EFFICACY OF SOME MANAGEMENT PRACTICES AGAINST INSECT PESTS COMPLEX OF BRRI dhan50

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CERTIFICATE

This is to certify that the thesis entitled **'Efficacy of Some Management Practices against Insect Pests Complex of BRRI dhan50'** 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 **Karma Mahato**, Registration number: **09-03396** 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.

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DEDICATED

TO

MY BELOVED PARENTS

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ABSTRACT

The experiment was conducted in the experimental area of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November 2014 to May 2015 to evaluate the efficacy of some management practices against insect pest complex of BRRI dha50. BRRI dhan50 were used as the test crop in this experiment. The experiment comprised of the following control measure as treatment- T_1 = Spraying Diazinon 60EC @ 2ml/Litre of water sprayed at 7 days interval; T_2 = Spraying Suntap 50 WP @ 1.2g/Litre of water at 7 days interval; T_3 = Applying Mechanical control at 7 days interval; T_4 = Applying Cultural control at 7 days interval and T_5 = Untreated control. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Data was recorded on pest incidence, number of healthy, infested plants & leaf for different pests and infestation level and also yield contributing characters and yield of BRRI dhan50 and significant variations was observed for different treatments. Data revealed that 8 common species of insect pests were found in rice field and they were belongs to 7 family under 6 orders. Among the insect species 2 species belong to the family Pyralidae. Insect population for 5 selected hills/plot were observed with clean observation and in the experimental plot yellow stem borer, leaf folder, rice hispa, grasshopper, brown plant hopper, green leaf hopper, rice bug and rice stink bug was observed and the highest number of the insect pests was recorded from T_5, whereas the lowest number of these insect pests was observed from T_2 treatment. In case of tillers, leaf and panicle infestation in different crop stages caused by different rice insect pests, the lowest infestation was recorded from T_2, whereas the highest infestation was observed from T_5. In consideration of yield contributing characters and yield of BRRI dhan50, the maximum number of filled grains (93.74) was recorded from T_2, while the minimum number of filled grains/panicle (84.77) from T_5. The highest grain yield (5.67 t/ha) was recorded from T_2, while the lowest grain yield (3.35 t/ha) from T_5. Among the different control measures, spraying Suntap 50 WP @ 1.2g/ Litre of water at 7 days interval was the better for the controlling of insect pest complex of BRRI dha50.

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CHAPTER I

INTRODUCTION

Rice (*Oryza sativa*) is the most important food crop around the world and the staple food for approximately more than two billion people in the Asia (Hien *et al.*, 2006). Ninety percent of all rice is grown and consumed in Asia (Anon., 1997, Luh, 1991). The population of Bangladesh is increasing at an alarming rate and the cultivable land is reducing due to urbanization and industrialization resulting in shortage of food. The nation adding about 2.3 million every year to its total of 150 million people (Momin and Husain, 2009). Thus, the present population will swell progressively to 223 million by the year 2030 which will require additional 48 million tons of food grains (Julfiquar *et al*., 2008). Population growth demands a continuous increase in rice production. So, the highest priority has been given to produce more rice in Bangladesh (Bhuiyan, 2004). Rice production has to be increased at least 60% to meet up food requirement of the increasing population by the year 2020 (Masum, 2009).

In Bangladesh, the geographical, climatic and edaphic conditions are favorable for year round rice cultivation. 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, 2009). In Bangladesh, rice dominates over all other crops and covers 75% of the total cropped area of which around 79% is occupied by high yielding rice varieties (BBS, 2014). Rice yield can be increased in many ways of them developing new high yielding variety and by adopting proper agronomic management practices to achieve their potential yield. Suitable planting geometry, the most obvious advantage to be the yield increase without any new seeds or chemical and mechanical inputs (Stoop *et al.*, 2002) and that is reported to be from 50% to 200% (Uphoff, 2005; Deichert and Yang, 2002; Wang *et al.*, 2002; Wang *et al.*, 2006).

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 the yield per unit area. For vertical expansion, the use of modern production technologies should be included, use of quality seeds, high yielding and hybrid varieties, optimum age of seedling, optimum number of seedling hill^{-1}, adopting proper plant protection measures, seedling raising techniques, fertilizer management, insect pests management and so on. Among them insect pests complex is the major constraints for the successful rice production. Recently various rice varieties were developed and available as BRRI dhan 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.

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 symptom. Hybrid rice variety found to most susceptible to stem borer and cause yield loss 22.19-27.09% (Rabman *et al.*, 2004). Rice leaf folder or roller is considered another major harmful insect pest of rice. These insects do harm when they are at larvae stage. They do harm by rolling leaf and reducing photosynthesis area. Two species of plant hopper infest rice. These are the brown plant hopper (BPH) and the white backed plant hopper (WBH). High population of plant hoppers cause leaves to initially turn orange-yellow before becoming brown and drying. This condition, called hopper burn, kills the plant. The feeding damage caused by plant hoppers results in the yellowing of the plants. At high population density, crop loss may be 100% (Rahman *et al.*, 2004).

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 pest infestation and increased yield with the highest BCR (Alam *et al.*, 2003 and Rahman *et al.*, 2002). Cultural control is the deliberate manipulation of the environment and cultural practices can be usually employed such as sanitation or destruction of debris, destruction of alternate hosts and volunteer plants, changing dates of planting and harvesting to avoid pest attack, crop rotation to avoid building up of pests, tillage practices, cropping system or intercropping, plant density, trap crops or trap logs, water management, etc. Mechanical control denotes removal of insect pests or infested plant by using mechanical devices i.e. hand picking. Chemical control is generally being advocated for the management of insect pests of rice. Various control strategies have been adopted against rice pests, one common method being the use of synthetic insecticides, which can be environmentally disruptive and can result in the accumulation of residues in the harvested produce and creating health hazards (Chinniah *et al.*, 1998). The use of chemicals led to impose certain well known undesirable side effects including environmental pollution, resurgence, upset, resistance to pesticides, and develop high pesticide residues. On the other hand, non-chemical control plays an important role in evolving an ecologically sound and environmentally acceptable method.

Under the above perspective for the effective control insect pest complex of BRRI dhan50 the present study has been undertaken with fulfilling the following objectives.

- To document the abundance and damage severity of insect pest complex of BRRI dhan50;
- To find out the relationship between incidence of insect pest complex with rice yield and

- To find out the most suitable management practices for the management of insect pests complex of BRRI dhan50.

CHAPTER II

REVIEW OF LITERATURE

Yield and yield contributing characteristics of rice are considerably depended on manipulation of basic ingredients of agriculture. The basic ingredients include varieties of rice, environment, agronomic practices (planting time & density, fertilizer, irrigation etc.), and insect pest management etc. Among the mentioned factors management on insect pest complex in rice are more responsible for the growth and yield of rice. Rice suffers heavy losses every year due to attack of many pests, among those, Yellow stem borer (YSB), leaf roller and brown plant hopper (BPH) is most important. They cause huge damage of grain, leaf, stem and ultimately yield. But research works related to these pests and their management is limited in Bangladesh as well as the World. The research work so far done in Bangladesh and elsewhere is not adequate and conclusive. Nevertheless, some of the important and informative works and research findings related so far been done at home and abroad have been reviewed in this chapter under the following headings-

2.1 Rice stem borer

2.1.1 Species in Bangladesh

The principal lepidopterous borers in the wet rice area were *Tryporyza incertulas* (Walk.), *Chilo suppressalis* (Walk.) and *Sesamia inferes* (Walk.), while *Tryporyza innotata* (Walk.) and *Chilo auricilius* Dudg (Rothschild, 1971).

2.1.2 Systematic Position

Phylum: Arthropoda

Class: Insecta

Order:Lepidoptera

Family:Crambidae

Genus: Scirpophaga

Species: *Scirpophaga incertulas*

2.1.3 Distribution

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. Light trapping was used to determine borer abundance, but the data obtained bore little relation to population trends in the crop as both the species and the sexes were unequally attracted. During the off-season there was evidence of diapause 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

The biology of yellow stem borer, *Scirpophaga incertulas* (Wlk.) showed that eggs were oval, flattened and creamy white in both aerobic and transplanted rice reported by Hugar *et al*. (2010). 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.

A mass rearing system for *Trichogramma* spp. using host eggs killed before parasitization could improve current parasitoid production methods by making the system more efficient reported by Ozder (2002). Parasitism rates of *T. cacaeciae*, *T. evanescens* and *T. brassicae* reared on dead embryos of *E. kuehniella* kept at -20 degrees C during 1, 2 and 3 h were compared. The lowest parasitization rate was obtained on *E. kuehniella* eggs which had been kept at -20 degrees C for 3 h. Parasitization rates were 64, 65.60 and 63.60% for *T. cacaeciae*, *T. evanescens* and *T. brassicae*, respectively, reared on *E. kuehniella* eggs kept at -20 degrees C for 1 h. Subsequent trials focused on fitness of *T. cacaeciae*, *T. evanescens* and *T. brassicae* reared on killed embryos of *E. kuehniella*. Percentage of parasitized eggs and longevity of females were quantified. Exposure of eggs to low temperatures in a freezer reduced fecundity and longevity of females.

Life table parameter studies were conducted by Abd-El-Hafez *et al*. (2001) on four trichogrammatids, namely *Trichogramma embryophagum*, *T. brassicae*, *T. bactrae* and *T. evanescens* to compare their quality when reared on *P. gossypiella* eggs. The average number of progenies per female and female longevity differed significantly between the four parasitoid species. *T. embryophagum* female produced the most progenies (121.3) and survived the longest (5.04 days). On the other hand, *T. bactrae* female produced the lowest number of progenies (42.91) and survived the shortest (3.02 days). Survivorship of the four species was >93% and ranged between 93.76 and 95.25%. Female progeny always dominated the male. The mean generation duration (T) ranged between 10.24 days for *T. bactrae* and 11.52 days for *T. brassicae*, while it averaged 11.18 and 10.91 days for *T. embryophagum* and *T. evanescens*, respectively. Daily intrinsic rate of increase (rm) and finite rate of increase (exp.

rm) ranged between 0.3049-0.3850 and 1.36-1.47 days, respectively. The population of *T. embryophagum*, *T. brassicae*, *T. bactrae* and *T. evanescens* had the capacity to multiply every 1.8, 2.24, 2.12 and 2.17 days, respectively. *T. embryophagum* had good qualities of a parasitoid, including a high net reproductive rate (Ro=74.08 female), a high intrinsic rate of natural increase (rm=0.3850), a high finite rate of increase (exp. rm=1.47 days) and a short population doubling time (1.8 days).

