EFFECTIVENESS OF GRANULAR INSECTICIDES ON INSECT PESTS MANAGEMENT IN THREE AMAN RICE VARIETIES

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CERTIFICATE

This is to certify that the thesis entitled **'EFFECTIVENESS OF GRANULAR INSECTICIDES ON INSECT PESTS MANAGEMENT IN THREE AMAN RICE VARIETIES'** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science in Entomology** embodies the result of a piece of bonafide research work carried out by **MD. FAHIM HASAN**, Registration number: **11-04589** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: June, 2017
Dhaka, Bangladesh

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EFFECTIVENESS OF GRANULAR INSECTICIDES ON INSECT PESTS MANAGEMENT IN THREE AMAN RICE VARIETIES

ABSTRACT

A field experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during August to December, 2016 in T. aman season to find out the performance of three transplanted aman rice varieties *viz.* BRRI dhan33 (V_1), BRRI dhan49 (V_2) and BRRI dhan51 (V_3) against major insect pests with three granular insecticides *viz*. Furadan 5G (T_1), Diazinon 10G (T_2), Fifronil 3G (T_3) using two factorial randomized complete block design (RCBD) with three replications. Insect pest population for 5 selected hills/plot were observed 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 were observed. The highest number of the insect pests was recorded from V_3T_4 treatment combination whereas the lowest number of insect pests was observed from V_1T_1. In case of tillers, leaf and panicle infestation in different crop stages caused by different rice insect pests, the lowest infestation was recorded from V_1T_1 treatment combination whereas the highest infestation was observed from V_3T_4. In consideration of yield contributing characters the maximum number of filled grains/panicle (88.67) was recorded from V_1T_1 treatment combination while the minimum number of filled grains/panicle (79.33) was counted from $V_3T_{4.}$ The highest grain yield (22.33g) was recorded from V_1T_1 treatment combination while the lowest grain yield (17.33g) was recorded from V_3T_4. In respect of three granular insecticide Furadan 5G ($T_{1)}$ showed the best achievement against insect pests of rice than T_2 and T_3. In case of varieties, V_1 revealed the best performance than V_2 and $V_{3.}$

Dedicated to

My

Beloved Parents

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CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.) is an important staple food crop for more than half of the world population and accounts for more than 50% of the daily calorie intake **(**Khush, 2005)**.**It provides 27% of dietary energy and 20% of dietary protein in the developing countries. This crop is cultivated in at least 114, mostly developing countries and it is the primary source of income and employment for more than 100 million household in Asia (FAO, 2009)**.** Ninety percent of all rice is grown and consumed in Asia **(**Luh, 1991)**.** In Bangladesh, majority of food grains come from rice. The population of Bangladesh became almost double over last three decade from 72 million in 1972 to 140 million in 2005 with an average increase by over 2 million per year and to feed the increased population in 2020, about 32800 thousand metric tons of rice will be needed to produce in the country (MoA, 2008). About 80% of cropped area of this country is used for rice production, with annual production of 25.18 million tons from 10.29 million ha of land. Transplant aman covers the largest area of 5713 thousand hectare with a production of 11249 thousand metric ton and average yield was about 1.951 ton ha^{-1}(BBS,2010) The average yield of rice in Bangladesh is 2.45 t ha^{-1}. This average yield is almost less than 50% of the world average rice grain yield.

Insect pests cause damage in the crop fields throughout the world. It is often said that, crop production is a fight against insect pests (Mukhopadhyay and Ghosh, 1981). The prevailing climatic and edaphic conditions are highly favorable for luxuriant growth of numerous species of insect pests which offer a keen competition with rice crop. In Bangladesh, about 176 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).Hybrid rice variety found to most susceptible to stem borer and cause yield loss 22.19-27.09% (Rahman *et* *al.*, 2004). Rice leaf folder or roller is considered another major harmful insect pest of rice. These insects do damage when they are at larvae stage. They do damage 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).

Chemical control is still considered as the first line of defense in rice insect pest management. Application of various granular insecticides gives effective control of rice pests (Dash *et al.,* 1996).Among insecticides, the granular formulations are considered safe to natural enemies like spiders besides being effective against rice insect pests (Baitha *et al*., 2000). Application of a few granular formulations in the nursery was more effective in controlling early stage insect pests of rice in the main field (Dash *et al.,* 2004). But the indiscriminate use of chemical insecticides can be environmentally disruptive and can result in the accumulation of residues in the harvested produce (Dodan and Lal, 1999; Kaul and Sharma, 1999 and Rath, 1999 and 2001). Besides, new chemical products are being introduced in market every year in both granular and spray formulations. Several of the new products are effective against rice insect pests at very low amount of active ingredient and thus potentially less disruptive to the environment. Therefore, the time has now come to control the insect pests by using these safer compounds in an eco-friendly and more amicable manner.

Keeping the above facts in view, the present investigation entitled effectiveness of three granular insecticides on insect pests management in three aman rice varieties was undertaken with the following broad objectives.

- To observe the insect pest infestation status of three *T. aman* rice varieties

- To study the relative efficacy of granular insecticide in controlling major insect pests of rice.

CHAPTER II

REVIEW OF LITERATURE

For conducting any research in a scientific manner some ideas, fact, value can be undertaken into consideration. So, a comprehensive and systematic review of the past relevant literature is a prerequisite. A reference to the past studies provides guidelines not only to frame the future areas of research and methodologies to be adopted but also to conform and repudiate research outcome with all possible reasons. Insect pests are major limiting factor in realizing yield potential of rice cultivars. Various granular insecticides have been recommended to control the insect pests. However, in present day insecticides are used extensively to control insect and other pest which threat to population dynamics of soil microorganisms. Thus the present investigation aims at evaluating the granular insecticides on the extent of damage caused by insect pest of rice as well as occurrence of natural enemies. The relevant published literatures pertaining to present study have been reviewed and described below:-

Efficacy of granular insecticides against the rice pests:

2.1 Rice stem borer

2.1.1 Species in Bangladesh

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

2.1.2 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).

2.1.3 Systematic Position

Phylum: Arthropoda

Class: Insecta

Order: Lepidoptera

Family: Crambidae

Genus: *Scirpophaga*

Species: *Scirpophaga incertulas*

2.1.4 Management of stem borer

Sontakke and Dash (2000) evaluated the efficacy of some of the new granular insecticides, applied in the nursery 5 days before uprooting the seedlings and at 50 days after transplanting against the major pests of rice. Among the test granules, nursery application of isazofos and chlorpyrifos were most effective against stem borers causing dead heart infestation.

Studies on the efficacy of fipronil and other insecticides against rice stem borer *Scirpophaga incertulas* by Saljoqi *et al.* (2002) revealed that padan 4 G (cartap) @ 22.23 kg/ha was found to be most effective in reducing rice stem borer infestation followed by Regent 300 EC (fipronil) at 197.6 ml/ha, Regent 300 EC mixed with fertilizer at 197.6 ml/ha and Furadon 3G (carbofuran) @ 19.76 kg/ha.

