg/ha was found to be the most effective in reducing rice stem borer infestation, followed by Regent 300 EC (fipronil) at 197.6 mi/ha, Regent 300 EC. Roshan (2006) reported that application of cartap hydrochloride initiated at 50 and 70 DAT could not suppress the incidence of stem borers. Two applications of cartap hydrochloride at 30, 50 and 30, 70 DAT were equally effective to three applications of monocrotophos in managing the incidence of stem borers Mondal and Chakraborty (2016) stated that Fipronil showed the reduction of 56.28% dead hearts (DH) and 65.27% white head (WH) over control after 35 days of spraying. While the result for dursban was 30.01% DH and 40.27% WH. Rath (2015) reported that Imidacloprid 17.8% @ 300g/ha treatment recorded lowest percentage of DH (3.3%) and lowest percentage of WEH (3.33%). Islam *et al*. (2013) recorded a highly significant result was observed in Fipronil treatment after 21 days of spraying which showed the reduction of 51.89% dead heart 65.05% white head over control.

## 4.2 Incidence of rice hispa

### 4.2.1 Vegetative stage

Incidence of hispa of rice of vegetative stage at 40, 47, 54 and 61 DAT as 1st, 2nd, 3rd and 4th observation showed statistically significant variation due to different chemical insecticides (Appendix VI).

In vegetative stage, as 1st observation at 40 DAT, data revealed that the lowest number of rice hispa/2 sweeps (1.00) was observed from $T_1$ which was statistically similar (1.20) to $T_6$ and closely followed (1.45 and 1.50) by $T_5$ and $T_3$ and they were statistically similar, whereas the highest number of rice hispa/2 sweeps (4.10) was recorded from $T_7$ treatment which was closely followed (2.35) by $T_2$ (Table 3). In case of reduction over control the highest value (75.61%) was found from $T_1$ and the lowest value (42.68%) was observed from $T_2$ treatment.

Data revealed that in vegetative stage, as 2nd observation at 47 DAT, the lowest number of rice hispa/2 sweeps (1.20) was observed from $T_1$ which was statistically different from others treatment, whereas the highest number of rice hispa/2 sweeps (5.40) was recorded from $T_7$ treatment which was closely followed (3.50 and 3.30) by $T_2$ and $T_4$ treatment (Table 3). In case of reduction over control the highest value (77.78%) was found from $T_1$ and the lowest value (35.19%) was recorded from $T_2$ treatment.

The lowest number of rice hispa/2 sweeps (1.11) was observed from $T_1$ which was statistically similar (2.22, 3.33, 4.44 and 5.56) to $T_4$, $T_5$, $T_3$ and $T_6$ treatment, whereas the highest number of rice hispa/2 sweeps (15.56) was recorded from $T_7$ treatment in vegetative stage, as 3rd observation at 54 DAT (Table 3). In case of reduction over control the highest value (92.87%) was recorded from $T_1$ treatment and the lowest value (64.27%) was attained from $T_2$ treatment under the present trial.

**Table 3. Effect of some promising chemical insecticides on the rice hispa (RH) incidence at the vegetative stage of rice**

| Treatments | Rice Hispa (RH) incidence at the vegetative stage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1st observation (40 DAT) | | 2nd observation (47 DAT) | | 3rd observation (54 DAT) | | 4th observation (61 DAT) | |
| | RH (No./ 2 sweeps) | Reduction over control (%) | RH (No./ 2 sweeps) | Reduction over control (%) | RH (No./ 2 sweeps) | Reduction over control (%) | RH (No./ 2 sweeps) | Reduction over control (%) |
| $T_1$ | 1.00 e | 75.61 | 1.20 e | 77.78 | 1.11 d | 92.87 | 2.22 f | 87.51 |
| $T_2$ | 2.35 b | 42.68 | 3.50 b | 35.19 | 5.56 bc | 64.27 | 7.78 bc | 56.24 |
| $T_3$ | 1.50 d | 63.41 | 2.50 c | 53.70 | 3.33 bcd | 78.60 | 5.56 cde | 68.73 |
| $T_4$ | 1.95 c | 52.44 | 3.30 b | 38.89 | 2.22 cd | 85.73 | 3.33 ef | 81.27 |
| $T_5$ | 1.45 d | 64.63 | 2.45 c | 54.63 | 2.22 cd | 85.73 | 4.44 def | 75.03 |
| $T_6$ | 1.20 de | 70.73 | 1.85 d | 65.74 | 4.44 bcd | 71.47 | 6.67 bcd | 62.49 |
| $T_7$ | 4.10 a | -- | 5.40 a | -- | 15.56 a | -- | 17.78 a | -- |
| $LSD_{(0.05)}$ | 0.303 | -- | 0.474 | -- | 3.087 | -- | 2.812 | -- |
| CV(%) | 8.75 | -- | 9.21 | -- | 14.31 | -- | 22.67 | -- |

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 10 hills per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$T_1$: Marshall 20 EC @ 3.0 ml/L of water at 7 days interval

$T_2$: Malathion 57 EC @ 2.0 ml/L of water at 7 days interval

$T_3$: Diazinon 60 EC @ 3.5 ml/L of water at 7 days interval

$T_4$: Furadan 5G @ 2.5 g/plot at 7 days interval

$T_5$: Sevin 85 SP @ 3.0 g/plot at 7 days interval

$T_6$: Cartap 50 WP @ 3 g/L of water at 7 days interval

$T_7$: Untreated control

It was observed that in vegetative stage, as 4th observation at 61 DAT, the lowest number of rice hispa/2 sweeps (2.22) was observed from $T_1$ which was statistically similar (3.33 and 4.44) to $T_4$ and $T_5$ treatment, whereas the highest number of rice hispa/2 sweeps (17.78) was recorded from $T_7$ treatment which was followed by (7.78 and 6.67 to $T_2$ and $T_6$ treatment (Table 3). In case of reduction over control the highest value (87.51%) was found from $T_1$ and the lowest value (56.24%) was recorded from $T_2$ treatment.