Reznik *et al*. (2001) carried out a laboratory experiments with *T. principium* females that were offered *Sitotroga cerealella* eggs demonstrated that less than half of the ovipositing females started oviposition during the first 2 days of the experiment, whereas the rest of the ovipositing females showed a delay in parasitization ranging from 2 to 10 days after contact with the host. Almost 10% of the wasps refused to parasitize the grain moth eggs over 12 days. The delay in parasitization may be as long as 6-8 days without any significant decrease in the number of mature ovarial eggs, in the number of eggs laid during the first 48 h of oviposition, and in the total lifetime fecundity. This egg retention is responsible for the fact that in spite of a relatively short mean duration of the oviposition period in each individual female (approximately 4 days), host parasitization by a group of simultaneously emerged wasps was almost uniformly distributed over 8-10 days. When induced, the parasitization state (i.e. the tendency to parasitize sequentially offered portions of host eggs) was stable both in the presence of a host and under host deprivation extended up to 8 days.

Grenier *et al*. (2001) reported that the size of *Trichogramma* spp. adults and especially the ovipositor length depends on the species, but is also related to the host species and to the number of parasitoids per host. The length is greater in *T. evanescens* than in *T. pretiosum* itself greater than in *T. exiguum*, but the width is similar in the three species. For *T. evanescens*, the size obtained in Mamestra brassicae host when three or four insects emerged is similar to that obtained in *E. kuehniella* host when singly parasitized. The size of the ovipositor is important because it may influence the possibility of in vitro egg laying in artificial host eggs. A shorter or a narrower ovipositor could cause difficulties in egg-laying into artificial host eggs composed of a membrane of unsuitable thickness.

2.1.5 Nature of damage

Ragini *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%). DSB was least abundant during either season (4.29-7.18%). 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.

Alam (1988) studied the relative abundance and species composition of 3 Lepidopterous stem borers in upland and irrigated rice in Nigeria and they found that the pyralid *Maliarpha separatella* was the predominant species in upland and irrigated rice, followed in upland rice by the Noctuid *Sesamia clamistis* and another pyralid, *Chilo zacconius*, and in irrigated rice by *C. zacconius* and *S. calamistis* the proportion of *M. separatella* was higher in irrigated rice than in upland rice.

2.1.6 Management of stem borer

A field experiment was conducted by Hugar *et al*. (2009) at Shimoga, Karnataka, India, during the kharif season of 2006 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 fodder (61.25 kg/ha) yields, net return (14 729 rupees/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 system 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 (*Cnaphalocrocis medinalis*) and stem borer (*Tryporyza incertulas* [*Scirpophaga incertulas*]) 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.

Rice stem borers, *S. incertulas*, *Scirpophaga innotata and Sesamia inferens* pose a serious threat to scented rice in Haryana, India reported by Roshan (2006) when 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. The cost:beneltt ratio was the highest in monocrotophos (1:8.68), followed by cartap hydrochloride at 0.75 kg a.i./ha broadcasted at 30 and 50 DAT (1:7.64), but the lowest in cartap hydrochloride at 1.0 and 0.75 kg a.i./ha applied at 50 and 70 DAT (1:2.80).

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 relationship among yellow stem borer (YSB; *Scirpophaga Incertulas*) moth catch in a light trap, egg mass density, and parasitism (by *Telenomus digmus* and *rastichus schoenohil*) was determined by Manju *et al.* (2002) to correlate light trap data with levels of pest eggs in the field and to study whether parasites respond to increased egg density. A light trap was operated from January to December 1999 in a rice field in Tamil Nadu, India. Moth catch was positively correlated with the abundance of egg masses and parasitism levels in the field while egg population was positively correlated with parasitism. However the relationship was significant only between moth catch and parasitism.

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 (tones/ha)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 percentage of parasitism of stem borer egg mass was 56.7% in the mass trapping treatment, while no parasitism was observed for the farmers' practice. In both years, cost benefit ratios were higher with mass trapping than with farmers' practice.

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. 1./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 earheads/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). The greatest cost benefit ratio was found after acephate treatment (1:7.73) followed by triazophos (1:4.99) and buprofezin (1:4.71).

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-transpianting 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 mating disruption using the natural ratio of pheromone components, a 1:3 blend of (Z)-9- and (Z)-11-

hexadecenal, in replicated trials by Cork *et al*. (1998) at three locations in Andhra Pradesh, India, during the 1994 and 1995 dry seasons. 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 *S. incertulas* (Lepidoptera:Pyralidae) 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. The rice varieties TKM6, 1R22, 1R60, 1R66 and 1R74 were infested at 7, 10, 12 and 16 weeks after the addition of 5, 10, 20 and 40 neonates of *S. incertulas*. 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 Leaf roller

The rice leaf folder, *Cnaphalocrocis medinalis* Guenée (Lepidoptera: Pyralidae) is a predominant foliage feeder in all the rice ecosystems.

2.2.1 Systematic position

Kingdom: Animalia
Phylum: Arthropoda
Class: Insecta
Order: Lepidoptera
Family: Crambidae
Genus: Cnaphalocrocis
Species: *C. medinalis*

2.2.2 Distribution of leaf roller

Biswas and Islam (2012) observed that morphologically the full-grown larvae of leaf roller are light green in colour and 10-15 mm in length and 3-4 mm in breadth. Usually one larva can be found in none folded leaf. But sometimes 2-3 larvae are also observed within the same folded leaf. Leaf roller has six larval instars and the entire larval period of 12-15 days and the pupal period are spent within the folded leaves.

Kaushik (2010) observed that the rice leaf folder, *Cnaphalocrocis medinalis* Guenée (Lepidoptera: Pyralidae), is the most widely distributed and commonly found foliage feeder in all the rice growing tracts of Southeast Asia. An increase in *C. medinalis* population could be attributed to the large scale cultivation of high yielding varieties, application of fertilizers, and continuous use of insecticides leading to outbreak of this pest in several countries, including India.

Biswas (2008) observed that the leaf roller *Cnaphalocrocis medinalis* Guenée has appeared as the most damaging pest in recent years.

Tobin *et al*. (2003) observed that eggs are jelly-like, transparent, and ovoid with irregular upper surfaces. It is ventrally flattened. Eggs are laid singly or in groups of 3 to 8 along the mid rib of young leaves. A female lays about 135 to 175 eggs. Hatching occurs in about 5 days.

Chang and Wu (1988) observed that pupation occurs mostly at the base of the plant and a single leaf was folded for pupation. Pupal period range from 6 to 9 days. Godase and Dumbre (1982) observed that larva turns pinkish white just before pupation. *C. medinalis* completes its larval development in 14 to 18 days after passing through five instars.

2.2.3 Nature of Damage

The destructive stage of this insect is the larval stage. At this stage they fold the leaves longitudinally before feeding. They tie the leaf margins with the threadlike silk. They feed the green mesophyll of leaf inside the folded leaf. They feed by scraping. At first and second instar larvae feed within the slightly folded areas of leaf. At late second instar feed and roll up the maximum area of a leaf. There is one larva in one leaf. After feeding one leaf, larva moves to another leaf. In this way one larva can damage a number of leaves. Feeding reduces the photosynthesis area of leaves and vegetative growth and finally yield is hampered. Yield loss is maximum when flag leaf is damaged.

Bhanu and Reddy (2008) reported that the leaf folder affected the crop adversely under favourable conditions causing 60% loss in India. The synthetic chemical pesticides have been the widely used approach to reduce the estimated 45% gross crop uninhibited use of them has necessitated for alternatives mainly for environmental concerns. Therefore, an eco-friendly alternative is the need of the hour. Bio-pesticides or biological pesticides based on pathogenic microorganisms specific to a target pest offer an ecologically sound and effective solution to pest problems. They pose less threat to the environment and to human health.

Biswas *et al*. (2001) observed that the adult moth is creamy yellow to light brown with oblique wavy black lines on both pairs of wings. Females lay about

400 eggs in batches of 10-20 on the young leaves. Hatching out from the eggs in a week, the young larvae feed on the epidermal layer of the leaves. The larvae roll the leaves from tip downwards and then feed inside the young leaves and buds. Damaged leaves have a silvery-brown papery look and are noticeable from a distance.

Hariprasad (1999) reported that the peak population of leaf folder was recorded at higher RH. It was evident that a range of 85-95 per cent RH would be conducive in this coastal region for the rapid buildup of leaf folder population. With this background, present study was conducted to correlate the percentage of infection with the weather parameters.

Murugesan and Chelliah (1987) observed that quantification of the relationship between insect development and temperature is useful to predict the seasonal occurrence and population dynamics of the insects. The ability of an insect to develop at different temperatures is an important adaptation to survive under various climatic conditions (tropical, subtropical, and temperate).So far, there is no published report from India on the effect of constant temperatures on *C. medinalis*.This pest has been reported to attain the major pest status in important paddy growing areas.

2.2.4 Control measures

Sarode *et al*. (1995) observed that the neem products also act as repellent to the insect and thus reduce insect infestation. Dependence of the farmers of Noakhali region solely on the use of chemical insecticides for controlling the pests has posed a number of potential problems that include resistance of the pest, destruction of beneficial organisms and environmental pollution (McIntyre *et al*., 1989). Haque and Islam (1988) observed that botanicals are less toxic, naturally available materials, less expensive, and also safe for beneficial organisms. Neem products containing azadirachtin, salanin and meliontriol have been found to be effective for controlling different insect pests.