Dash and Mukherjee (2004) evaluated the efficacy of some granular and sprayable insecticides (0.05 kg fipronil, 1.0 kg chlorpyriphos, 1.0 kg carbofuran, 0.0125 kg lambda cyhalothrin , 0.3 kg amitraz , 0.025 kg imidacloprid, 0.1 kgsolafflufen, 0.1 kg methofenozide,0.05 kg profenofos and 0.5 kg chlorpyriphosa.i./ha) against the major insect pests of rice and reported that among the granulesfipronil @ 0.075 kg a.i./ha gave maximum protection against stem borer and resultedin the highest yield of 40.4 q/ha.

Hedge (2003) reported that, of the various rates of fipronil and carbofuran, regent (fipronil) 0.4% G @ 75 and 100g a.i./ha and carbofuran 3G @ 570g a.i./ha were most effective against yellow stem borer.

Prasad *et al.* (2005) evaluated the efficacy of chlorpyriphos 10 G @ 0.75, 1.0 and 1.25 kg a.i./ha; cartap 4 G @ 0.6, 0.8 and 1.0 kg a.i./ha; and fipronil 0.4 G @ 0.05,0.075 and 0.1 kg a.i./ha, carbofuran 3 G @ 1.0 kg a.i./ha in controlling yellow stem borer and the results indicated that cartap 4 G @ 0.6 kg a.i./ha followed by chlorpyriphos 10 g @ 1.25 kg a.i./ha, fipronil 0.4 G @ 0.075 kg a.i./ha and chlorpyriphos 10 G @ 0.75 kg a.i./ha were most effective with average yellow stem borer infestation of 2.9, 3.4, 3.4 and 3.4%,respectively, in comparison to 8.1% infestation in untreated control.

Lal (2006) conducted Field trials to evaluate the efficacy of fipronil 0.3 G applied at 56.2 g a.i./ha and 75 g ai/ha against stem borer and reported that when applied at 20 DAT protected the crop up to 60 DAT. Minimum incidence of stem borers and higher yield of paddy grain was recorded from fipronil 0.3G @ 75 g a.i/ ha applied at 20,50 and 70 DAT. Chlorpyriphos 20 EC was found least effective insecticide in reducing the damage and realizing yield.

Field experiment carried out during *kharif* 2006 showed superiority of fipronil 0.3G @ 7.5 g a.i./ha followed by carbosulfan 6G @ 1000 g a.i./ha and carbofuran 3G @ 750 g a.i./ha which were moderately effective and cartap hydrochloride 4 G @ 1000 g a.i./ha was least effective among the granular formulations. Among the spray formulations beta-cyfluthrin 2.5 EC @ 12.5 g a.i./ha was highly effective followed by monocrotophos 36 SL @ 500 g a.i./ha and flubendiamide 500 SC @ 24 g a.i./ha. The next best was indoxacarb 14.5 SC @ 30 g a.i./ha but imidacloprid 17.8 SL @ g a.i./ha andSeed treatment of imidacloprid 70 WS @ 5ml/kg seed and lambda cyhalothrin 2.5 EC @ 12.5 g a.i./ha were less effective against rice yellow stem borer. (Hugar *et al*., 2009).Tanveer *et al*. (2012) reported that cartap hydrochloride (4 G) was found to be more effective against stem borer followed by fipronil (0.3G) and carbofuran (3 G).Abro *et al.*, (2013) reported that field trial was conducted under Pakistan condition on the efficacy ofinsecticides in reducing the infestation of rice stem borer, *S. incertulas* (Walker) and the results revealed that second application cartap hydrochloride 4Gwas found most effective insecticide with the minimum percent infestation (4.37%)followed by carbofuran 3 G (7.08%), fipronil 4.95 EC (8.68%) and control(38.53%).

Four solid formulations of insecticides Viz., Carbofuran, Phorate, Cartap @ 1kg a.i./ha and Chlorpyriphos @ 0.5kg a.i./ha along with the check, liquid formulation of monocrotophos @ 0.5 kg a.i./ha were applied against insect pest of rice. Result of the experiment conducted during dry season of 2009 revealed that Carbofuran treatment recorded lowest % of dead heart (4.2%), white ear head (4.5%) and highest grain yield of 4.852 t/ha in variety Jaya followed by the treatment phorate, cartap, chlorpyriphos and monocrotophos. During dry season 2010, also Carbofuran treatment recorded lowest % of DH (3.7%), WEH (4.2%) and highest grain yield of 4.13 t/ha followed by the treatment phorate, cartap, chlorpyriphos and monocrotophos. (Rath, 2013)

Rath and Nayak (2013) evaluated the efficacy of a new molecule cyazypyr (HGW 86 10%OD) against yellow stem borer and revealed that the test compound at 100 and 120 g a.i./ha was highly effective in reducing stem borer incidence (71.01 to 88.80% reduction over control during the period of study) than the check insecticides like monocrotophos and triazophos which were observed to be less effective than the test compound.

Suri and Brar (2013) reported that Chlorantraniliprole @ 40 g a.i./haprovided an effective control of stem borers (1.48% dead hearts and 2.05% white head), which was at par with its higher dose of 50 g a.i./ha (1.36% dead hearts and1.88% white-ears) and the check, cartap hydrochloride (1.36% dead hearts and 1.92% white ears) but was significantly better than its lower doses of 30 and 20 g a.i./ha and the untreated control.

Chormule *et al.* (2014) evaluated the efficacy of seven granular insecticides against yellow stem borer infesting rice. Among the evaluated granular insecticide molecules lasenta 80 WG @ 250 g a.i./ha proved to be most effective against *S.incertulas* followed by ferterra 0.4 G @ 30 g a.i./ha, fipronil 0.3 G @ 7.5 g a.i./ha, cartap hydrochloride 4 G @ 750 g a.i./ha, chlorpyriphos 10 G @ 1 kg a.i./ha, carbofuran 10 G @ 750 g a.i./ha and phorate 10 G 750 g a.i./ha.

Satyanarayana *et al*. (2014) reported that Fipronil 0.6% GR @ 60g a.i./ha was the most effective and significantly superior over all other treatments in reducing the dead hearts to minimum level of 3.40 per cent followed by fipronil 0.6 per cent GR @ 50g a.i./ha which recorded 4.45% dead hearts. The Carbofuran 3 GR @ 750g a.i./ha. Proved least effective in which higher per cent of dead hearts of 5.08 were observed.

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 color 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 17 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.

2.2.3. Control measures

According to Madhumathi and Srinivas (2001), two applications given at 30 and 45 days after transplanting with cartap hydrochloride 4 G @ 25 kg a.i./ha and ethofenoprox 10EC @ 1.5ml/l of water were effective against rice leaf folder.

Sehrawat *et al.* (2002) reported that among seven treatments i.e. cartap hydrochloride 4 G, monocrotophos 36 SL, *Bacillus thurinenesis* var kurstaki, endosulfan 35EC, 300 ppm neem(azadirachtin), ethofenprox 10EC and release of egg parasitoid *T. chilonis* against the rice leaf folder, cartap hydrochloride 4G @ 0.75 kg a.i./ha found to be most effective.