### 4.2.2 Reproductive stage

Statistically significant variation was recorded in terms of incidence of hispa of rice of reproductive stage at 92, 99, 106 and 113 DAT as 1st, 2nd, 3rd and 4th observation due to different chemical insecticides under the present trial (Appendix VII).

Data revealed that in reproductive stage, as 1st observation at 92 DAT, the lowest number of rice hispa/2 sweeps (1.33) was found from $T_1$ which was statistically similar to other treatment except $T_7$ and the highest number of rice hispa/2 sweeps (3.67) was observed from $T_7$ treatment (Table 4). In case of reduction over control the highest value (63.76%) was found from $T_1$ and the lowest value (45.50%) from other treatment except $T_4$ and $T_1$.

In reproductive stage, as 2nd observation at 99 DAT, the lowest number of rice hispa/2 sweeps (1.33) was observed from $T_1$ which was statistically similar (1.67 and 2.00) to $T_3$, $T_4$, $T_6$ and $T_5$ treatment, whereas the highest number of rice hispa/2 sweeps (3.00) was recorded from $T_7$ treatment which was statistically similar (2.33) to $T_2$ treatment (Table 4). In case of reduction over control the highest value (55.67%) was found from $T_1$ and the lowest value (33.33%) was recorded from $T_5$ treatment.

**Table 4. Effect of some promising chemical insecticides on the rice hispa incidence at the reproductive stage of rice**

| Treatments | Rice Hispa (RH) incidence at the reproductive stage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1st observation (92 DAT) | | 2nd observation (99 DAT) | | 3rd observation (106 DAT) | | 4th observation (113 DAT) | |
| | RH (No./ 2 sweeps) | Reduction over control (%) | RH (No./ 2 sweeps) | Reduction over control (%) | RH (No./ 2 sweeps) | Reduction over control (%) | RH (No./ 2 sweeps) | Reduction over control (%) |
| $T_1$ | 1.33 b | 63.76 | 1.33 c | 55.67 | 0.67 c | 74.91 | 0.00 c | 100.00 |
| $T_2$ | 2.00 b | 45.50 | 2.33 ab | 22.33 | 2.33 a | 12.73 | 2.00 ab | 14.16 |
| $T_3$ | 2.00 b | 45.50 | 1.67 bc | 44.33 | 2.00 ab | 25.09 | 1.00 abc | 57.08 |
| $T_4$ | 1.67 b | 54.50 | 1.67 bc | 44.33 | 1.33 bc | 50.19 | 1.67 ab | 28.33 |
| $T_5$ | 2.00 b | 45.50 | 2.00 bc | 33.33 | 1.33 bc | 50.19 | 1.67 ab | 28.33 |
| $T_6$ | 2.00 b | 45.50 | 1.67 bc | 44.33 | 1.00 c | 62.55 | 0.67 bc | 71.24 |
| $T_7$ | 3.67 a | -- | 3.00 a | -- | 2.67 a | -- | 2.33 a | -- |
| $LSD_{(0.05)}$ | 0.662 | -- | 0.854 | -- | 0.854 | -- | 1.378 | -- |
| CV(%) | 8.04 | -- | 14.99 | -- | 10.14 | -- | 9.01 | -- |

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 10 hills per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$T_1$: Marshall 20 EC @ 3.0 ml/L of water at 7 days interval

$T_2$: Malathion 57 EC @ 2.0 ml/L of water at 7 days interval

$T_3$: Diazinon 60 EC @ 3.5 ml/L of water at 7 days interval

$T_4$: Furadan 5G @ 2.5 g/plot at 7 days interval

$T_5$: Sevin 85 SP @ 3.0 g/plot at 7 days interval

$T_6$: Cartap 50 WP @ 3 g/L of water at 7 days interval

$T_7$: Untreated control

The lowest number of rice hispa/2 sweeps (0.67) was observed from $T_1$ which was statistically similar (1.00 and 1.33) to $T_6$, $T_4$ and $T_5$ treatment, whereas the highest number of rice hispa/2 sweeps (2.67) was recorded from $T_7$ treatment which was statistically similar (2.00 and 2.33) to $T_3$ and $T_2$ treatment in reproductive stage, as 3rd observation at 106 DAT (Table 4). In case of reduction over control the highest value (74.91%) was found from $T_1$ and the lowest value (12.73%) was recorded from $T_2$ treatment.

In reproductive stage, as 4th observation at 113 DAT, no rice hispa/2 sweeps was recorded from $T_1$, whereas the highest number of rice hispa/2 sweeps (2.33) was recorded from $T_7$ treatment which was statistically similar (2.00, 1.67 and 1.00) to $T_2$, $T_4$, $T_5$ and $T_3$ treatment (Table 4). In case of reduction over control the highest value (100.00%) was observed from $T_1$ and the lowest value (14.16%) was recorded from $T_5$ treatment.

Rice hispa is one of the major pests of rice and causing about 35-65% loss in yield by attacking generally at the vegetative stage (Puzari and Hazarika, 1992). Under post flood situation, the late transplanted rice crop severely suffers and 100% loss because of its attack (Hazarika, 1999). Rice crops, kharif and rabi, are subjected to sporadic outbreaks of *D. armigera* and may be severely attacked (Karim, 1986). Budhraja *et al*. (1980) found varieties differed in their ability to recover from hispa attack after “rescue” by insecticides as (in yield in MT/Ha, respectively unprotected/“rescued”): Anupama 0.9/2.0; Chatri 1.5/2.0; Numgi 1.2/1.8; Ratna 0.7/5.0. Budhraja *et al.* (1980) found all granular insecticides obtained positive economic returns in controlling hispa. Haque *et al.* (2000) indicate that under high densities of rice hispa, the leaf growth of younger plants (with greater than 20% leaf damage) is severely retarded. Puzari *et al*. (2015) reported that half of the recommended dose of chlorpyriphos proved superiority then the commonly applied insecticides in decreasing the rice hispa pest population.