2.3 Brown Plant Hopper

The pest, BPH belongs to the plant sucking group of insects called Homoptera. It has been a serious pest of rice in Japan for many years and in Taiwan since 1960.

Until 1970, the insect was only a minor pest in the tropics, but now the BPH has greatly increased in abundance and caused heavy yield losses in many countries. Considering the unpredictable nature of infestations and the severe damage caused, the BPH is regarded as the most serious pest of rice in today's South, South-East Asia and the Fareast (Alam *et al*., 1988).

2.3.1 Systematic position of brown plant hopper

Order: Homoptera

Family: Delphacidae

Genus: Nilaparvata

Species: *Nitaparvata lugens*

2.3.2 Distribution of brown plant hopper

BPH cannot survive the winter in Japan and migrate to Japan each year from the Chinese mainland. Plant hoppers must have the ability to fly continuously for at least 30 and up to 48 hours. The migrations of BPH from the Asian mainland to Japan entail over-water flights of at least 750 km, or if the migrants originate in south-east China, over 1200 km (Holt *et al*., 1996).

The BPH is widely distributed in South, South East and East Asia in the South Pacific Islands and Australia. Earlier reports listed specific countries of incidence. But presently, the insect is distributed in Bangladesh, India, Pakistan, Sri Lanka, Nepal, Cambodia, Vietnam, Thailand, China, Taiwan, Malaysia, Singapore, Indonesia, Philippines, Korea, Hong Kong, Japan, Australia and on many Islands of South East Asia, Micronesia and Melanesia like Caroline and

Mariana Islands, Fiji, Papua New Guinea and Solomon Islands (Alam *et al*., 1988).

The mass immigration of plant hoppers occurs every year during late June to middle July because this timing is the rainy season in Japan and plant hoppers can fly to Japan on the lower jet stream that is formed in a seasonal rain front from main land China to Japan.

2.3.3 Nature of damage

Nath and Bhagabati (2005) reported that the leafhopper population was first appeared in the rice seedbed during June- July, reaching the peak in October - November in the main rice field and disappeared from field from December to May. They also reported that the population of *N. virescens*, the most efficient vector of rice tungro virus disease was low compared *to N. nigropictus*, but more than *Recilia dorsalis*.

Tsueda *et al*. (2002) studied on the occurrence of rice bugs, a total of 22 species, in rice fields. They also observed that *Stenotus rubrovittatus* was the important species and the peak occurrence of it coincided with the date of heading of early -ripening rice. They further reported the populations of bugs and rate of damaged rice was related to the area of heading rice.

Sharivastava *et al.* (2000) found that the major period of activity of both species was September to November with the highest in October. The frequency of peaks in the catches indicated the possibility of the completion of 4 to 5 generations during the kharif season (July to December).

Mallick and Chowdhury (2000) observed the population dynamics of zigzag leafhopper in rice ecosystems. They found that one peak appearance of this insect was from April to May and the second one from October to November. They also reported that *R. dorsalis* was the less efficient vectors of rice tungro virus than *N. virescens* and *N. nigropictus* to some extent; its presence in seed beds was expected to play a vital role on the carryover of the virus.

Reddy *et al*. (1995) stated that both nymphs and adults infest the rice crop at all stages of plant growth. They insett their stylets into plant tissue and suck sap from the phloem cells. Apart from the direct damage, brown plant hopper (BPH) acts as a vector of virus disease in several rice growing countries.

Raddy *et al*. **(**1993) observed that among the insect pests of rice, BPH is one to the most important. It remains at the base of the plant and sucks the phloem sap from the growing plant. Both the nymph and adult infest the rice crop at all stages of plant growth. They insert their stylets into the plant tissue and suck sap from the phloem cells. Apart from the direct damage, BPH also acts as vector of virus diseases in several rice growing countries. As a result of their feeding, the lower leaves start drying from the tips.

Chakraborty *et al*. (1990) studied that the abundance of rice pests at 2 sites in Bihar and Orissa, India. Patterns of relative pest abundance were similar in most years of the study. ‘Ibey also flund that *Nilapurvata lugens* was the most abundant pest at the Orissa site. While *Nephotettix sp*. were the most abundant at the Bihar site. The most abundant natural enemies of rice pests at both sites were *Cyrtorhinus lividipennls* and spiders of the families Lycosidae and Tetragnathidae.

Cook and Perfect (1989) investigated the population dynamics of 3 vectors of rice tungro bacillifrom and spherical viruses, *N. virescens, N. nigropictus and Recilia* d*orsalis* in farmers’ fields. They also reported that *R. dorsalis* was the most abundant vector species on the rice seed beds.

Gupta *et al*. (1989) reported that the pentatomids Nezara viridula and Eusarcoirs yen/ru/is cmised 6.9%-14.8% grain damage during the dry season and 2.3%-8.1% grain damage during the wet season.

Reduced settling on the resistant varieties was attributed to chemical cues, mainly the hydrocarbon and carbonyl containing fractions of the surface wax (Woodhead and Padgham, 1988).

Velusamy (1988) reported that significantly more individual of *N. lugens* were settled on susceptible TNI rice plants than resistant ones.

As a result of feeding both the nymphs and adults at the base of tillers, plants turn yellow and dry up rapidly. At early infestation, round yellow patches appear which soon turn brownish due to the drying up of the plants. This condition is called hopper burn. The patches of infestation then may spread out and cover the entire field (Heinrichs *et al*., 1985).

Misra *et al.* (1985) reported that the seasonal changes in population density of *Nephotettix virescens, N. nigropictus, Nilaparvata lugens, Sogatella furcfera, Recilia dorsalis,* and *Nisia airovenosa,* which are important pests of rice in India during the kharif season.

Heinrichs *et al.* (1985) reported that at early infestation stage of feeding by BPH caused round yellow patches in the field, which soon turned brownish due to the drying up of the plants Thus condition is called "Hopper burn' which may spread out and cover the entire field.

Reissig *et al*. (1985) observed that the BPH removes more plant sap than it can digest. The excess plant sap, which is high in sugar is expelled from the body as honeydew. The honey dew drops fall on the base of plants and in time turn black from infection by a sooty mold fungus.

The green leaf hoppers, *Nephotettix spp*. (Homoptera: Cicadellidae) are most devastating pests of rice throughout the rice growing areas of Asia (Razzaque *et al*. 1985). These have been reported from Bangladesh, Bhutan India, Indonesia, Kampuchca, Malaysia, Nepal, Phillippiiiess, Sri Lanka, Thailand, and Vietnam (Reissing *et al*., 1985). They don’t do only cause direct damage by sucking plant sap and by ovipositing on the leaf sheath but also act as efficient vector of rice tungro virus, one of the most menacing diseases of rice.

Zhang *et al.* (1984) reported that population number of *N. lugens* on the new rice lines viz. Hong-Yuan and Tainuo-Xuan were less than the susceptible variety TN1. Alam *et al.* (1983) reported that the brown plant hopper has become a serious pest of high yielding variety of rice. The leaf hoppers feed on the leaves and supper parts of the rice plant whereas the plant hopper confines themselves to the basal parts. In the warm and humid tropics, different species of leaf hoppers and plant hoppers remain active year round and their population fluctuates according to the availability of food plants, natural enemies end environmental conditions (Heinrichs *et al*., 1982).

Misra (1980) observed that yellowing starts uniformly up to the mid half from the tip of the leaf and the other half remains yellowish green. Then the whole leaf dries up in addition, the BPH blocks the ascent of nutrition by laying numerous egg masses in the midribs of leaf sheath and leaf blade.

2.3.4 Control measures

Watanabe *et al.* (2009) observed that more than 60% of the rice fields in Japan are planted following the application of persistent systemic insecticides to seeds in nursery–box applications. This treatment provides effective control of the first immigrants.

Emmanuel *et al.* (2003) evaluated 65 rice genotypes for their resistance against the white backed plant hopper (*S. furcifera*). The overall assessment in the present study indicated that resistance in rice to WBPH was shown by the combined influence of non-preference, antibiosis and tolerance.

Misra *et al.* (2001) evaluated 27 cultivars for growth performance and pest and disease resistance. Brown plant hopper, *Nilaparvata lugnes* and green leaf hopper, *Nephotettix virescens* were below moderate levels on all cultivars except Suryu- 52, IRRI- 137, MTU- 1001 and Nagarjuna. Yellow stem borer

(*Scirpophaga incertulas*) incidence was low to moderate in Pusa-basmati, IRRI-123. Basmati and Nagarjuna, hut was trace to low in all other cultivars. The occurrence of biological control agents and natural enemies in these cultivars was also recorded.

Quing *et al*. (2000) reported that white-backed plant hopper (*Sogatetta fwqfera*) is becoming a major pest in the rice- cultivating area around Luzhou, Sichuan, China, with the extension of hybrid rice growing in recent years.

White -backed plant hopper, *Sogatella furcfera* which was previously only a minor pest of rice in the Kuttanad region of Kerala, India reached the status of a major pest during the rabi season of 1997-98. The population packed during January 1998 (Ambikadevi *at al*., 1998).

Different scientists conducted research on varietal performances of different rice varieties to different insect pest infestation. Koral *et al.* (1998) evaluated rice cultivars for resistance to insect pests. Mo-1 Co-29 and lET- 10750 were resistant to major insect pests (white backed plant hopper, leaf folder and stem borer) of rice. These cultivars yielded 17.54-17.94% higher grain yields over presently recommended high yielding varieties like Masuri and Narmada Breeders can utilize these promising cultures as donor for developing high yielding and pest resistant variety of rice.

Holt *et al.* (1996) observed that insecticide applications are the main control method against BPH in Japan. Crop breeders have made many attempts to develop resistant varieties. However, resistant-breaker strains of plant hoppers have easily appeared. In Japan, the planthopper’s natural enemies decline to very low densities during the winter. When BPH populations start to grow rapidly, the numbers of predators are insufficient to prevent the increase.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to evaluate the efficacy of some management practices against insect pest complex of BRRI dha50. The details of the materials and methods i.e. location of experiment, soil and climate condition of the experimental plot, materials used, design of the experiment, 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 November 2014 to May 2015.