Mishra *et al.* (2007) evaluated the efficacy of certain granular insecticides viz., cartap 4 G, carbofuran 3 G, phorate 10 G, fenthion 5 G and fenitrothion 5 G against leaf folder of rice (*Cnaphalocrocis medinalis*) and reported that the minimum leaf damage and maximum grain yield was obtained using cartap hydrochloride @ 1.0kg/ha which was statistically at par with that of carbofuran and phorate @ 1.0 kg/ha.

Controlled release formulations of Cartap polyvinyl chloride (PVC) and Carboxymethyl cellulose (CMC) granules and its commercial formulation, 4G were tested against rice leaf folder, *Cnaphalocrocis medinalis* (Guenee) by Prasad *et al.* (2009**)** and found that Cartap CMC granules at half dose proved as effective as its commercial formulation. Both Cartap PVC and CMC granules proved effective in controlling leaf folder damage as compared to untreated control.

Suri and Brar (2013) evaluated the efficacy of chlorantraniliprole (Ferterra 0.4% GR) @ 20, 30 40 and 50 g a.i./ha and compared with the check, cartap hydrochloride (Padan 4G) @ 1000 g a.i./ha against leaf folder. The results revealed that the per cent leaves damaged by the leaf folder in chlorantraniliprole @ 40 g a.i./ha (4.12%) was at par with its higher dose of 50 g a.i. ha-1 (3.82%) and cartap hydrochloride (3.86%).

Mishra *et al.* (2007) tested the efficacy of four doses of ferterra 0.4% GR (chlorantraniliprole) @ 20, 30, 40 and 50 g a.i. /ha and cartap hydrochloride 4G @1000g a.i. /ha against leaf folder infesting basmati rice. The results revealed that leaf folder infestation at all the ferterra doses were at par with standard check 70 DAT (2.69-3.87 %), whereas, 80DAT ferterra doses @ 30, 40, 50 and standard check were at par (2.95-3.49) but significantly better than lower dose and untreated control.

Field studies were undertaken to assess the comparative efficacy of new insecticide rynaxypyr 0.4 G ,18.5 SC (chlorantraniliprole), and emmamectin benzoate 5 SG at different uses against rice leaf folder along with recommended insecticides like fipronil, carbofuran and profenophos.the results revealed that the granular formulation of rynaxypyr (0.4 G) @ 50g a.i./ha was found to be the most effective in reducing the damage (80.27 and 86.12% reduction over control) with the highest grain yield (51q/ha and 55q/ha). With respect to damage reduction over control (77.03% and 84.98%) and grain yield (49q/ha and 53q/ha), the next best was rynaxypyr 0.4G @ 40g a.i./ha . (Chanu and Sontakke, 2015)

2.3 Brown Plant Hopper

The pest, BPH belongs to the plant sucking group of insects called Homopterous. 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

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

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. 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 Control measures

Application of chlorpyrifos, quinalphos and fipronil granules were effective against the leaf folder. Carbofuran followed by isazofos only could reduce the population of plant hoppers. (Sontakke and Dash, 2000)

A field experiment was conducted to study the relative bio-efficacy of new insecticides against mixed population of plant hoppers (BPH and WBPH) and the results revealed that among granules, phorate 10 G @1000 g a.i./ha and carbosulfan 6G @ 1000 g a.i./ha were inferior to standard check, carbofuran 3 G @ 1000g a.i./ha in reducing plant hopper population. (Bhavani, 2006)

Suri and Brar (2013) reported that thiamethoxam (56, 75, 94, 113, 225g a.i. /ha.) treatments were inferior to the standard check carbofuran 3G @ 1000 g a.i. /ha which was the most efficient in reducing leafhopper population.

Satyanarayana *et al.* (2014) reported that Plots treated with Fipronil 0.6% GR @ 60 g a.i./ha was the most effective and significantly superior over all other treatments in reducing the hopper infestation (2.0/hill) as compared to untreated control (13.7/hill) and realizing 60.0 % increase in grain yield over control. Fipronil 0.3% GR @ 60g a.i./ha stood second in order of effectiveness which recorded 58.27 percent. Cartap hydrochloride 4% GR @ 750g a.i./ha proved least effective in which 28.86 per cent increase in yield was observed.

CHAPTER III

MATERIALS AND METHODS

This chapter describes the materials and methods which were used in the field to conduct the experiment during the period from August to December 2016. It comprises a short description of experimental site, soil and climate, variety, growing of the crops, experimental design and treatments and collection of data presented under the following headings-

3.1 Experimental site

The study was conducted at the Agronomy Farm, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh.

3.2 Climate and weather

The climate of the experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October (Edris*et al*., 1979). Details of the meteorological data during the period of the experiment was collected from the Bangladesh Meteorological Department, Agargoan, Dhaka and presented in Appendix II.

3.3 Planting material

The rice varieties were collected from Bangladesh Rice Research Institute (BRRI) and BRRI dhan33, BRRI dhan49 and BRRIdhan51 were used as planting materials.

3.4 Design of the experiment

The two factorial experiments were laid out in a RCBD with three replications.

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3.5 Treatment of the experiment

There were two factors in the experiment as follows:

Factor-A: Three varieties of Rice

V_1= BRRI dhan33

V_2= BRRI dhan49

V_3=BRRI dhan51

Factor-B: Four insecticidal treatments

T_1=Furadan 5G (@ 10g/plot 2 application)

T_2= Diazinon 10G (@ 10g/plot 2 application)

T_3= Fifronil 5G @ (10g/plot 2 application)

T_4= Untreated Control

3.6 Management of the Crop

The crop in each treatment was raised under same level of management practices. The management practices followed in this experiment is described below: -

3.6.1 Collection of seeds

The seeds of BRRI dhan33, BRRI dhan49 and BRRI dhan51 were collected from Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur.

3.6.2 Seed sprouting

The collected seeds were healthy. The seeds were immersed in a bucket filled with water for 24 hours. Then the seeds were taken out of water and kept thickly in gunny bags. The seeds started sprouting after 48 hours and were sown after 72 hours.

Plate 1. The experimental field of the present study at the central farm of SAU, Dhaka

3.6.3 Preparation of seedling nursery and sowing of seeds

For raising rice seedlings a piece of high land was selected at the Agronomy Field Laboratory, Sher-e-Bangla Agricultural University, Dhaka. The land was puddle with moldboard plough and leveled with ladder. Then the sprouted seeds were sown in the nursery beds on 5 August 2016**.** Weeds were removed and irrigation was given in the seedling nursery as and when necessary.

3.6.4 Preparation of experimental land

Tillage was given in the experimental land with a power tiller. Then the land was puddle thoroughly by repeated ploughing and cross ploughing with a moldboard plough and subsequently leveled by laddering. Immediately after final land preparation the layout of experimental plot was made on 25 August 2016 according to experimental design.

3.6.5 Fertilizer application

A fertilizer dose of 100-70-60-5 kg ha-1 of triple superphosphate (TSP), muriate of potash (MoP), gypsum and zinc sulphate, respectively were applied at the time of final land preparation. Amount of urea was applied as a source of nitrogen

3.6.6 Uprooting of seedlings

The seedlings were uprooted without causing any mechanical injury to the roots. Then the uprooted seedlings were transplanted in the main field.