### 4.3 Yield contributing character and yield of rice

#### 4.3.1 Number of filled grains/panicle

Number of filled grains/panicle of rice showed statistically significant variation due to different chemical insecticides (Appendix VIII).

It was observed that the highest number of filled grains/panicle (95.74) was recorded from $T_1$ which was statistically similar (92.33 and 91.38) to $T_5$ and $T_6$, whereas the lowest number of filled grains/panicle (81.77) was recorded from $T_7$ which was closely followed (87.57, 91.25 and 91.17) by $T_2$, $T_4$ and $T_3$ treatment, respectively and they were statistically similar (Table 5). Korat *et al*. (1999) reported that the maximum filled grains from the plots treated with buprofezin followed by acephate, carbofuran 30 and monocrotophos.

In case of % of total grains, the highest filled grains/panicle (93.86%) was recorded from $T_1$ which was statistically similar (91.52%, 91.40%, 90.33% and 90.27%) to $T_6$, $T_4$, $T_5$ and $T_3$ treatment, while the lowest filled grains/panicle (84.30%) was found in $T_7$ which was closely followed (88.63%) by $T_2$ treatment. In case of reduction over control the highest value (11.34%) was observed from $T_1$ treatment and the lowest value (5.14%) was recorded from $T_2$ treatment (Table 5).

#### 4.3.2 Number of unfilled grains/panicle

Statistically significant variation was recorded in terms of number of unfilled grains/panicle of rice due to different chemical insecticides (Appendix VIII).

Data revealed that the lowest number of unfilled grains/panicle (6.26) was recorded from $T_1$ which was statistically similar (8.59 and 8.55) to $T_4$ and $T_6$ and closely followed (9.83 and 9.78) by $T_3$ and $T_5$, whereas the highest number of unfilled grains/panicle (15.23) was observed from $T_7$ which was closely followed (11.43) by $T_2$ treatment (Table 5).

**Table 5. Effect of some promising chemical insecticides on the number of grains of rice**

| Treatments | Filled grains | | | Unfilled grains | | |
|---|---|---|---|---|---|---|
| | No. of filled grains/panicle | % of total grains | Increase/decrease over control (%) | No. of unfilled grains/panicle | % of total grains | Increase/decrease over control (%) |
| $T_1$ | 95.74 a | 93.86 a | 11.34 | 6.26 d | 6.14 c | 60.91 |
| $T_2$ | 87.57 c | 88.63 b | 5.14 | 11.43 b | 11.55 b | 26.47 |
| $T_3$ | 91.17 bc | 90.27 a | 7.08 | 9.83 c | 9.73 c | 38.01 |
| $T_4$ | 91.25 bc | 91.40 a | 8.42 | 8.59 d | 8.60 c | 45.20 |
| $T_5$ | 91.38 ab | 90.33 a | 7.15 | 9.78 c | 9.67 c | 38.43 |
| $T_6$ | 92.33 ab | 91.52 a | 8.56 | 8.55 d | 8.48 c | 46.02 |
| $T_7$ | 81.77 d | 84.30 c | -- | 15.23 a | 15.70 a | -- |
| $LSD_{(0.05)}$ | 2.136 | 2.891 | -- | 0.576 | 2.014 | -- |
| CV(%) | 8.22 | 4.55 | -- | 5.67 | 6.78 | -- |

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 10 panicles per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$T_1$: Marshall 20 EC @ 3.0 ml/L of water at 7 days interval

$T_2$: Malathion 57 EC @ 2.0 ml/L of water at 7 days interval

$T_3$: Diazinon 60 EC @ 3.5 ml/L of water at 7 days interval

$T_4$: Furadan 5G @ 2.5 g/plot at 7 days interval

$T_5$: Sevin 85 SP @ 3.0 g/plot at 7 days interval

$T_6$: Cartap 50 WP @ 3 g/L of water at 7 days interval

$T_7$: Untreated control

In case of % total grains, the lowest unfilled grains/panicle (6.14%) was recorded from $T_1$ which was statistically similar (8.48%, 8.60%, 9.67% and 9.73) to $T_6$, $T_4$, $T_5$ and $T_3$ treatment, whereas the highest unfilled grains/panicle (15.70%) was recorded in $T_7$ which was followed (11.55%) by $T_2$ treatment. In case of reduction over control the highest value (60.91%) was observed from $T_1$ and the lowest value (26.47%) was recorded from $T_2$ treatment (Table 5).

**4.3.3 Weight of filled grains/panicle**

Number of filled grains/panicle of rice varied significantly due to different chemical insecticides (Appendix IX).

It was observed that the highest weight of filled grains/panicle (20.34 g) was recorded from $T_1$ which was statistically similar (20.15 g, 19.88 g, 19.45 g and 19.33 g) to $T_6$, $T_3$, $T_4$ and $T_5$, whereas the lowest weight of filled grains/panicle (17.15 g) was recorded from $T_7$ which was closely followed (18.23 g) by $T_2$ treatment (Table 6).

In case of % of total grains, the highest weight of filled grains/panicle (90.56%) was recorded from $T_1$ which was statistically similar (90.24%, 89.35% and 88.41%) to $T_6$, $T_3$ and $T_4$ treatment, while the lowest weight of filled grains/panicle (85.32%) in $T_7$ which was followed (86.323%) by $T_2$ treatment. In case of reduction over control the highest value (6.14%) was observed from $T_1$ and the lowest value (1.17%) was recorded from $T_2$ treatment (Table 6).

**4.3.4 Weight of unfilled grains/panicle**

Different chemical insecticides showed statistically significant differences in terms of weight of unfilled grains/panicle of rice (Appendix IX).