3.1.2 Site description

The present piece of research work was conducted in the experimental area 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.

3.1.3 Climatic condition

The geographical location of the experimental site was under the subtropical climate and its climatic conditions is characterized by three distinct seasons, namely winter season from the month of November to February, the pre-monsoon period or hot season from the month of March to April and monsoon period from the month of May to October (Edris *et al*., 1979). Details of the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment has been presented in Appendix I.

3.1.4 Soil characteristics of the experimental plot

The soil belonged to “The Modhupur Tract”, AEZ-28 (FAO, 1988). Top soil was Silty Clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and had organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land. The details have been presented in Appendix II.

3.2 Experimental details

3.2.1 Planting material

BRRI dhan50 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 = Spraying Diazinon 60EC @ 2ml/Litre of water sprayed at 7 days interval

T_2 = Spraying Suntap 50 WP @ 1.2g/ Litre of water at 7 days interval

T_3 = Applying Mechanical control method at 7 days interval

T_4 = Applying Cultural control method at 7 days interval

T_5 = 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 5 unit plots as treatments demarked with raised bunds. Thus the total numbers of plots were 15. 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. 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 1st week of January 2015 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.

3.3.4 Fertilizers and manure application

The fertilizers N, P, K, S, Zn and B in the form of USG, 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). Urea was applied as urea super granule (USG). The entire amount of TSP, MP, gypsum, zinc sulphate and borax were applied during the final preparation of land. USG was applied in two equal installments at tillering and panicle initiation stages.

3.3.5 Transplanting of seedling

Twenty five days old seedlings were carefully uprooted from the seedling nursery and transplanted on 16 January, 2015 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. Plant protection measures were followed as and when necessary. 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 05 May, 2015 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 period of rice grain. Fresh weight of rice grain and straw were recorded plot wise from 1 m^2 area. The grains were dried, cleaned and weighed for individual plot and adjusted to a moisture content of

14%. Yields of rice grain and straw 1 m^{-2} were recorded from each plot and converted to t ha^{-1}.

Plate 1. The experimental field (A+B) of the present study at SAU, Dhaka

3.5 Data collection and calculation

The infestation was expressed as percent dead hearts and white ear heads calculated by using the formula as suggested by Shafiq *et al.* (2000).

3.5.1 Infestation level

Five hills were selected at random per replicate for each treatment. The dead hearts and white heads were counted. In case of dead heart, it was counted in tillering, panicle initiation and milking stage and converted into per plant. On the other hand, white head infected tillers was counted at panicle initiation, milking and grain filing stages. The observation was recorded at the first observation of symptom and was continued up to maturity of the grains at 7 days interval.

3.5.1.1 Percent dead heart infestation

Number of dead heart infested tillers will counted at tillering, panicle initiation and milking stage from total tillers per five hills and converted into per plant 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 will counted at panicle initiation, milking stage and grain filing stage from total tillers per five hills and percent whitehead was calculated by using the following formula:

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

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 Panicle length

The length of panicle was measured with a meter scale from 10 selected panicles and the average length was recorded as per panicle in cm.

3.5.2.2 Filled grains panicle^{-1}

The total numbers of filled grain were collected randomly from selected 10 panicle of a plot on the basis of grain in the spikelet and then average numbers of filled grains panicle^{-1} was recorded.

3.5.2.3 Unfilled grains panicle^{-1}

The total numbers of unfilled grain was collected randomly from selected 10 plants of a plot on the basis of not grain in the spikelet and then average numbers of unfilled grains panicle^{-1} was recorded.

3.5.2.4 Weight of 1000-grains

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

3.5.2.5 Grain yield

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of central 1 m^2 area in each plot were taken the final grain yield plot^{-1} and finally converted to ton hectare^{-1} (t ha^{-1}).

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 Least Significant Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to evaluate the efficacy of some management practices against insect pest complex of BRRI dha50. Data was recorded on pest incidence, number of healthy, infested plants & leaf for different pests and infestation level and also yield contributing characters and yield of BRRI dhan50. The analysis of variance (ANOVA) of the data on different parameters has been presented in Appendix III-X. The results have been discussed and presented under the following headings:

4.1 Incidence of insect pest in rice

4.1.1 Species of insect pests

Rice plants compete with numerous insect pests under favorable condition which is the common phenomenon of rice cultivation. Under the present experiment 8 common species of insect pests were found and they were belongs to 7 family under 6 orders. The common name, scientific name, order, family, stages of insects as rice pests and nature of damage are presented in Table 1. Among the recorded insect pests 2 species belong to the family Pyralidae and only 1 species for each of Chrysomelidae, Acrididae, delphacidae, Cicadellidae, coreidae and Pentatomidae family. Most of the insect pests were more destructive in nymphal stage. The nature of the damage of theses insects also presented in Table 1.

4.1.2 Insect population

Insect population for 5 selected hills/plot were observed with clean observation and in the experimental plot yellow stem borer, leaf folder, rice hispa, grasshopper, brown plant hopper, green leaf hopper, rice bug and rice stink bug was counted and recorded (Table 2). For different treatment number of different insect pests varied significantly under the present trial. In Bangladesh, about 175 insect pest species have been reported, which cause damage to the rice plants (Mustafi *et al.*, 2007).

Table 1. List of the insect pests found in the experimental rice field during study period

Sl. No.	Common name	Scientific name	Order	Family	**Stage(g) of insects**	**Nature of damage**
1.	Yellow stem borer	*Scirpophaga incertulas*	Lepidoptera	Pyralidae	Larvae (Caterpillar)	Feeds inside the growing points and rice stem
2.	Leaf folder	*Cnaphalocrocis medinalis*	Lepidoptera	Pyralidae	Larvae (Caterpillar)	Feed leaf surface by scraping inside the leaf folder
3.	Rice hispa	*Dicladispa armigera*	Coleoptera	Chrysomelidae	Adult and Grub	Feed upper surface of leaf by scraping
4.	Grasshopper	*Oxya velox*	Orthoptera	Acrididae	Adult and nymph	Feed the leaf
5.	Brown plant hopper	*Nilaparvata lugens*	Homoptera	Delphacidae	Adult and nymph	Sucking cell sap from the leaf blade and leaves sheath
6.	Green leaf hopper	*Nephotettix virescens*	Homoptera	Cicadellidae	Adult and nymph	Sucking cell sap from the leaf blade and leaves sheath
7.	Rice bug	*Leptocorisa acuta*	Hemiptera	Coreidae	Adult and nymph	Sucking cell sap from the developing rice grain
8.	Rice stink bug	*Eysarcoris ventralis*	Hemiptera	Pentatomidae	Adult and nymph	Sucking cell sap from the tended leaves

Table 2. Incidence of different insect pests by number at different stage in the experimental rice field during study period

Treatment	Number of different insect pests							
	Yellow stem borer	Leaf folder	Rice hispa	Grasshopper	Brown plant hopper	Green leaf hopper	Rice bug	Rice stink bug
T_1	1.11 c	1.56 c	1.07 c	1.92 c	1.22 c	1.90 c	1.35 c	1.45 c
T_2	1.00 c	1.18 c	1.85 c	1.48 c	1.19 c	1.53 c	1.18 c	1.35 c
T_3	2.04 b	5.11 b	6.26 b	7.07 b	7.30 b	5.78 b	4.02 b	5.03 b
T_4	2.15 b	5.41 b	6.37 b	7.07 b	7.48 b	5.80 b	4.24 b	5.20 b
T_5	5.00 a	9.00 a	8.18 a	12.41 a	11.41 a	9.03 a	8.87 a	7.84 a
$LSD_{(0.05)}$	0.205	0.587	0.591	0.584	0.614	0.118	0.413	0.431
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	9.51	11.58	9.65	8.41	8.46	6.76	10.25	8.62

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 selected hills/plot of each 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 = Spraying Diazinon 60EC @ 2ml/Litre of water sprayed at 7 days interval

T_2 = Spraying Suntap 50 WP @ 1.2g/ Litre of water at 7 days interval

T_3 = Applying Mechanical control method at 7 days interval

T_4 = Applying Cultural control method at 7 days interval

T_5 = Untreated control

4.1.2.1 Yellow stem borer

In case of yellow stem borer, the highest number (5.00) of yellow stem borer was recorded from T_5 (untreated control), whereas the lowest number (1.00) was observed from T_2 (Spraying Suntap 50 WP @ 1.2g/ Litre of water at 7 days interval) which was statistically similar (1.11) to T_1 (Spraying Diazinon 60EC @ 2ml/Litre of water sprayed at 7 days interval) and closely followed (2.04 and 2.15) by T_3 (Applying Mechanical control method at 7 days interval) and T_4 (Applying Cultural control method at 7 days interval), respectively and they were statistically similar. Ragini *et al.* (2005) reported that yellow stem borer (YSB) infestation was predominant from early tillering to maximum tillering stage. Rao and Israel (2004) reported that rice stem borers are generally considered as the most serious of pest of rice and 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.

4.1.2.2 Leaf folder

In consideration of leaf folder, the highest number (9.00) of leaf folder was recorded from T_5, which was followed (5.41 and 5.11) to T_4 and T_3 and they were statistically similar, while the lowest number (1.18) was observed from T_2 which was statistically similar (1.56) to T_1. Kaushik (2010) observed that the rice leaf folder, *Cnaphalocrocis medinalis* Guenée (Lepidoptera: Pyralidae), is the most widely distributed and commonly found foliage feeder in all the rice growing tracts of Southeast Asia.

4.1.2.3 Rice hispa

For rice hispa, the highest number (8.18) was recorded from T_5, which was followed (6.37 and 6.26) to T_4 and T_3 and they were statistically similar, while the lowest number (1.07) was observed from T_1 which was statistically similar (1.85) to T_2.