3.6.7 Transplanting of seedlings

The seedlings were transplanted 30 august 2016.Two to three seedlings were transplanted in each hill maintaining the spacings of 25 cm x 20 cm.

3.7 Intercultural operations

3.7.1 Gap filling

Seedling in some hills died off and these were replaced by gap filling after one week of transplanting with seedlings from the same source.

3.7.2 Management of weeds

Two times weed collections were done in order to keep the crop weed free at 20 and 40 days after transplanting.

3.7.3 Water management

Water was supplied at 5-7 cm depth to all the plots throughout the growing period to fulfill the water requirement of the rice plant.

3.7.4 Crop protection measures

No major disease incidence was observed. But, the crop was mildly attacked by green leaf hopper, brown plant hopper and stem borer at the vegetative growth stage. Diazinon (60 EC) was applied at the rate of 1.5 liters per hectare to control the insect pests.

3.8 Harvesting, threshing and cleaning

The crop was harvested at full maturity 5 December 2016 when 80-90%of the grains were turned into straw colored. The harvested crop was bundled separately, properly tagged and brought to threshing floor. Enough care was taken during threshing and cleaning 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}.

3.9 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).

3.9.1 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.

3.9.1.1 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:

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

3.5.9.2 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:

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

3.9.1.3 Treatment effects on infestation

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

$$\text{Percent population reduction over control} = \frac{X2-X1}{X2} \times 100$$

Where, X1 = the mean value of treated plots

X2 = the mean value of untreated plots

3.9.2 Yield contributing characters and yield of rice

3.9.2.1 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.

3.9.2.2 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.

3.9.2.3 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.

3.9.2.4 Weight of 1000-grains

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

3.9.2.5 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 $hectare^{-1}$.

3.10 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 effectiveness of some granular insecticides against insect pest of three aman rice varieties(BRRI dhan33,BRRI dhan49 and BRRI dhan51).Data was recorded on pest incidence, number of healthy, infested plants and leaf for different pests and infestation level and also yield contributing characters and yield of aman rice . The analysis of variance (ANOVA) of the data on different parameters has been given 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 various insect pests under favorable condition which is the common phenomenon of rice cultivation. Under the present experiment 8 species of insect pests were found and they belongs to 7 family under 6 orders. The common name, scientific name, order, family, damaging stages of insects as rice insect pests are represented in Table 1.

4.1.2 Insect population

Insect pest population for 5 selected hills/plot were noticed 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 was recorded in (Table 2). For different treatment number of different insect pests varied significantly under the present trial. In Bangladesh, about 177 insect pest species have been reported, which cause damage to the rice plants (Mustafi *et al.*, 2008).

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

Sl. No.	Common name	Scientific name	Order	Family	Damaging Stages
1.	Yellow stem borer	*Scirpophaga incertulas*	Lepidoptera	Pyralidae	Larvae (Caterpillar)
2.	Leaf folder	*Cnaphalocrocis medinalis*	Lepidoptera	Pyralidae	Larvae (Caterpillar)
3.	Rice hispa	*Dicladispa armigera*	Coleoptera	Chrysomelidae	Adult and Grub
4.	Grasshopper	*Oxyavelox*	Orthoptera	Acrididae	Adult and nymph
5.	Brown plant hopper	*Nilaparvata lugens*	Homoptera	Delphacidae	Adult and nymph
6.	Green leaf hopper	*Nephotettixvirescens*	Homoptera	Cicadellidae	Adult and nymph
7.	Rice bug	*Leptocorisaacuta*	Hemiptera	Coreidae	Adult and nymph
8.	Rice stink bug	*Eysarcorisventralis*	Hemiptera	Pentatomidae	Adult and nymph

Table 2.Efficiency of variety and granular insecticides on the incidence of insect pests in the rice field during the study period

Treatment	Yellow stem borer	Leaf folder	Rice hispa	Grass hopper	Brown plant hopper	Green leaf hopper	Rice bug	Rice stink bug
V_1	1.72c	2.40 c	2.16 c	3.92 c	2.88 c	2.77 c	2.33 c	2.02 c
V_2	3.49 b	5.17 b	5.21 b	8.64 b	6.97 b	5.07 b	4.63 b	4.00 b
V_3	5.02 a	8.82 a	8.00 a	12.97 a	10.91 a	8.66 a	6.94 a	6.75 a
LSD $_{(0.05)}$	**0.21**	**0.29**	**0.25**	**0.37**	**0.28**	**0.23**	**0.20**	**0.19**
CV (%)	**7.36**	**6.20**	**5.69**	**5.19**	**4.74**	**5.02**	**5.08**	**5.31**
T_1	2.95d	4.33 d	4.21 d	6.87 d	5.48 d	4.51 d	3.54 d	3.42 d
T_2	3.22c	5.21 c	4.71 c	7.87 c	6.49 c	5.06 c	4.52 c	3.97 c
T_3	3.49b	5.83 b	5.44 b	9.01 b	7.31 b	5.95 b	4.94 b	4.67 b
T_4	3.98 a	6.50 a	6.13 a	10.30 a	8.39 a	6.47 a	5.53 a	4.97 a
LSD $_{(0.05)}$	**0.25**	**0.33**	**0.29**	**0.43**	**0.32**	**0.27**	**0.23**	**0.22**
CV (%)	**7.36**	**6.20**	**5.69**	**5.19**	**4.74**	**5.02**	**5.08**	**5.31**
Influence of treatment combination								
V_1T_1	1.25 h	1.76 i	1.11 i	2.08 k	1.28 l	1.98 j	1.42 i	1.44i
V_1T_2	1.53 gh	2.10 hi	2.10 h	3.29 j	2.43 k	2.46 i	2.33 h	1.69 i
V_1T_3	1.90fg	2.47 h	2.43h	4.46 i	3.23 j	3.30 h	2.52 h	2.36 h
V_1T_4	2.20 f	3.30 g	3.00 g	5.86 h	4.60 i	3.33 h	3.06 g	2.59 h
V_2T_1	2.96 e	3.70 g	4.40 f	6.66 g	5.63 h	4.13 g	3.61 f	3.26 g
V_2T_2	3.19 e	5.10 f	4.69 f	8.29 f	6.60 g	4.36 g	4.63 e	3.70 f
V_2T_3	3.63 d	5.76 e	5.63 e	9.30 e	7.30 f	5.46 f	4.73 e	4.45 e
V_2T_4	4.16 c	6.13 e	6.13 d	10.33d	8.36 e	6.33 e	5.56 d	4.59 e
V_3T_1	4.63 b	7.53 d	7.13 c	11.87 c	9.53 d	7.43 d	5.60 d	5.55 d
V_3T_2	4.93 b	8.43c	7.35 c	12.03 c	10.46 c	8.36 c	6.61 c	6.52 c
V_3T_3	4.95 b	9.26 b	8.26 b	13.27 b	11.40 b	9.10 b	7.57 b	7.20 b
V_3T_4	5.60 a	10.09 a	9.28 a	14.71 a	12.23 a	9.75 a	7.98 a	7.73 a
LSD $_{(0.05)}$	**0.43**	**0.57**	**0.49**	**0.75**	**0.56**	**0.47**	**0.40**	**0.38**
CV (%)	**7.36**	**6.20**	**5.69**	**5.19**	**4.74**	**5.02**	**5.08**	**5.31**

4.1.2.1 Yellow stem borer

4.1.2.1.1 Effect of variety

The incidence of insect pest (Yellow stem borer) varied significantly due to varietal variation (Table 2).It was observed that, the highest number (5.03) of yellow stem borer (YSB) found in V_3 and the lowest number (1.72) of YSB found in V_1 whereas the intermediate value (3.49) for YSB recorded in V_2.Therefore it was showed that V_1 was a resistant and V_3 was a susceptible to insect pests.