Data revealed that the lowest weight of unfilled grains/panicle (2.12 g) was recorded from $T_1$ which was similar (2.18 g) to $T_6$ and closely followed (2.37 g) by $T_3$ treatment, while the highest weight of unfilled grains/panicle (2.95 g) was observed from $T_7$ which was statistically similar (2.89 g) to $T_2$ and closely followed (2.68 g and 2.55 g) by $T_5$ and $T_4$ treatment (Table 6).

**Table 6. Effect of some promising chemical insecticides on the weight of grains of rice**

| Treatments | Filled grains | | | Unfilled grains | | |
|---|---|---|---|---|---|---|
| | Weight of filled grains (g) | % of filled grains | Increase/decrease over control (%) | Weight of unfilled grains (g) | % of unfilled grains | Increase/decrease over control (%) |
| $T_1$ | 20.34 a | 90.56 a | 6.14 | 2.12 d | 9.44 d | 35.69 |
| $T_2$ | 18.23 b | 86.32 bc | 1.17 | 2.89 a | 13.68 a | 6.77 |
| $T_3$ | 19.88 a | 89.35 a | 4.72 | 2.37 c | 10.65 c | 27.42 |
| $T_4$ | 19.45 a | 88.41 a | 3.62 | 2.55 b | 11.59 b | 21.02 |
| $T_5$ | 19.33 a | 87.82 b | 2.93 | 2.68 b | 12.18 b | 17.04 |
| $T_6$ | 20.15 a | 90.24 a | 5.77 | 2.18 d | 9.76 d | 33.48 |
| $T_7$ | 17.15 c | 85.32 c | -- | 2.95 a | 14.68 a | -- |
| $LSD_{(0.05)}$ | 0.914 | 2.323 | -- | 0.178 | 0.789 | -- |
| CV(%) | 4.89 | 6.78 | -- | 3.89 | 4.55 | -- |

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 10 panicles per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$T_1$: Marshall 20 EC @ 3.0 ml/L of water at 7 days interval

$T_2$: Malathion 57 EC @ 2.0 ml/L of water at 7 days interval

$T_3$: Diazinon 60 EC @ 3.5 ml/L of water at 7 days interval

$T_4$: Furadan 5G @ 2.5 g/plot at 7 days interval

$T_5$: Sevin 85 SP @ 3.0 g/plot at 7 days interval

$T_6$: Cartap 50 WP @ 3 g/L of water at 7 days interval

$T_7$: Untreated control

In case of % total grains, the lowest weight unfilled grains/panicle (9.44%) was recorded from $T_1$ which was statistically similar (9.76%) by $T_6$ treatment and closely followed (10.65%) by $T_3$ treatment, while the highest weight of unfilled grains/panicle (14.68%) was recorded in $T_7$ treatment which was statistically similar (13.68%) to $T_2$ treatment. In case of reduction over control the highest value (35.69%) was observed from $T_1$ and the lowest value (6.77%) was recorded from $T_2$ treatment (Table 6).

### 4.3.5 Panicle length

Statistically significant variation was recorded in terms of panicle length of rice due to use of different chemical insecticides (Appendix X).

It was observed that the longest panicle (26.22 cm) was recorded from $T_1$ which was statistically similar (25.98 cm) to $T_6$ and closely followed (25.34 cm, 25.26 cm, 24.62 cm and 24.13 cm) by $T_5$, $T_3$, $T_4$ and $T_2$ treatment and they were statistically similar, whereas the shortest panicle (22.34 cm) was observed from $T_7$ treatment. In case of reduction over control the highest value (17.37%) was observed from $T_1$ and the lowest value (8.01%) was recorded from $T_2$ treatment (Table 7).

### 4.3.6 Weight of 1000-seeds

Weight of 1000-seeds of rice showed statistically significant differences due to different chemical insecticides under the present trial (Appendix X).

Data revealed that the highest weight of 1000-seeds (22.34 g) was recorded from $T_1$ which was statistically similar (22.23 g) to $T_6$ and closely followed (21.38 g, 21.30 g and 20.53 g) by $T_5$, $T_3$ and $T_4$ treatment and they were statistically similar, whereas the lowest weight of 1000-seeds (19.83 g) was observed from $T_7$ treatment. In case of reduction over control the highest value (12.66%) was observed from $T_1$ and the lowest value (1.01%) was recorded from $T_2$ treatment (Table 7).

**Table 7. Effect of some promising chemical insecticides on panicle length, 1000 seeds weight and yield of rice**

| Treatments | Panicle length (cm) | Increase/decrease over control (%) | Weight of 1000-seeds (g) | Increase/decrease over control (%) | Yield/hectare (ton) | Increase/decrease over control (%) |
|---|---|---|---|---|---|---|
| $T_1$ | 26.22 a | 17.37 | 22.34 a | 12.66 | 5.67 a | 69.25 |
| $T_2$ | 24.13 b | 8.01 | 20.03 c | 1.01 | 4.42 b | 31.94 |
| $T_3$ | 25.26 b | 13.07 | 21.30 b | 7.41 | 4.90 b | 46.27 |
| $T_4$ | 24.62 b | 10.21 | 20.53 b | 3.53 | 4.56 b | 36.12 |
| $T_5$ | 25.34 b | 13.43 | 21.38 b | 7.82 | 4.69 b | 40.00 |
| $T_6$ | 25.98 ab | 16.29 | 22.23 a | 12.10 | 5.02 b | 49.85 |
| $T_7$ | 22.34 c | -- | 19.83 c | -- | 3.35 c | -- |
| $LSD_{(0.05)}$ | 0.986 | -- | 0.823 | -- | 0.606 | -- |
| CV(%) | 3.67 | -- | 4.55 | -- | 7.04 | -- |

In a column, numeric data represents the mean value of 3 replications

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$T_1$: Marshall 20 EC @ 3.0 ml/L of water at 7 days interval

$T_2$: Malathion 57 EC @ 2.0 ml/L of water at 7 days interval

$T_3$: Diazinon 60 EC @ 3.5 ml/L of water at 7 days interval

$T_4$: Furadan 5G @ 2.5 g/plot at 7 days interval

$T_5$: Sevin 85 SP @ 3.0 g/plot at 7 days interval

$T_6$: Cartap 50 WP @ 3 g/L of water at 7 days interval

$T_7$: Untreated control

### 4.3.7 Yield/hectare

Statistically significant variation was recorded in terms of yield/hectare of rice due to different chemical insecticides under the present trial (Appendix X).