4.1.2.4 Grasshopper

The highest number of grasshopper (12.41) was recorded from T_5, which was followed (7.07) by T_4 and T_3 and they were statistically similar, while the lowest number of grasshopper under the present trial (1.48) was found from T_1 which was statistically similar (1.92) to T_2.

4.1.2.5 Brown plant hopper

In consideration of brown plant hopper, the highest number (11.41) of brown plant hoper was recorded from T_5, which was followed (7.48 and 7.30) to T_4 and T_3 and they were statistically similar, whereas the lowest number of brown plant hopper (1.19) was observed from T_2 which was statistically similar (1.22) to T_1. Alam *et al*. (1988) reported that Considering the unpredictable nature of infestations and the severe damage caused, the BPH is regarded as the most serious pest of rice in today's South, South-East Asia and the Fareast.

4.1.2.6 Green leaf hopper

In case of green leaf hopper, the highest number (9.03) of green leaf hopper was recorded from T_5, which was followed (5.80 and 5.78) to T_4 and T_3 and they were statistically similar, whereas the lowest number of green leaf hopper (1.53) was observed from T_2 which was statistically similar (1.90) to T_1.

4.1.2.7 Rice bug

For rice bug, the highest number (8.87) was recorded from T_5, which was followed (4.24 and 4.02) to T_4 and T_3 and they were statistically similar, while the lowest number of rice bug (1.18) was observed from T_1 which was statistically similar (1.35) to T_2.

4.1.2.8 Rice stink bug

Under the present trial, the highest number of rice stink bug (7.84) was recorded from T_5, which was followed (5.20 and 5.03) by T_4 and T_3 and they were statistically similar, while the lowest number of rice stink bug (1.35) was found from T_1 which was statistically similar (1.45) to T_2.

4.2 Infestation by different insect pests in different stages

4.2.1 Dead heart infestation

Statistically significant variation was recorded for dead heart infestation caused by yellow stem borer at vegetative stages (Table 3). Data recorded from 5 selected hills/plot revealed that the highest number of healthy tillers (52.60) was recorded from T_2 which was closely followed (50.80) by T_1, while the lowest number of healthy tillers (45.20) was observed from T_5 which was followed (48.40 and 49.20) by T_4 and T_3, respectively and they were statistically similar. In case of infested tillers, the lowest number (0.60) was found from T_2 which was statistically similar (0.80) to T_1 and followed (1.80) by T_3, while the highest number of infested tillers (4.80) from T_5 which was followed (2.80) by T_4. This symptom of stem borer called dead heart symptom. For infestation level the lowest infestation (1.13%) was recorded from T_2 which was statistically similar (1.55%) to T_1 and followed (3.53%) by T_3, whereas the highest infestation (9.60%) was observed from T_5 which was closely followed (5.47%) by T_4. In case of reduction over control the highest value (88.25) was recorded from T_2 and the lowest value (43.03) was recorded from T_4 treatment. Hybrid rice variety found to most susceptible to stem borer and cause yield loss 22.19-27.09% (Rabman *et al.*, 2004).

4.2.2 White head infestation

White head infestation of rice due to yellow stem borer varied significantly at the entire reproductive stages when (Table 4). It was revealed that the highest number of healthy tillers (52.40) was recorded from T_2 which was closely followed (50.40) by T_1. On the other hand, the lowest number of healthy tillers (45.20) was observed from T_5 which was followed (48.60 and 49.20) by T_4 and T_3, respectively and they were statistically identical. In case of infested tillers, the lowest number (0.60) was found from T_2 which was statistically similar (0.80) to T_1 and followed (2.20 and 2.40) by T_3 and T_4 and they were statistically similar, whereas the highest number of infested tillers (4.60) was recorded from T_5. For infestation level the lowest infestation (1.20%) was recorded from T_2

Table 3. Efficiency of some management practices against rice yellow stem borer (dead heart) infestation of BRRI dhan50 throughout the vegetative stage

Treatment	Healthy tillers (No.)	Infested tillers (No.)	% infestation	Increase/decrease over control
T_1	50.80 b	0.80 d	1.55 d	83.85
T_2	52.60 a	0.60 d	1.13 d	88.25
T_3	49.20 c	1.80 c	3.53 c	63.24
T_4	48.40 c	2.80 b	5.47 b	43.03
T_5	45.20 d	4.80 a	9.60 a	0.00
$LSD_{(0.05)}$	0.921	0.367	0.582	--
Level of significance	0.05	0.01	0.01	--
CV(%)	7.46	4.78	6.09	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 selected hills/plot of each 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 = Spraying Diazinon 60EC @ 2ml/Litre of water sprayed at 7 days interval

T_2 = Spraying Suntap 50 WP @ 1.2g/ Litre of water at 7 days interval

T_3 = Applying Mechanical control method at 7 days interval

T_4 = Applying Cultural control method at 7 days interval

T_5 = Untreated control

Table 4. Efficiency of some management practices against on rice yellow stem borer (white head infestation) at the reproductive stage of BRRI dhan50

Treatment	Healthy tillers (No.)	Infested tillers (No.)	% infestation	Increase/decrease over control
T_1	50.40 b	0.80 c	1.65 c	82.46
T_2	52.40 a	0.60 c	1.20 c	87.27
T_3	49.20 c	2.20 b	4.38 b	53.51
T_4	48.80 c	2.40 b	4.78 b	49.28
T_5	45.60 d	4.60 a	9.43 a	0.00
$LSD_{(0.05)}$	0.518	0.391	0.733	--
Level of significance	0.05	0.01	0.01	--
CV(%)	8.98	5.04	6.77	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 selected hills/plot of each 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 = Spraying Diazinon 60EC @ 2ml/Litre of water sprayed at 7 days interval

T_2 = Spraying Suntap 50 WP @ 1.2g/ Litre of water at 7 days interval

T_3 = Applying Mechanical control method at 7 days interval

T_4 = Applying Cultural control method at 7 days interval

T_5 = Untreated control

Plate 2. The rice plants showing dead heart symptom in the experimental field

Plate 3. The rice plants showing white head symptom in the experimental field

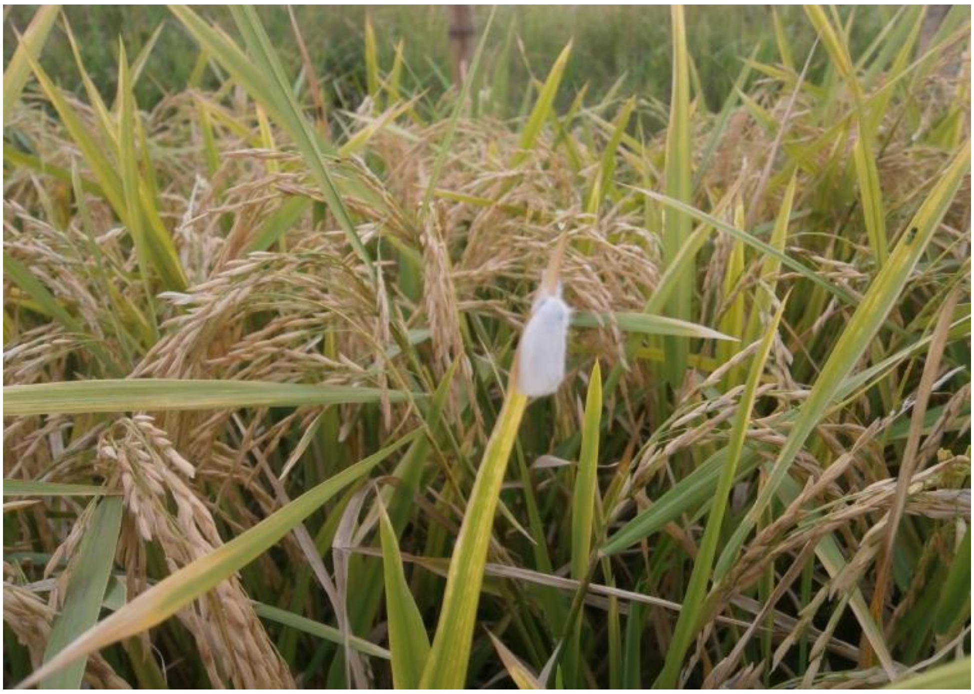

Plate 4. Photograph showing adult yellow stem borer in the rice plants of the experimental field

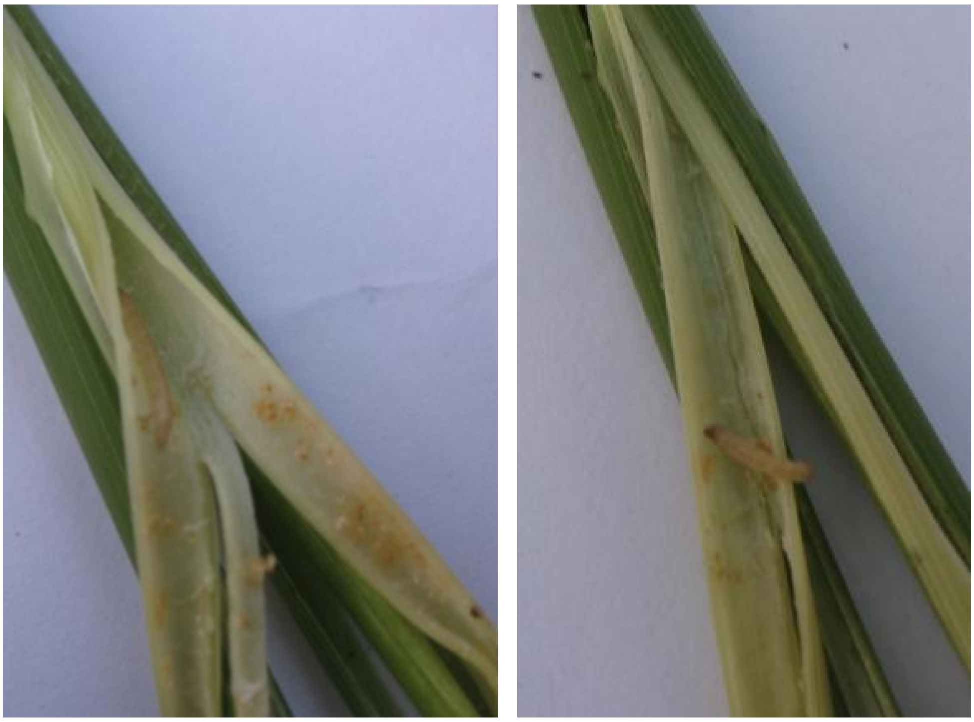

Plate 5. Infested rice sheath with caterpillar of due to white head symptom causes by yellow stem borer

which was statistically similar (1.65%) to T_1 and followed (4.38% and 4.78%) by T_3 and T_4 and they were statistically similar, whereas the highest infestation (9.43%) was observed from T_5. In consideration of reduction over control the highest value (87.27) was recorded from T_2 and the lowest value (49.28) was recorded from T_4 treatment.