4.1.2.1.2 Effect of insecticide

The incidence of insect pest(Yellow stem borer) varied significantly due to insecticidal treatments (Table 2).In case of yellow stem borer, the highest number (3.99) of yellow stem borer was recorded from T_4 (untreated control), whereas the lowest number (2.95) was observed from T_1(applying Furadan 5G @ 10g/plot in two application).The incidence of insect pests (YSB) found in T_3(3.49) and T_2 (3.22) (applying Diazinon 10 G and Fifronil 3G respectively @ 10g/plot in two application) . This data was revealed that T_1 (Furadan 5G) was the most effective insecticide and followed by T_2 (Diazinon 10G) and T_3(Fifronil 3G).Similar kinds of results were also reported by Khan and Tarique (2011) and Mamun *et al.* (2011).

4.1.2.1.3Interaction effect of variety and different insecticides

The interaction effect of variety and different insecticides had significant effect on the incidence of insect pest (YSB) in *T. aman* rice field (Table 2).It was observed that the treatment combination of V_3T_4 resulted with the highest number (5.60) yellow stem borer and the lowest number(1.25) of YSB was found in V_1T_1 which was statistically similar with V_1T_2.

4.1.2.2 Leaf folder

4.1.2.2.1 Effect of variety

The incidence of insect pest (Leaf folder) varied significantly due to varietal variation (Table 2). It was observed that, the highest number (8.83) of leaf folder found in V_3 and the lowest number (2.41) of LF found in V_1 whereas the intermediate value (5.18) for leaf folder recorded in V_2.Therefore it was showed that V_1 was a resistant and V_3 was a susceptible to insect pest. Ahmed *et al.* (1997) and Alam *et al.* (1996) also reported that similar result.

4.1.2.2.2 Effect of insecticide

The incidence of insect pest (Leaf folder) varied significantly due to insecticidal treatments (Table 2).The highest number (6.51) of leaf folder was recorded from T_4 (untreated control), whereas the lowest number (4.33) was observed from T_1(appying Furadan 5G @ 10g/plot in two application).The incidence of insect pest(leaf folder) found in T_3(5.83) and T_2 (5.21) (applying Diazinon 10G and Fifronil 3G respectively @ 10g/plot in two application).The data was disclosed that T_1(Furadan 5G) was effective insecticide and followed by T_2 (Diazinon 10G) and T_3(Fifronil 3G). Islam *et al.* (2001) and Singh and Kumar (1999) also reported similar results.

4.1.2.2.3 Interaction effect of variety and different insecticides

The interaction effect of variety and different insecticides had significant effect on the incidence of insect pest (Leaf folder) in *T. aman* rice field (Table 2).It was observed that the treatment combination of V_3T_4 resulted with the highest number (10.09) leaf folder and the lowest number(1.76) of leaf folder found in V_1T_1 which was statistically similar with V_1T_2.

4.1.2.3 Rice hispa

4.1.2.3.1 Effect of variety

The incidence of insect pest (Rice hispa) varied significantly due to varietal variation (Table 2). It was observed that, the highest number (8.00) of rice hispa found in V_3 and the lowest number (2.16) of rice hispa found in V_1 whereas the intermediate value (5.21) for rice hispa was recorded in V_2.Therefore it was revealed that V_1 was a tolerant and V_3 was a susceptible to rice hispa.

4.1.2.3.2 Effect of insecticide

The incidence of insect pest (Rice hispa) varied significantly due to insecticidal treatments (Table 2).The highest number (6.14) of rice hispa was recorded from T_4 (untreated control), whereas the lowest number (4.21) was observed from T_1(applying Furadan 5G @ 10g/plot in two application).The incidence of insect pest (Rice hispa) found in T_3(5.44) and T_2 (4.72) (applying Diazinon 10G and Fifronil 3G respectively @ 10g/plot in two application).The data was proven that T_1(Furadan 5G) was effective insecticide and followed by T_2(Diazinon 10G) and T_3(Fifronil 3G).

4.1.2.3.3 Interaction effect of variety and different insecticides

The interaction effect of variety and different insecticides had significant effect on the incidence of insect pest (Rice hispa) in *T. aman* rice field (Table 2).It was observed that the treatment combination of V_3T_4 resulted with the highest number (9.28) rice hispa and the lowest number(1.11) of rice hispa found in V_1T_1.

4.1.2.4 Grasshopper

4.1.2.4.1 Effect of variety

The incidence of insect pest (Grasshopper) varied significantly due to varietal variation (Table 2). It was observed that, the highest number (12.97) of grasshopper found in V_3 and the lowest number (3.93) of grasshopper found in V_1 whereas the intermediate value (8.65) for grasshopper recorded in V_2.Therefore it was showed that V_1 was a tolerant and V_3 was a susceptible to grass hopper.

4.1.2.4.2 Effect of insecticide

The incidence of insect pests (Grasshopper) varied significantly due to insecticidal treatments (Table 2).The highest number (10.30) of grasshopper was recorded from T_4 (untreated control), whereas the lowest number (6.88) was observed from T_1(applying Furadan 5G @ 10g/plot in two application).The incidence of insect pest (Grasshopper) found in T_3(9.01) and T_2 (7.88) (applying Diazinon 10G and Fifronil 3G respectively @ 10g/plot in two application).This data was disclosed that

T_1(Furadan 5G) was effective insecticide and followed by T_2 (Diazinon 10G) and T_3(Fifronil 3G). Chandra and Pandey (2001), Ahmed *et al.* (1997) and Alam *et al.* (1996) also reported that similar result.

4.1.2.4.3 Interaction effect of variety and different insecticides

The interaction effect of variety and different insecticides had significant effect on the incidence of insect pest (Grasshopper) in *T. aman* rice field (Table 2).It was observed that the treatment combination of V_3T_4 resulted with the highest number (14.71) grasshopper and the lowest number (2.08) of grasshopper found in V_1T_1.

4.1.2.5 Brown plant hopper

4.1.2.5.1 Effect of variety

The incidence of insect pest (Brown plant hopper) varied significantly due to varietal variation (Table 2). It was observed that, the highest number (10.91) of BPH found in V_3 and the lowest number (2.89) of BPH found in V_1 whereas the intermediate value (6.97) for BPH recorded in V_2.Therefore it was showed that V_1 was a tolerant and V_3 was a susceptible to brown plant hopper.