It was observed that the highest yield/hectare (5.67 ton) was recorded from $T_1$ which was statistically similar (5.02 ton) to $T_6$ and closely followed (4.90 ton, 4.69 ton, 4.56 ton and 4.42 tom) by $T_3$, $T_5$, $T_4$ and $T_2$ treatment and they were statistically similar, whereas the lowest yield/hectare (3.35 ton) was observed from $T_7$ treatment. In case of reduction over control the highest value (69.25%) was observed from $T_1$ and the lowest value (31.94%) was recorded from $T_2$ treatment (Table 7). Mondal and Chakraborty (2016) recorded that Fipronil and Dursban treated plot showed yield of 3.18 and 3.04 t/ha respectively. Rath (2015) stated that the grain yield of treatment imidacloprid17.8% @ 300g/ha was highest (5.28 and 5.21 t/ha) significantly superior to check insecticide monocrotophus 36 % @ 1390 ml/ha (4.65 and 4.62t/ha) and at par with thiamethoxam 25%@100g/ha (4.9 and 4.85 t/ha), triazophos 40% @625g/ha (4.78 and 4.8 t/ha) and new insecticide Sulfoxaflor 24% @ 375g/ha (4.96 and 4.92t/ha)

## 4.4 Economic analysis

The analysis was done in order to estimate out the most profitable chemical insecticides based on cost and benefit of various components. The results of economic analysis of rice cultivation revealed that the highest net benefit of Tk. 248,100/ha was obtained in $T_1$ treatment and the second highest was found Tk. 194,700/ha in $T_2$ (Table 8). The highest benefit cost ratio (2.28) was estimated for $T_1$ treatment and the lowest (1.03) for $T_2$ treatment under the trial. The highest BCR was found in the treatment $T_1$ may be due to the minimum pest infestation compared to the other treatment and the highest yield of this treatment.

**Table 8. Estimation of benefit for rice cultivation by using some promising chemical insecticides**

| Treatments | Cost of pest Management (Tk.) | Yield (t/ha) | Gross return (Tk.) | Net Return (Tk.) | Adjusted net return (Tk.) | Benefit cost ratio |
|---|---|---|---|---|---|---|
| $T_1$ | 35,400 | 5.67 | 283,500 | 248,100 | 80,600 | 2.28 |
| $T_2$ | 26,300 | 4.42 | 221,000 | 194,700 | 27,200 | 1.03 |
| $T_3$ | 32,200 | 4.90 | 245,000 | 212,800 | 45,300 | 1.41 |
| $T_4$ | 28,400 | 4.56 | 228,000 | 199,600 | 32,100 | 1.13 |
| $T_5$ | 30,200 | 4.69 | 234,500 | 204,300 | 36,800 | 1.22 |
| $T_6$ | 35,400 | 5.02 | 251,000 | 215,600 | 48,100 | 1.36 |
| $T_7$ | 0 | 3.35 | 167,500 | 167,500 | -- | -- |

Price of rice @ Tk. 50000/ton

$T_1$: Marshall 20 EC @ 3.0 ml/L of water at 7 days interval

$T_2$: Malathion 57 EC @ 2.0 ml/L of water at 7 days interval

$T_3$: Diazinon 60 EC @ 3.5 ml/L of water at 7 days interval

$T_4$: Furadan 5G @ 2.5 g/plot at 7 days interval

$T_5$: Sevin 85 SP @ 3.0 g/plot at 7 days interval

$T_6$: Cartap 50 WP @ 3 g/L of water at 7 days interval

$T_7$: Untreated control

# Chapter V

# Summary and Conclusion

# CHAPTER V

# SUMMARY AND CONCLUSION

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from April to August, 2016 to incidence and management of rice yellow stem borer and rice hispa on rice variety BRRI dhan43. BRRI dhan43 were used as the test crop in this experiment. The experiment comprised of the following control measure as treatment- $T_1$: Marshall 20 EC @ 3.0 ml/L of water at 7 days interval; $T_2$: Malathion 57 EC @ 2.0 ml/L of water at 7 days interval; $T_3$: Diazinon 60 EC @ 3.5 ml/L of water at 7 days interval; $T_4$: Furadan 5G @ 2.5 g/plot at 7 days interval; $T_5$: Sevin 85 SP @ 3.0 g/plot at 7 days interval; $T_6$: Cartap 50 WP @ 3 g/L of water at 7 days interval and $T_7$: Untreated control. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Data was recorded on dead heart and white head infestation, incidence of rice hispa and also yield attributes and yield of BRRI dhan43 and found statistically significant differences for different treatment.

As 1$^{st}$ observation at 40 DAT, the lowest dead heart infestation (2.90%) was observed from $T_1$, while the highest dead heart infestation (7.50%) was recorded from $T_7$. In case of reduction over control the highest value (61.33%) was found from $T_1$ and the lowest value (34.40%) was observed from $T_2$ treatment. The lowest dead heart infestation (3.05%) was recorded from $T_1$, whereas the highest dead heart infestation (9.71%) was found from $T_7$. In case of reduction over control the highest value (67.93%) was recorded from $T_1$ and the lowest value (32.81%) was obtained from $T_2$ treatment at 47 DAT as 2$^{nd}$ observation. As 3$^{rd}$ observation at 54 DAT, the dead heart infestation was recorded only for $T_7$ treatment and it was 4.74%. In case of reduction over control the highest value (100%) was found from all the treatment compare to the control. The dead heart infestation only 3.90% was observed from $T_7$ treatment and it was 4.74% and in case of reduction over control the highest value (100%) was found from all the treatment compare to the control at 61 DAT.