4.2.3 Leaf infestation by leaf folder

Leaf infestation of rice caused by leaf folder showed statistically significant variation (Table 5). The highest number of healthy leaves (517.80) was recorded from T_2 which was statistically similar (512.40) to T_1 and closely followed (498.60) by T_3, whereas the lowest number of healthy leaves (476.20) was observed from T_5 which was followed (488.80) by T_4. In case of infested leaves, the lowest number (5.40) was found from T_2 which was statistically similar (8.20) to T_1 and followed (14.20 and 18.60) by T_3 and T_4 and they were statistically similar, whereas the highest number of infested leaves (32.80) was recorded from T_5. For infestation level the lowest leaf infestation (1.03%) was recorded from T_2 which was statistically similar (1.58%) to T_1 and followed (2.77% and 3.67%) by T_3 and T_4 and they were statistically similar, whereas the highest leaf infestation (6.44%) was observed from T_5. In consideration of reduction over control the highest value (83.98) was recorded from T_2 and the lowest value (43.11) was recorded from T_4 treatment.

4.2.4 Leaf infestation by rice hispa

Leaf infestation of rice caused by rice hispa showed statistically significant variation (Table 6). The highest number of healthy leaves (512.20) was recorded from T_2 which was statistically similar (507.80) to T_1 and closely followed (488.40) by T_3, whereas the lowest number of healthy leaves (465.20) was observed from T_5 which was followed (476.60) by T_4. In case of infested leaves, the lowest number (12.40) was found from T_2 which was followed (17.80) by T_1, while the highest number of infested leaves (58.20) was recorded from T_5 which was followed (38.50) by T_4. For infestation level the lowest leaf infestation (2.36%) was recorded from T_2 which was statistically similar (3.39%) to T_1 and

Table 5. Efficiency of some management practices against leaf infestation of BRRI dhan50 caused by leaf folder

Treatment	Healthy leaf (No.)	Infested leaf (No.)	% infestation	Increase/decrease over control
T_1	512.40 a	8.20 c	1.58 c	75.56
T_2	517.80 a	5.40 c	1.03 c	83.98
T_3	498.60 b	14.20 b	2.77 b	57.03
T_4	488.80 c	18.60 b	3.67 b	43.11
T_5	476.20 d	32.80 a	6.44 a	0.00
$LSD_{(0.05)}$	6.198	5.056	1.014	--
Level of significance	0.05	0.01	0.01	--
CV(%)	4.98	6.22	4.67	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 selected hills/plot of each 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 = Spraying Diazinon 60EC @ 2ml/Litre of water sprayed at 7 days interval

T_2 = Spraying Suntap 50 WP @ 1.2g/ Litre of water at 7 days interval

T_3 = Applying Mechanical control method at 7 days interval

T_4 = Applying Cultural control method at 7 days interval

T_5 = Untreated control

Table 6. Efficiency of some management practices against leaf infestation of BRRI dhan50 caused by rice hispa

Treatment	Healthy leaf (No.)	Infested leaf (No.)	% infestation	Increase/decrease over control
T_1	507.80 a	17.80 d	3.39 c	69.54
T_2	512.20 a	12.40 e	2.36 c	78.74
T_3	488.40 b	31.60 c	6.08 b	45.35
T_4	476.60 c	38.50 b	7.47 b	32.78
T_5	465.20 d	58.20 a	11.12 a	0.00
$LSD_{(0.05)}$	5.491	4.091	1.781	--
Level of significance	0.01	0.01	0.01	--
CV(%)	3.78	5.44	6.09	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 selected hills/plot of each 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 = Spraying Diazinon 60EC @ 2ml/Litre of water sprayed at 7 days interval

T_2 = Spraying Suntap 50 WP @ 1.2g/ Litre of water at 7 days interval

T_3 = Applying Mechanical control method at 7 days interval

T_4 = Applying Cultural control method at 7 days interval

T_5 = Untreated control

followed (6.08% and 7.47%) by T_3 and T_4 and they were statistically similar, whereas the highest leaf infestation (11.12%) was observed from T_5. In consideration of reduction over control the highest value (78.74) was recorded from T_2 and the lowest value (32.78) was recorded from T_4 treatment.

4.2.5 Leaf infestation by grasshopper

Leaf infestation of rice caused by grasshopper showed statistically significant variation (Table 7). The highest number of healthy leaves (502.60) was recorded from T_2 which was statistically similar (498.40) to T_1 and closely followed (474.80) by T_3, whereas the lowest number of healthy leaves (456.20) was observed from T_5 which was followed (465.80) by T_4. In case of infested leaves, the lowest number (16.40) was found from T_2 which was followed (22.60) by T_1, while the highest number of infested leaves (66.40) was recorded from T_5. For infestation level the lowest leaf infestation (3.16%) was recorded from T_2 which was statistically similar (4.34%) to T_1 and followed (7.37% and 8.59%) by T_3 and T_4 and they were statistically similar, whereas the highest leaf infestation (12.71%) from T_5. In consideration of reduction over control the highest value (75.13) was recorded from T_2 and the lowest value (32.35) from T_4 treatment.

4.2.6 Tiller infestation by brown plant hopper

Tillers infestation of rice caused by brown plant hopper varied significantly (Table 8). It was revealed that the highest number of healthy tillers (49.40) was recorded from T_2 which was statistically similar with the other treatment except T_5 and the lowest number of healthy tillers (44.20) was observed from T_5. In case of infested tillers, the lowest number (1.40) was found from T_2 which was statistically similar (1.80) to T_1 and followed (3.40 and 4.60) by T_3 and T_4 and they were statistically similar, whereas the highest number of infested tillers (6.80) was recorded from T_5. For infestation level the lowest infestation (2.76%) was recorded from T_2 which was statistically similar (3.64%) to T_1 and followed (6.61% and 8.78%) by T_3 and T_4, whereas the highest infestation (13.33%) was observed from T_5. In consideration of reduction over control the highest value (79.33) was recorded from T_2 and the lowest value (34.16) from T_4 treatment.

Table 7. Efficiency of some management practices against leaf infestation of BRRI dhan50 caused by grasshopper

Treatment	Healthy leaf (No.)	Infested leaf (No.)	% infestation	Increase/decrease over control
T_1	498.40 a	22.60 d	4.34 c	65.86
T_2	502.60 a	16.40 e	3.16 c	75.13
T_3	474.80 b	37.80 c	7.37 b	41.96
T_4	465.80 c	43.80 b	8.59 b	32.35
T_5	456.20 d	66.40 a	12.71 a	0.00
$LSD_{(0.05)}$	4.891	3.901	1.681	--
Level of significance	0.05	0.01	0.01	--
CV(%)	6.98	4.37	5.86	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 selected hills/plot of each 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 = Spraying Diazinon 60EC @ 2ml/Litre of water sprayed at 7 days interval

T_2 = Spraying Suntap 50 WP @ 1.2g/ Litre of water at 7 days interval

T_3 = Applying Mechanical control method at 7 days interval

T_4 = Applying Cultural control method at 7 days interval

T_5 = Untreated control

Plate 6. Grass hopper infested rice leaf blade of the experimental field

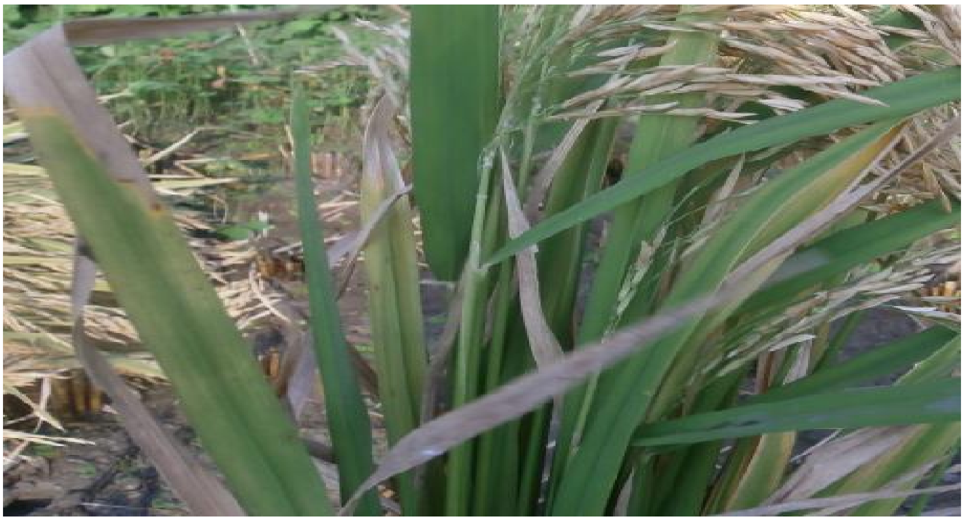

Plate 7. The rice plants showing hopper burn symptom due to Brown plant hopper

Plate 8. The rice plants showing white streak symptom due to scraping of rice leaf blade by Rice hispa

Table 8. Efficiency of some management practices against tillers infestation of BRRI dhan50 caused by brown plant hopper (BPH)