4.1.2.5.2 Effect of insecticide

The incidence of insect pest (Brown plant hopper) varied significantly due to insecticidal treatments (Table 2).The highest number (8.34) of Brown plant hopper was recorded from T_4 (untreated control), whereas the lowest number (5.48) was observed from T_1(applying Furadan 5G @ 10g/plot in two application).The incidence of insect pest (Brown plant hopper) found in T_3(7.31) and T_2 (6.45) (applying Diazinon 10G and Fifronil 3G respectively @ 10g/plot in two application).The data was proven that T_1(Furadan 5G) was effective insecticide and followed by T_2 (Diazinon 10G) and T_3(Fifronil 3G).

4.1.2.5.3 Interaction effect of variety and different insecticides

The interaction effect of variety and different insecticides had significant effect on the incidence of insect pest (Brown plant hopper) in *T. aman* rice field (Table 2).It was observed that the treatment combination of V_3T_4 resulted with the highest number (12.23) Brown plant hopper and the lowest number (1.28) of Brown plant hopper found in V_1T_1.

4.1.2.6 Green leaf hopper

4.1.2.6.1 Effect of variety

The incidence of insect pest (Green leaf hopper) varied significantly due to varietal variation (Table 2). It was observed that, the highest number (8.66) of GLH found in V_3 and the lowest number (2.77) of GLH found in V_1 whereas the intermediate value (5.07) for GLH recorded in V_2.Therefore it was showed that V_1 was a resistant and V_3 was a susceptible to green plant hopper.

4.1.2.6.2 Effect of insecticide

The incidence of insect pest (Green leaf hopper) varied significantly due to insecticidal treatments (Table 2).The highest number (6.47) of Green leaf hopper was recorded from T_4 (untreated control), whereas the lowest number (4.51) was observed from T_1(applying Furadan 5G @ 10g/plot in two application).The incidence of insect pest (Green leaf hopper) found in T_3(5.96) and T_2 (5.06) (applying Diazinon 10G and Fifronil 3G respectively @ 10g/plot in two application).The data was proven that T_1(Furadan 5G) was effective insecticide and followed by T_2 (Diazinon 10G) and T_3(Fifronil 3G).

4.1.2.6.3 Interaction effect of variety and different insecticides

The interaction effect of variety and different insecticides had significant effect on the incidence of insect pest (Green leaf hopper) in *T. aman* rice field (Table 2).It was observed that the treatment combination of V_3T_4 resulted with the highest number(9.76) Green leaf hopper and the lowest number (1.98) of Green leaf hopper found in V_1T_1.

4.1.2.7 Rice bug

4.1.2.7.1 Effect of variety

The incidence of insect pest (Rice bug) varied significantly due to varietal variation (Table 2). It was observed that, the highest number (6.94) of rice bug found in V_3 and the lowest number (2.33) of rice bug found in V_1 whereas the intermediate value (4.63) for rice bug recorded in V_2.Therefore it was showed that V_1 was a resistant and V_3 was a susceptible to rice bug.

4.1.2.7.2 Effect of insecticide

The incidence of insect pest (Rice bug) varied significantly due to insecticidal treatments (Table 2).The highest number (5.53) of Rice bug was recorded from T_4 (untreated control), whereas the lowest number (3.54) was observed from T_1(applying Furadan 5G @ 10g/plot in two application).The incidence of insect pest (Rice bug) found in T_3(4.94) and T_2 (4.52) (applying Diazinon 10G and Fifronil 3G respectively @ 10g/plot in two application).The data was revealed that T_1(Furadan 5G) was effective insecticide and followed by T_2 (Diazinon 10G) and T_3(Fifronil 3G).

4.1.2.7.3 Interaction effect of variety and different insecticides

The interaction effect of variety and different insecticides had significant effect on the incidence of insect pest (Rice bug) in *T. aman* rice field (Table 2).It was observed that the treatment combination of V_3T_4 resulted with the highest number (7.98) Rice bug and the lowest number (1.42) of Rice bug found in V_1T_1.

4.1.2.8 Rice stink bug

4.1.2.8.1 Effect of variety

The incidence of insect pest (Rice stink bug) varied significantly due to varietal variation (Table 2). It was observed that, the highest number (6.75) of Rice stink bug found in V_3 and the lowest number (2.02) of Rice stink bug found in V_1.whereas the intermediate value (4.00) for Rice stink bug recorded in V_2.Therefore it was disclosed that V_1 was a resistant and V_3 was a susceptible to rice stink bug.

4.1.2.8.2 Effect of insecticide

The incidence of insect pest (Rice stink bug) varied significantly due to insecticidal treatments (Table 2).The highest number (4.97) of Rice stink bug was recorded from T_4 (untreated control), whereas the lowest number (3.42) was observed from T_1(applying Furadan 5G @ 10g/plot in two application).The incidence of insect pest (Rice stink bug) found in T_3(4.68) and T_2 (3.97) (applying Diazinon 10G and Fifronil 3G respectively @ 10g/plot in two application).The data was proven that T_1(Furadan 5G) was effective insecticide and followed by T_2 (Diazinon 10G) and T_3(Fifronil 3G).Bisne *et al.* (2006) and Jones *et al.* (1996) also found similar results.

4.1.2.8.3 Interaction effect of variety and different insecticides

The interaction effect of variety and different insecticides had significant effect on the incidence of insect pest (Rice stink bug) in *T. aman* rice field (Table 2).It was observed that the treatment combination of V_3T_4 resulted with the highest number (7.73) Rice stink bug and the lowest number (1.44) of Rice stink bug found in V_1T_1which was statistically similar with V_1T_2.

4.2 Infestation by different insect pests in different stages

4.2.1 Dead heart symptom

4.2.1.1 Effect of variety

The effect of variety on dead heart infestation caused by yellow stem borer at vegetative stages was given in Table 3. Data was counted from 5 selected hills/plot observed that the highest number of healthy tillers (42.37) was recorded from V_1which was followed (37.63) by V_2.The lowest number of healthy tillers (33.25) was recorded from V_3.. In case of infested tillers, the lowest number (1.28) was observed from V_1 and the highest number (4.52) found in V_3.This symptom of YSB is called dead heart symptom.The lowest infestation (2.98%) was counted from V_1which was followed by (7.80%) to V_2.The highest infestation was recorded (12.04%) from V_3.

4.2.1.2 Effect of insecticides

The effect of granular insecticides on dead heart infestation caused by yellow stem borer at vegetative stages was given in (Table 3).Data recorded from 5 selected hills/plot observed that the highest number of healthy tillers (39.56) was recorded from T_1(applying Furadan 5G @ 10g/plot in two application) which was statistically similar with T_2. The lowest number of healthy tillers (35.56) was recorded in T_4 (untreated control).In case of infested tillers, the lowest number (2.24) was recorded in T_1 which was followed (2.75 and 3.31) from T_2 and T_3 respectively, Whereas the highest number of infested tillers (3.67) from T_4. This symptom of YSB called dead heart symptom. During infestation level the lowest infestation (5.53%) was observed from T1, whereas the highest infestation (9.61%) was recorded from T_4. Similar kinds of results were also reported by Khan and Tarique (2011) and Hassan *et al.* (2010).