As 1st observation at 92 DAT, the lowest white head infestation (3.43%) was observed from $T_1$, whereas the highest white head infestation (6.73%) was recorded from $T_7$. In case of reduction over control the highest value (49.03%) was found from $T_1$ and the lowest value (5.35%) was observed from $T_2$ treatment. At 99 DAT as 2nd observation, the lowest white head infestation (4.24%) was observed from $T_1$, while the highest white head infestation (8.55%) was recorded from $T_7$ which was similar (8.13%, 7.90% and 7.62%) to $T_5$, $T_2$ and $T_4$. In case of reduction over control the highest value (50.41%) was found from $T_1$ and the lowest value (4.91%) from $T_5$ treatment. At 106 DAT as 3rd observation, the lowest white head infestation (4.90%) was observed from $T_1$, while the highest white head infestation (9.05%) was recorded from $T_7$. In case of reduction over control the highest value (45.86%) was found from $T_1$ and the lowest value (1.99%) was observed from $T_4$ treatment. As 4th observation at 113 DAT, the lowest white head infestation (5.56%) was observed from $T_1$, whereas the highest white head infestation (10.62%) was recorded from $T_7$. In case of reduction over control the highest value (47.65%) was found from $T_1$ and the lowest value (9.42%) was observed from $T_5$ treatment.

In vegetative stage, as 1st observation at 40 DAT, the lowest number of rice hispa/2 sweeps (1.00) was observed from $T_1$, whereas the highest number of rice hispa/2 sweeps (4.10) was recorded from $T_7$ treatment. In case of reduction over control the highest value (75.61%) was found from $T_1$ and the lowest value (42.68%) was observed from $T_2$ treatment. In vegetative stage, as 2nd observation at 47 DAT, the lowest number of rice hispa/2 sweeps (1.20) was observed from $T_1$, whereas the highest number of rice hispa/2 sweeps (5.40) was recorded from $T_7$ treatment. In case of reduction over control the highest value (77.78%) was found from $T_1$ and the lowest value (35.19%) was recorded from $T_2$ treatment. The lowest number of rice hispa/2 sweeps (1.11) was observed from $T_1$, whereas the highest number of rice hispa/2 sweeps (15.56) was recorded from $T_7$ treatment in vegetative stage, as 3rd observation at 54 DAT. In case of reduction over control the highest value (92.87%) was found from $T_1$ and the lowest value (64.27%) was recorded from $T_2$ treatment. In vegetative stage, as 4th observation at 61 DAT, the lowest number of rice hispa/2 sweeps (2.22) was observed from $T_1$, whereas the highest number of rice hispa/2 sweeps (17.78) was recorded from $T_7$ treatment. In case of reduction over control the highest value (87.51%) was found from $T_1$ and the lowest value (56.24%) from $T_2$ treatment.

In reproductive stage, as 1st observation at 92 DAT, the lowest number of rice hispa/2 sweeps (1.33) was found from $T_1$ and the highest number of rice hispa/2 sweeps (3.67) was observed from $T_7$ treatment. In case of reduction over control the highest value (63.76%) was found from $T_1$ and the lowest value (45.50%) from other treatment except $T_4$ and $T_1$. In reproductive stage, as 2nd observation at 99 DAT, the lowest number of rice hispa/2 sweeps (1.33) was observed from $T_1$, whereas the highest number of rice hispa/2 sweeps (3.00) was recorded from $T_7$ treatment. In case of reduction over control the highest value (55.67%) was found from $T_1$ and the lowest value (33.33%) was recorded from $T_5$ treatment. The lowest number of rice hispa/2 sweeps (0.67) was observed from $T_1$, whereas the highest number of rice hispa/2 sweeps (2.67) was recorded from $T_7$ treatment in reproductive stage, as 3rd observation at 106 DAT. In case of reduction over control the highest value (74.91%) was found from $T_1$ and the lowest value (12.73%) was recorded from $T_2$ treatment. In reproductive stage, as 4th observation at 113 DAT, no rice hispa/2 sweeps was recorded from $T_1$, whereas the highest number of rice hispa/2 sweeps (2.33) was recorded from $T_7$ treatment. In case of reduction over control the highest value (100.00%) was observed from $T_1$ and the lowest value (14.16%) from $T_5$ treatment.

The highest number of filled grains/panicle (95.74) was recorded from $T_1$, whereas the lowest number of filled grains/panicle (81.77) was recorded from $T_7$. In case of % of total grains, the highest filled grains/panicle (93.86%) was recorded from $T_1$, while the lowest filled grains/panicle (84.30%) was found in $T_7$ which was closely followed (88.63%) by $T_2$ treatment. In case of reduction over control the highest value (11.34%) was observed from $T_1$ and the lowest value (5.14%) was recorded from $T_2$ treatment. The lowest number of unfilled grains/panicle (6.26) was recorded from $T_1$, whereas the highest number of unfilled grains/panicle (15.23) was observed from $T_7$. In case of % total grains, the lowest unfilled grains/panicle (6.14%) was recorded from $T_1$, whereas the highest unfilled grains/panicle (15.70%) was recorded in $T_7$ treatment. In case of reduction over control the highest value (60.91%) was observed from $T_1$ and the lowest value (26.47%) was recorded from $T_2$ treatment. The highest weight of filled grains/panicle (20.34 g) was recorded from $T_1$, whereas the lowest weight of filled grains/panicle (17.15 g) was recorded from $T_7$. In case of % of total grains, the highest weight of filled grains/panicle (90.56%) was recorded from $T_1$, while the lowest weight of filled grains/panicle (85.32%) was found in $T_7$. The lowest weight of unfilled grains/panicle (2.12 g) was recorded from $T_1$, while the highest weight of unfilled grains/panicle (2.95 g) was observed from $T_7$. In case of % total grains, the lowest weight unfilled grains/panicle (9.44%) was recorded from $T_1$, while the highest weight of unfilled grains/panicle (14.68%) was recorded in $T_7$ treatment. In case of reduction over control the highest value (35.69%) was observed from $T_1$ and the lowest value (6.77%) was recorded from $T_2$ treatment. The longest panicle (26.22 cm) was recorded from $T_1$, whereas the shortest panicle (22.34 cm) was observed from $T_7$ treatment. In case of reduction over control the highest value (17.37%) was observed from $T_1$ and the lowest value (8.01%) was recorded from $T_2$ treatment. The highest weight of 1000-seeds (22.34 g) was recorded from $T_1$, whereas the lowest weight of 1000-seeds (19.83 g) was observed from $T_7$ treatment. In case of reduction over control the highest value (12.66%) was observed from $T_1$ and the lowest value (1.01%) was recorded from $T_2$ treatment. The highest yield/hectare (5.67 ton) was recorded from $T_1$, whereas the lowest yield/hectare (3.35 ton) was observed from $T_7$ treatment. In case of reduction over control the highest value