Treatment	Healthy tiller (No.)	Infested tiller (No.)	% infestation	Increase/decrease over control
T_1	47.60 a	1.80 c	3.64 c	72.67
T_2	49.40 a	1.40 c	2.76 c	79.33
T_3	48.00 a	3.40 b	6.61 b	50.39
T_4	47.80 a	4.60 b	8.78 b	34.16
T_5	44.20 b	6.80 a	13.33 a	0.00
$LSD_{(0.05)}$	2.571	1.236	2.381	--
Level of significance	0.05	0.01	0.01	--
CV(%)	8.99	5.48	5.89	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 selected hills/plot of each 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 = Spraying Diazinon 60EC @ 2ml/Litre of water sprayed at 7 days interval

T_2 = Spraying Suntap 50 WP @ 1.2g/ Litre of water at 7 days interval

T_3 = Applying Mechanical control method at 7 days interval

T_4 = Applying Cultural control method at 7 days interval

T_5 = Untreated control

4.2.7 Leaf infestation by green leaf hopper

Leaf infestation of rice caused by green leaf hopper showed statistically significant variation (Table 9). The highest number of healthy leaves (572.60) was recorded from T_2 which followed (469.20) to T_1, whereas the lowest number of healthy leaves (430.80) was observed from T_5 which was followed (448.20) by T_4. In case of infested leaves, the lowest number (19.20) was found from T_2 which was followed (32.60) by T_1, while the highest number of infested leaves (83.20) was recorded from T_5 which was followed (61.20) by T_4. For infestation level the lowest leaf infestation (3.24%) was recorded from T_2 which was statistically similar (6.50%) to T_1 and followed (10.60% and 12.01%) by T_3 and T_4 and they were statistically similar, whereas the highest leaf infestation (16.19%) was observed from T_5. In consideration of reduction over control the highest value (79.96) was recorded from T_2 and the lowest value (25.78) was recorded from T_4 treatment.

4.2.8 Tiller infestation by rice bug

Tillers infestation of rice caused by rice bug varied significantly (Table 10). It was revealed that the highest number of healthy tillers (51.87) was recorded from T_2 which was statistically similar with the other treatment except T_5 and the lowest number of healthy tillers (45.20) was observed from T_5. In case of infested tillers, the lowest number (1.60) was found from T_2 which was statistically similar (2.00) to T_1 and followed (3.80 and 5.20) by T_3 and T_4 and they were statistically similar, whereas the highest number of infested tillers (7.60) was recorded from T_5. For infestation level the lowest infestation (2.99%) was recorded from T_2 which was statistically similar (3.81%) to T_1 and followed (7.18% and 9.60%) by T_3 and T_4 and they were statistically similar, whereas the highest infestation (14.37%) was observed from T_5. In consideration of reduction over control the highest value (79.24) was recorded from T_2 and the lowest value (33.26) was recorded from T_4 treatment.

Table 9. Efficiency of some management practices against leaf infestation of BRRI dhan50 caused by green leaf hopper

	Healthy leaf (No.)	Infested leaf (No.)	% infestation	Increase/decrease over control
T_1	469.20 b	32.60 d	6.50 c	59.86
T_2	572.60 a	19.20 e	3.24 d	79.96
T_3	458.80 c	54.40 c	10.60 b	34.51
T_4	448.20 d	61.20 b	12.01 b	25.78
T_5	430.80 e	83.20 a	16.19 a	0.00
$LSD_{(0.05)}$	4.091	7.091	2.781	--
Level of significance	0.05	0.01	0.01	--
CV(%)	4.34	6.09	5.55	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 selected hills/plot of each 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 = Spraying Diazinon 60EC @ 2ml/Litre of water sprayed at 7 days interval

T_2 = Spraying Suntap 50 WP @ 1.2g/ Litre of water at 7 days interval

T_3 = Applying Mechanical control method at 7 days interval

T_4 = Applying Cultural control method at 7 days interval

T_5 = Untreated control

Table 10. Efficiency of some management practices against panicle infestation of BRRI dhan50 caused by rice bug

Treatment	Healthy panicle (No.)	Infested panicle (No.)	% infestation	Increase/decrease over control
T_1	50.40 a	2.00 d	3.81 c	73.47
T_2	51.87 a	1.60 d	2.99 c	79.24
T_3	49.07 a	3.80 c	7.18 b	50.09
T_4	48.87 ab	5.20 b	9.60 b	33.26
T_5	45.20 b	7.60 a	14.37 a	0.00
$LSD_{(0.05)}$	3.124	1.023	2.561	--
Level of significance	0.05	0.01	0.01	--
CV(%)	6.09	3.55	7.06	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 selected hills/plot of each 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 = Spraying Diazinon 60EC @ 2ml/Litre of water sprayed at 7 days interval

T_2 = Spraying Suntap 50 WP @ 1.2g/ Litre of water at 7 days interval

T_3 = Applying Mechanical control method at 7 days interval

T_4 = Applying Cultural control method at 7 days interval

T_5 = Untreated control

4.2.9 Tiller infestation by rice stink bug

Tillers infestation of rice caused by rice stink bug varied significantly (Table 11). It was revealed that the highest number of healthy tillers (48.60) was recorded from T_2 which was statistically similar with the other treatment except T_5 and the lowest number of healthy tillers (43.00) was observed from T_5. In case of infested tillers, the lowest number (1.80) was found from T_2 which was statistically similar (2.40) to T_1 and followed (4.40 and 5.40) by T_3 and T_4 and they were statistically similar, whereas the highest number of infested tillers (7.60) was recorded from T_5. For infestation level the lowest infestation (3.57%) was recorded from T_2 which was statistically similar (4.94%) to T_1 and followed (8.53% and 10.42%) by T_3 and T_4 and they were statistically similar, whereas the highest infestation (15.02%) was observed from T_5. In consideration of reduction over control the highest value (76.22) was recorded from T_2 and the lowest value (30.59) was recorded from T_4 treatment.

4.3 Yield contributing characters and yield

Yield contributing characters and yield of BRRI dhan50 showed statistically significant variation in terms of different yield contributing characters and yield of BRRI dhan50 (Table 12).

4.3.1 Length of panicle

In consideration of length of panicle, the longest panicle (24.69 cm) was recorded from T_2, which was statistically similar (23.70 cm) to T_1 and closely flowed (22.67 cm and 21.75 cm) by T_3 and T_4 and they were statistically similar, while the shortest panicle (20.26 cm) was found from T_5 (Table 12).

4.3.2 Number of filled grains/panicle

In consideration of number of filled grains, the maximum number of filled grains (93.74) was recorded from T_2, which was statistically similar (91.33) to T_1 and closely flowed (90.17 and 88.57) by T_3 and T_4 and they were statistically similar, while the minimum number of filled grains/panicle (84.77) was found from T_5 (Table 12).

Table 11. Efficiency of some management practices against tiller infestation of BRRI dhan50 caused by rice stink bug

Treatment	Healthy tillers (No.)	Infested tillers (No.)	% infestation	Increase/decrease over control
T_1	46.20 a	2.40 c	4.94 c	67.12
T_2	48.60 a	1.80 c	3.57 c	76.22
T_3	47.20 a	4.40 b	8.53 b	43.23
T_4	46.40 a	5.40 b	10.42 b	30.59
T_5	43.00 b	7.60 a	15.02 a	0.00
$LSD_{(0.05)}$	2.781	1.061	1.591	--
Level of significance	0.01	0.01	0.01	--
CV(%)	4.56	5.09	6.22	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 selected hills/plot of each 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 = Spraying Diazinon 60EC @ 2ml/Litre of water sprayed at 7 days interval

T_2 = Spraying Suntap 50 WP @ 1.2g/ Litre of water at 7 days interval

T_3 = Applying Mechanical control method at 7 days interval

T_4 = Applying Cultural control method at 7 days interval

T_5 = Untreated control

Table 12. Efficiency of some management practices on yield contributing characters and yield of BRRI dhan50

Treatment	Length of panicle (cm)	Number of filled grains/panicle	Number of unfilled grains/panicle	Weight of 1000 grains (g)	Grain yield (t/ha)	Yield increase over control
T_1	23.70 ab	91.33 ab	8.67 d	22.23 a	5.02 ab	31.21
T_2	24.69 a	93.74 a	6.26 d	22.34 a	5.67 a	43.36
T_3	22.67 bc	90.17 bc	9.83 c	21.30 b	4.90 bc	28.97
T_4	21.75 cd	88.57 c	11.43 b	20.53 b	4.56 bc	22.62
T_5	20.26 d	84.77 d	15.23 a	19.83 c	3.35 c	--
$LSD_{(0.05)}$	1.283	2.136	0.576	0.824	0.796	--
Significance level	0.05	0.01	0.01	0.05	0.05	--
CV(%)	6.78	8.22	5.67	4.55	7.04	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 selected hills/plot of each 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 = Spraying Diazinon 60EC @ 2ml/Litre of water sprayed at 7 days interval

T_2 = Spraying Suntap 50 WP @ 1.2g/ Litre of water at 7 days interval

T_3 = Applying Mechanical control method at 7 days interval

T_4 = Applying Cultural control method at 7 days interval

T_5 = Untreated control

4.3.3 Number of unfilled grains/panicle

In consideration of number of unfilled grains, the maximum number of unfilled grains (15.23) was recorded from T_5, which was followed (11.43) by T_4, whereas the minimum number of unfilled grains/panicle (6.26) was recorded from T_2 which was statistically similar (8.67) to T_1 and followed (9.83) by T_3 (Table 12).

4.3.4 Weight of 1000-grains

In consideration of weight of 1000-grains, the highest weight (22.34 g) was recorded from T_2, which was statistically similar (22.23 g) to T_1 and closely followed (21.30 g and 20.53 g) by T_3 and T_4 and they were statistically similar, while the lowest weight of 1000-grains (19.83 g) was found from T_5 (Table 12).

4.3.5 Grain yield

In consideration of grains yield, the highest grain yield (5.67 t/ha) was recorded from T_2, which was statistically similar (5.02 t/ha) to T_1 and closely followed (4.90 t/ha and 4.56 t/ha) by T_3 and T_4 and they were statistically similar, while the lowest grain yield (3.35 t/ha) was found from T_5. In consideration of yield increase over control the highest value (43.36) was recorded from T_2 and the lowest value (22.62) was recorded from T_4 (Table 12).