Plate 2. The rice plants showing dead heart (A) white head (B) symptom in the experimental field

4.2.1.3 Interaction effect of variety and different insecticides

The interaction effect of variety and different insecticides had significant effect on the number of healthy tillers(Table 3).The highest number of healthy tillers (44.67) was recorded from V_1T_1 which was statistically similar with V_1T_2.The lowest number healthy tillers (31.00) observed from V_3T_4 which was statistically similar with V_3T_3.In case of infested tillers, The lowest number infested tillers (0.62) was recorded from V_1T_1 which was statistically similar with V_1T_2 and the highest number of infested tillers (5.22) was observed from V_3T_4.During infestation level the lowest infestation (1.37%) was revealed from V_1T_1which was statistically similar with V_1T_2, whereas the highest infestation (14.42%) was recorded from V_3T_4

Plate 03: Adult rice stem borer in the rice plants in the experimental field during the study period

Plate 4. Infested rice sheath with caterpillar of due to white head symptom causes by yellow stem borer

Table 3.Efficiency of variety and granular insecticides against rice yellow Stem borer (dead heart) infestation

Influence of variety

Treatment	No. of healthy tillers	No. of infested tillers	Percentage of infested tillers
V_1	42.37 a	1.28 c	2.98 c
V_2	37.63 b	3.17 b	7.80 b
V_3	33.25 c	4.52 a	12.04 a
LSD $_{(0.05)}$	1.19	0.19	0.43
CV (%)	3.74	7.28	6.64

Influence of insecticide treatment

Treatment	No. of healthy tillers	No. of infested tillers	Percentage of infested tillers
T_1	39.56 a	2.24 d	5.53 d
T_2	38.82 a	2.75 c	6.82 c
T_3	37.07 b	3.31 b	8.44 b
T_4	35.56 c	3.67 a	9.61 a
LSD $_{(0.05)}$	1.38	0.21	0.49
CV (%)	3.74	7.28	6.64

Influence of treatment combination

Treatment	No. of healthy tillers	No. of infested tillers	Percentage of infested tillers
V_1T_1	44.67 a	0.62 f	1.37 i
V_1T_2	42.80 ab	0.95 f	2.17 i
V_1T_3	41.67 bc	1.60 e	3.71 h
V_1T_4	40.33 cd	1.96 e	4.66 g
V_2T_1	38.00 def	2.46 d	6.09f
V_2T_2	39.67 cde	2.80 d	6.59 f
V_2T_3	37.53 efg	3.60 c	8.75 e
V_2T_4	35.33 gh	3.83 c	9.77 d
V_3T_1	36.00 fgh	3.63 c	9.14 de
V_3T_2	34.00 hi	4.50 b	11.71 c
V_3T_3	32.00 ij	4.73 b	12.88 b
V_3T_4	31.00 j	5.22 a	14.42 a
LSD $_{(0.05)}$	2.39	0.37	0.86
CV (%)	3.74	7.28	6.64

V_1=BRRI dhan33, V_2=BRRI dhan49, V_3=BRRI dhan51

T_1=Furadan 5G, T_2=Diazinon 10G, T_3=Fifronil 3G,T_4=untreated control

4.2.2 White head symptom

4.2.2.1 Effect of variety

The effect of variety on white head infestation caused by yellow stem borer at reproductive stages was given in (Table 4). Data was recorded from 5 selected hills/plot observed that the highest number of healthy tillers (42.58) was recorded from V_1which was followed (38.69) by V_2.The lowest number of healthy tillers (34.67) was recorded from $V_{3.}$.In case of infested tillers, the lowest number (1.26) was observed from V_1 and the highest number (5.13) found in $V_{3.}$This symptom of YSB is called white head symptom. The lowest infestation (2.89%) was counted from V_1which was followed by (7.57%) to $V_{2.}$The highest infestation was recorded (12.92%) from $V_{3.}$

4.2.2.2 Effect of insecticides

Data recorded from 5 selected hills/plot observed that the highest number of healthy tillers (41.06) was recorded from T_1 (applying Furadan 5G @ 5g at 30 days interval in two times) which was closely followed (39.14 and 38.06) from $T_2$and T_3respectively (applying Diazinon 10G and Fifronil 3G respectively 10g/plot in two application). The lowest number of healthy tillers (36.33) was recorded in T_4 (untreated control).In case of infested tillers, the lowest number (2.45) was recorded in T1 which was followed (2.98 and 3.32) from T2 and T_3 respectively, Whereas the highest number of infested tillers (3.94) from T4. This symptom of YSB called white head symptom. During infestation level the lowest infestation (5.77%) was observed from T1, whereas the highest infestation (9.96%) was recorded from T4. Similar kinds of results were also reported by Khan and Tarique (2011) and Mamun *et al.* (2011).

4.2.2.3 Interaction effect of variety and different insecticides

The interaction effect of variety and different insecticides had significant effect on the number of healthy tillers(Table 4).The highest number of healthy tillers (44.68) was recorded from V_1T_1 which was statistically similar with V_1T_2 and the lowest number healthy tillers (32.67) observed from V_3T_4 which was statistically similar with V_3T_3.In case of infested tillers, The lowest number infested tillers (0.64) was recorded from V_1T_1 which was statistically similar with V_1T_2 and the highest number of infested tillers (5.90) was observed from V_3T_4.The lowest infestation (1.42%) was observed from V_1T_1, whereas the highest infestation (15.30%) was recorded from V_3T_4.

4.2.3 Leaf infestation by leaf folder

4.2.3.1 Effect of variety

The effect of variety on leaf infestation caused by leaf folder showed statistically significant variation (Table 5). Data was counted from 5 selected hills/plot observed that the highest number of healthy leaves (492.5) was recorded from V_1 and the lowest number of healthy leaves (451.7) was recorded from V_3which was statistically similar with V_2.In case of infested leaves, the lowest number (11.73) was observed from V_1 and the highest number (36.14) found in V_3. During infestation level the lowest infestation (2.33%) was counted from V_1 followed by (5.06%) to V_2.The highest infestation was recorded (7.44%) from V_3.

Table 4'Efficiency of variety and granular insecticides against rice yellow stem borer (White head symptom) infestation

Influence of variety

Treatment	No. of healthy tillers	No. of infested tillers	Percentage of infested tillers
V_1	42.58 a	1.25 c	2.89 c
V_2	38.69 b	3.14 b	7.56 b
V_3	34.67 c	5.12 a	12.92 a
LSD $_{(0.05)}$	0.80	0.22	0.34
CV (%)	2.43	8.11	5.19
Influence of insecticide treatment			
Treatment	No. of healthy tillers	No. of infested tillers	Percentage of infested tillers
T_1	41.06 a	2.44 d	5.76 d
T_2	39.14 b	2.98 c	7.25 c
T_3	38.06 c	3.32 b	8.19 b
T_4	36.33 d	3.94 a	9.96 a
LSD $_{(0.05)}$	0.92	0.25	0.40
CV (%)	2.43	8.11	5.19
Influence of treatment combination			
Treatment	No. of healthy tillers	No. of infested tillers	Percentage of infested tillers
V_1T_1	44.67 a	0.64 h	1.42 j
V_1T_2	43.33 ab	1.04 gh	2.36 i
V_1T_3	42.00 bc	1.30 g	3.00 i
V_1T_4	40.33 de	2.03 f	4.80 h
V_2T_1	41.50 cd	2.26 f	5.19 h
V_2T_2	39.10 ef	3.06 e	7.27 g
V_2T_3	38.17 fg	3.33e	8.03 f
V_2T_4	36.00 hi	3.90 d	9.77 e
V_3T_1	37.00 gh	4.43 c	10.69 d
V_3T_2	35.00 ij	4.83 c	12.13 c
V_3T_3	34.00 jk	5.33 b	13.56 b
V_3T_4	32.67 k	5.90 a	15.30 a
LSD $_{(0.05)}$	1.59	0.44	0.69
CV (%)	2.43	8.11	5.19