(69.25%) was observed from $T_1$ and the lowest value (31.94%) was recorded from $T_2$ treatment.

The results of economic analysis of rice cultivation revealed that the highest net benefit of Tk. 248,100/ha was obtained in $T_1$ treatment and the highest benefit cost ratio (2.28) was estimated for $T_1$ treatment and the lowest (1.03) for $T_2$ treatment under the trial.

Among the different control measures, spraying Marshall 20 EC @ 3.0 ml/L of water at 7 days interval was the better for the of rice yellow stem borer and rice hispa on rice variety BRRI dhan43.

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Other chemical, different pest management practices and rice variety may be use in future study.
2. This experiment should be carried out in different agro-ecological zones (AEZ) of Bangladesh for confirmation of the results.

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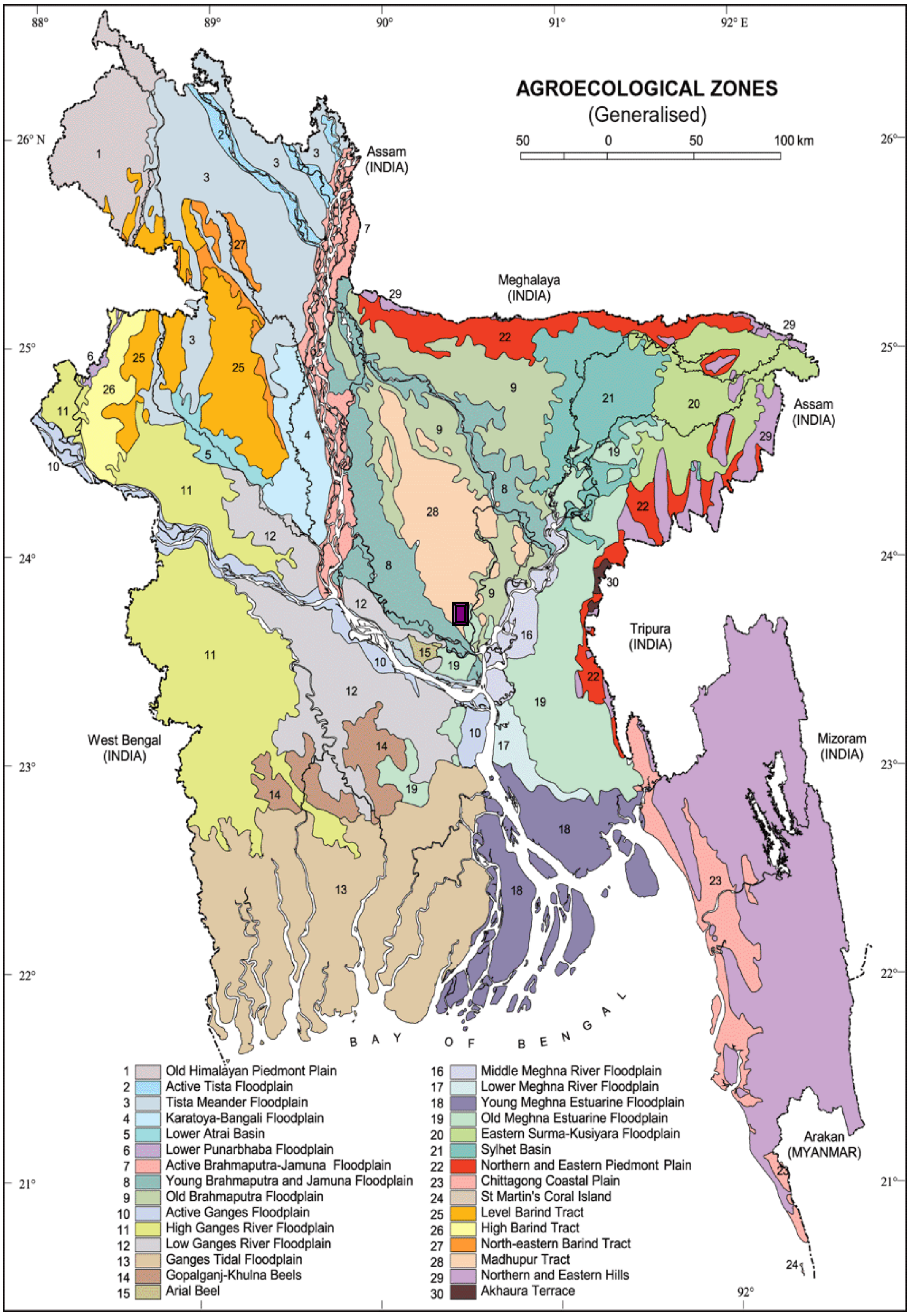
# Appendices

# APPENDICES

## Appendix I. The Map of the experimental site



**Appendix II. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from April to August 2016**

| Month (2016) | Air temperature ($^0$C) | | Relative humidity (%) | Rainfall (mm) |
|---|---|---|---|---|
| | Maximum | Minimum | | |
| April | 34.2 | 23.4 | 61 | 128 |
| May | 34.7 | 25.9 | 70 | 289 |
| June | 35.4 | 22.5 | 80 | 427 |
| July | 36.2 | 24.6 | 83 | 553 |
| August | 36.0 | 23.6 | 81 | 312 |