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the experimental area of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November 2014 to May 2015.to evaluate the efficacy of some management practices against insect pest complex of BRRI dha50. BRRI dhan50 were used as the test crop in this experiment. The experiment comprised of the following control measure as treatment- T_1 = Spraying Diazinon 60EC @ 2ml/Litre of water sprayed at 7 days interval; T_2 = Spraying Suntap 50 WP @ 1.2g/ Litre of water at 7 days interval; T_3 = Applying Mechanical control at 7 days interval; T_4 = Applying Cultural control at 7 days interval and T_5 = Untreated control. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Data was recorded on pest incidence, number of healthy, infested plants & leaf for different pests and infestation level and also yield contributing characters and yield of BRRI dhan50 and significant variations was observed for different treatments.

Under the present experiment 8 common species of insects were found belongs to 7 family and 6 orders were found infested in the experimental field. Among the insect species 2 species belong to the family Pyralidae. Insect population for 5 selected hills/plot were observed with clean observation and in the experimental plot yellow stem borer, leaf folder, rice hispa, grasshopper, brown plant hopper, green leaf hopper, rice bug and rice stink bug was observed and the highest number of theses insect pests was recorded from T_5, whereas the lowest number of these insect pests was observed from T_2 treatment.

In case dead heart infestation caused by yellow stem borer at vegetative stages the lowest infestation (1.13%) was recorded from T_2, whereas the highest infestation (9.60%) was observed from T_5. In white head infestation of rice due to yellow stem borer the lowest infestation (1.20%) was recorded from T_2, whereas the highest infestation (9.43%) was observed from T_5. In leaf infestation of rice caused by leaf folder the lowest leaf infestation (1.03%) was recorded from T_2, whereas the highest leaf infestation (6.44%) was observed from T_5. In case of leaf infestation of rice caused by rice hispa the lowest leaf infestation (2.36%) was recorded from T_2, whereas the highest leaf infestation (11.12%) was observed from T_5. In consideration of leaf infestation the lowest leaf infestation (3.16%) was recorded from T_2, whereas the highest leaf infestation (12.71%) was observed from T_5. In tillers infestation of rice caused by brown plant hopper the lowest infestation (2.76%) was recorded from T_2, whereas the highest infestation (13.33%) was observed from T_5. For leaf infestation of rice caused by green leaf hopper, the lowest number (19.20) was found from T_2, while the highest number (83.20) from T_5. In case of tillers infestation of rice caused by rice bug the lowest infestation (2.99%) was recorded from T_2, whereas the highest infestation (14.37%) was observed from T_5. In tillers infestation of rice caused by rice stink bug he lowest infestation (3.57%) was recorded from T_2, whereas the highest infestation (15.02%) from T_5.

In consideration of yield contributing characters and yield of BRRI dhan50, the longest panicle (24.69 cm) was recorded from T_2, while the shortest panicle (20.26 cm) was found from T_5. In consideration of number of filled grains, the maximum number of filled grains (93.74) was recorded from T_2, while the minimum number of filled grains/panicle (84.77) from T_5. The maximum number of unfilled grains (15.23) was recorded from T_5, whereas the minimum number of unfilled grains/panicle (6.26) was recorded from T_2, The highest weight (22.34 g) was recorded from T_2, while the lowest weight of 1000-grains (19.83 g) was found from T_5. The highest grain yield (5.67 t/ha) was recorded from T_2, while the lowest grain yield (3.35 t/ha) from T_5.

Among the different control measures, spraying Suntap 50 WP @ 1.2g/ Litre of water at 7 days interval was the better for the controlling of insect pest complex of BRRI dha50.

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APPENDICES

Appendix I. Monthly record of air temperature, relative humidity, rainfall and sunshine hour of the experimental site during the period from November 2014 to May 2015

Month	*Air temperature (ºc)		*Relative humidity (%)	Total Rainfall (mm)	*Sunshine (hr)
	Maximum	Minimum			
November, 2014	25.8	16.0	78	00	6.8
December, 2014	22.4	13.5	74	00	6.3
January, 2015	24.5	12.4	68	00	5.7
February, 2015	27.1	16.7	67	30	6.7
March, 2015	28.1	19.5	68	00	6.8
April, 2015	33.4	23.2	67	78	6.9
May, 2015	34.7	25.9	70	185	6.8

* Monthly average,

* Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka – 1212

Appendix II. Characteristics of soil of experimental field

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agricultural Botany field , 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	6.1
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 III. Analysis of variance of the data on incidence of different rice insect pests by number at different stage as influenced by different management practices

Source of variation	Degrees of freedom	Mean square			
		Number of different insect pests			
		Yellow stem borer	Leaf folder	Rice hispa	Grasshopper
Replication	2	0.004	0.001	0.023	0.001
Treatment	4	1.205**	5.228**	3.349**	5.562**
Error	8	0.006	0.047	0.029	0.071

** Significant at 0.01 level of probability

Appendix III. (Contd')

Source of variation	Degrees of freedom	Mean square			
		Number of different insect pests			
		Brown plant hopper	Green leaf hopper	Rice bug	Rice stink bug
Replication	2	0.008	0.054	0.083	0.124
Treatment	4	17.035**	23.241**	38.181**	71.243**
Error	8	0.060	0.071	0.150	0.319

** Significant at 0.01 level of probability

Appendix IV. Analysis of variance of the data on rice yellow stem borer (dead heart) infestation of BRRI dhan50 throughout the vegetative stage as influenced by different management practices

Source of variation	Degrees of freedom	Mean square		
		Healthy tillers (No.)	Infested tillers (No.)	% infestation
Replication	2	0.375	0.375	4.167
Treatment	4	6.375**	6.375**	70.833**
Error	8	0.232	0.232	2.579

** Significant at 0.01 level of probability

Appendix V. Analysis of variance of the data on rice yellow stem borer (white head infestation) at the reproductive stage of BRRI dhan50 as influenced by different management practices

Source of variation	Degrees of freedom	Mean square		
		Healthy tillers (No.)	Infested tillers (No.)	% infestation
Replication	2	0.042	0.042	0.463
Treatment	4	8.452**	8.452**	93.915**
Error	8	0.185	0.185	2.050

** Significant at 0.01 level of probability

Appendix VI. Analysis of variance of the data on leaf infestation of BRRI dhan50 caused by leaf folder as influenced by different management practices

Source of variation	Degrees of freedom	Mean square		
		Healthy leaf (No.)	Infested leaf (No.)	% infestation
Replication	2	3.784	0.006	0.014
Treatment	4	105.214**	8.205**	20.656**
Error	8	17.496	0.009	0.417

** Significant at 0.01 level of probability

Appendix VII. Analysis of variance of the data on against leaf infestation of BRRI dhan50 caused by rice hispa as influenced by different management practices

Source of variation	Degrees of freedom	Mean square		
		Healthy leaf (No.)	Infested leaf (No.)	% infestation
Replication	2	0.542	0.542	6.019
Treatment	4	78.762**	28.762**	97.355**
Error	8	0.208	0.208	2.315

** Significant at 0.01 level of probability

Appendix VIII. Analysis of variance of the data on leaf infestation of BRRI dhan50 caused by grasshopper as influenced by different management practices

Source of variation	Degrees of freedom	Mean square		
		Healthy leaf (No.)	Infested leaf (No.)	% infestation
Replication	2	2.215	0.634	1.520
Treatment	4	106.002*	15.811**	31.470**
Error	8	27.794	0.291	0.914

** Significant at 0.01 level of probability

Appendix IX. Analysis of variance of the data on tillers infestation of BRRI dhan50 caused by brown plant hopper (BPH) as influenced by different management practices

Source of variation	Degrees of freedom	Mean square		
		Healthy tillers (No.)	Infested tillers (No.)	% infestation
Replication	2	1.170	0.009	0.104
Treatment	4	16.137*	1.475**	9.184**
Error	8	4.970	0.102	0.436

** Significant at 0.01 level of probability

Appendix X. Analysis of variance of the data on leaf infestation of BRRI dhan50 caused by green leaf hopper as influenced by different management practices

Source of variation	Degrees of freedom	Mean square		
		Healthy leaf (No.)	Infested leaf (No.)	% infestation
Replication	2	4.500	0.080	0.011
Treatment	4	173.182**	19.602**	44.057**
Error	8	25.980	0.720	0.685

** Significant at 0.01 level of probability

Appendix XI. Analysis of variance of the data on panicle infestation of BRRI dhan50 caused by rice bug as influenced by different management practices

Source of variation	Degrees of freedom	Mean square		
		Healthy panicle (No.)	Infested panicle (No.)	% infestation
Replication	2	0.670	0.020	0.115
Treatment	4	27.274*	2.237**	10.905**
Error	8	8.243	0.037	0.214

** Significant at 0.01 level of probability

Appendix XII. Analysis of variance of the data on tiller infestation of BRRI dhan50 caused by rice stink bug as influenced by different management practices

Source of variation	Degrees of freedom	Mean square		
		Healthy tillers (No.)	Infested tillers (No.)	% infestation
Replication	2	0.619	0.002	0.046
Treatment	4	16.549*	1.537**	14.503**
Error	8	5.452	0.030	0.533

** Significant at 0.01 level of probability

Appendix XIII. Analysis of variance of the data on yield contributing characters and yield of BRRI dhan50 as influenced by different management practices

Source of variation	Degrees of freedom	Mean square				
		Length of panicle (cm)	Number of filled grains/ panicle	Number of unfilled grains/ panicle	Weight of 1000 grains (g)	Grain yield (t/ha)
Replication	2	14.825	4.005	0.004	0.002	0.012
Treatment	4	121.135*	24.541*	0.069**	0.097*	0.055*
Error	8	33.745	6.776	0.012	0.032	0.017

** Significant at 0.01 level of probability