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka-1207

**Appendix III. Characteristics of the soil of experimental field**

**A. Morphological characteristics of the experimental field**

| Morphological features | Characteristics |
|---|---|
| Location | Research Farm, SAU, Dhaka |
| AEZ | Madhupur Tract (28) |
| General Soil Type | Shallow red brown terrace soil |
| Land type | High land |
| Soil series | Tejgaon |
| Topography | Fairly leveled |

**B. Physical and chemical properties of the initial soil**

| Characteristics | Value |
|---|---|
| % Sand | 27 |
| % Silt | 43 |
| % clay | 30 |
| Textural class | Silty-clay |
| pH | 5.7 |
| Organic matter (%) | 1.13 |
| Total N (%) | 0.03 |
| Available P (ppm) | 20.00 |
| Exchangeable K (me/100 g soil) | 0.10 |
| Available S (ppm) | 23 |

**Source:** Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

**Appendix IV. Analysis of variance of the data on rice yellow stem borer (dead heart) infestation by number as influenced by some promising chemical insecticides**

| Source of variations | Degrees of freedom | Mean square | | | |
|---|---|---|---|---|---|
| | | Dead heart/plot by number at different days after transplanting (DAT) | | | |
| | | 40 DAT | 47 DAT | 54 DAT | 61 DAT |
| Replication | 2 | 0.129 | 0.089 | 0.045 | 0.034 |
| Treatment | 6 | 3.479** | 1.895** | 0.894** | 0.756** |
| Error | 12 | 0.558 | 0.376 | 0.073 | 0.049 |

**: Significant at 0.01 level of probability

**Appendix V. Analysis of variance of the data on rice yellow stem borer (white head) infestation by number as influenced by some promising chemical insecticides**

| Source of variations | Degrees of freedom | Mean square | | | |
|---|---|---|---|---|---|
| | | White head/plot by number at different days after transplanting (DAT) | | | |
| | | 92 DAT | 99 DAT | 106 DAT | 113 DAT |
| Replication | 2 | 0.178 | 0.078 | 0.145 | 0.345 |
| Treatment | 6 | 2.089** | 1.957** | 2.067** | 3.198** |
| Error | 12 | 0.322 | 0.239 | 0.479 | 0.773 |

**: Significant at 0.01 level of probability

**Appendix VI. Analysis of variance of the data on rice hispa (RH) incidence at the vegetative stage of rice as influenced by some promising chemical insecticides**

| Source of variations | Degrees of freedom | Mean square | | | |
|---|---|---|---|---|---|
| | | Rice Hispa (RH) incidence at the vegetative stage | | | |
| | | 40 DAT | 47 DAT | 54 DAT | 61 DAT |
| Replication | 2 | 0.012 | 0.026 | 0.675 | 0.398 |
| Treatment | 6 | 0.678** | 0.913** | 11.198** | 7.894** |
| Error | 12 | 0.029 | 0.071 | 3.012 | 2.498 |

**: Significant at 0.01 level of probability

**Appendix VII. Analysis of variance of the data on rice hispa (RH) incidence at the reproductive stage of rice as influenced by some promising chemical insecticides**

| Source of variations | Degrees of freedom | Mean square | | | |
|---|---|---|---|---|---|
| | | Rice Hispa (RH) incidence at the reproductive stage | | | |
| | | 92 DAT | 99 DAT | 106 DAT | 113 DAT |
| Replication | 2 | 0.012 | 0.165 | 0.138 | 0.209 |
| Treatment | 6 | 1.067** | 1.904** | 2.098** | 3.234** |
| Error | 12 | 0.138 | 0.231 | 0.231 | 0.600 |

**: Significant at 0.01 level of probability

**Appendix VIII. Analysis of variance of the data on number basis filled and unfilled grains of rice as influenced by some promising chemical insecticides**

| Source of variations | Degrees of freedom | Mean square | | | |
|---|---|---|---|---|---|
| | | Filled grains/panicle | | Unfilled grains/panicle | |
| | | Number | % of total grains | Number | % of total grains |
| Replication | 2 | 0.324 | 0.894 | 0.033 | 0.187 |
| Treatment | 6 | 4.098** | 4.078* | 1.678** | 6.034** |
| Error | 12 | 1.442 | 2.641 | 0.105 | 1.282 |

**: Significant at 0.01 level of probability, *: Significant at 0.05 level of probability

**Appendix IX. Analysis of variance of the data on weight basis filled and unfilled grains of rice as influenced by some promising chemical insecticides**

| Source of variations | Degrees of freedom | Mean square | | | |
|---|---|---|---|---|---|
| | | Filled grains/panicle | | Unfilled grains/panicle | |
| | | Weight (g) | % of total grains | Weight (g) | % of total grains |
| Replication | 2 | 0.113 | 0.451 | 0.002 | 0.056 |
| Treatment | 6 | 2.451** | 3.189* | 0.567* | 1.903** |
| Error | 12 | 0.264 | 1.705 | 0.010 | 0.197 |

**: Significant at 0.01 level of probability, *: Significant at 0.05 level of probability

**Appendix X. Analysis of variance of the data on panicle length, 1000 seeds weight and yield of rice as influenced by some promising chemical insecticides**

| Source of variations | Degrees of freedom | Mean square | | |
|---|---|---|---|---|
| | | Panicle length (cm) | Weight of 1000-seeds (g) | Yield/hectare (ton) |
| Replication | 2 | 0.067 | 0.056 | 0.011 |
| Treatment | 6 | 1.189* | 0.834* | 0.894** |
| Error | 12 | 0.307 | 0.214 | 0.116 |

**: Significant at 0.01 level of probability, *: Significant at 0.05 level of probability