V_1=BRRI dhan33, V_2=BRRI dhan49, V_3=BRRI dhan51

T_1=Furadan 5G, T_2=Diazinon 10G, T_3=Fifronil 3G,T_4=untreated control

4.2.3.2 Effect of insecticides

The effect of granular insecticides on leaf infestation caused by leaf folder showed statistically significant variation (Table 5).Data recorded from 5 selected hills/plot observed that the highest number of healthy leaves (480.8) was recorded from T_1(applying Furadan 5G @ 10g/plot in two application) which was statistically similar with T_2 and T_3. The lowest number of healthy leaves (455.7) was recorded in T_4 (untreated control).In case of infested leaves, the lowest number (19.08) was recorded in T_1 which was followed (22.44 and 26.11) from T_2 and T_3 respectively, Whereas the highest number of infested leaves (29.08) from T_4.The lowest infestation (3.84%) was observed from T_1, whereas the highest infestation (6.05%) was recorded from T_4. Bisne *et al.* (2006) and Jones *et al.* (1996) also found similar results.

4.2.3.3 Interaction effect of variety and different insecticides

The interaction effect of variety and different insecticides had significant effect on the number of healthy leaves. (Table 5).The highest number of healthy leaves (501.7) was recorded from V_1T_1 which was statistically similar with V_1T_2,V_1T_3,V_1T_4,$V_2T_1$and V_2T_2.The lowest number healthy leaves (433.3) observed from V_3T_4 which was statistically similar with V_3T_3,V_3T_2,V_3T_1,V_2T_4 and V_2T_3.In case of infested leaves, The lowest number infested leaves (7.23) was recorded from V_1T_1 and the highest number of infested leaves (40.90) was observed from V_3T_4.The lowest infestation (1.42%) was observed from V_1T_1 which was statistically similar with V_1T_2 whereas the highest infestation (8.66%) was recorded from V_3T_4.

Table 5.Efficiency of variety and granular insecticides against leaf infestation caused by leaf folder

Influence of variety			
Treatment	No. of healthy leaves	No. of infested leaves	Percentage of infested leaves
V_1	492.5 a	11.73 c	2.33 c
V_2	463.6 b	24.67 b	5.06 b
V_3	451.7 b	36.14 a	7.44 a
LSD $_{(0.05)}$	17.26	1.15	0.32
CV (%)	4.34	5.62	7.68
Influence of insecticide treatment			
Treatment	No. of healthy leaves	No. of infested leaves	Percentage of infested leaves
T_1	480.8 a	19.08 d	3.84 d
T_2	474.2 ab	22.44 c	4.55 c
T_3	466.3 ab	26.11 b	5.34 b
T_4	455.7 b	29.08 a	6.05 a
LSD $_{(0.05)}$	19.93	1.33	0.37
CV (%)	4.34	5.62	7.68
Influence of treatment combination			
Treatment	No. of healthy leaves	No. of infested leaves	Percentage of infested leaves
V_1T_1	501.7 a	7.23 j	1.42 h
V_1T_2	496.7 ab	10.00 i	1.97 h
V_1T_3	490.0 abc	14.00 h	2.79 g
V_1T_4	481.7 abcd	15.67 h	3.15 fg
V_2T_1	475.0 abcd	18.33 g	3.72 f
V_2T_2	468.3 abcd	23.00 f	4.70 e
V_2T_3	459.0 cde	26.67 e	5.48 d
V_2T_4	452.0 de	30.67 d	6.35 c
V_3T_1	465.7 bcde	31.67 d	6.38 c
V_3T_2	457.7 cde	34.33 c	6.98 c
V_3T_3	450.0 de	37.67 b	7.76 b
V_3T_4	433.3 e	40.90 a	8.66 a
LSD $_{(0.05)}$	34.51	2.30	0.64
CV (%)	4.34	5.62	7.68

V_1=BRRI dhan33, V_2=BRRI dhan49, V_3=BRRI dhan51

T_1=Furadan 5G, T_2=Diazinon 10G, T_3=Fifronil 3G,T_4=untreated control

4.2.4 Leaf infestation by rice hispa

4.2.4.1 Effect of variety

The effect of variety on leaves infestation caused by Rice hispa revealed statistically significant variation (Table 6). Data was counted from 5 selected hills/plot observed that the highest number of healthy leaves (479.8) was recorded from V_1 which was followed (458.7) by $V_2$and the lowest number of healthy leaves (437.8) was recorded from $V_{3.}$ In case of infested leaves, the lowest number (13.63) was observed from V_1 and the highest number (47.42) found in V_3.The lowest infestation (2.76%) was counted from V_1which was followed by (5.36%) from $V_{2.}$The highest infestation was recorded (9.77%) from $V_{3.}$

4.2.4.2 Effect of insecticides

The effect of granular insecticides on leaf infestation caused by Rice hispa showed statistically significant variation (Table 6).Data recorded from 5 selected hills/plot observed that the highest number of healthy leaves (468.1) was recorded from T_1(applying Furadan 5G @ 10g/plot in two application) which was statistically similar with T_2. The lowest number of healthy leaves (449.6) was recorded in T_4 (untreated control) which was statistically similar with T_3.In case of infested leaves, the lowest number (21.61) was recorded in T_1 which was followed (26.33 and 33.00) from T_2 and T_3 respectively, Whereas the highest number of infested leaves (35.11) from T_4. The lowest infestation (4.44%) was observed from T_1, whereas the highest infestation (7.26%) was recorded from T_4.Chandra and Pandey (2001), Ahmed *et al.* (1997) and Alam *et al.* (1996) also reported that similar result.

4.2.3.3 Interaction effect of variety and different insecticides

The highest number of healthy leaves (488.3) was recorded from V_1T_1 which was statistically similar with V_1T_2, V_1T_3 and V_1T_4.The lowest number of healthy leaves (425.00) was observed from V_3T_4 which was statistically similar with $V_3T_3$and V_3T_2.In case of infested leaves, The lowest number of infested leaves (11.17) was recorded from V_1T_1 which was statistically similar with V_1T_2 and the highest number of infested leaves (57.33) which was statistically similar with V_3T_3.The lowest infestation (2.23%) was observed from V_1T_1 which was statistically similar with V_1T_2,whereas the highest infestation (11.88%) was recorded from V_3T_4which was statistically similar with V_3T_3.

4.2.5 Leaf infestation by grasshopper

4.2.5.1 Effect of variety

The effect of variety on leaves infestation caused by Grass hopper showed statistically significant variation (Table 7). Data was counted from 5 selected hills/plot observed that the highest number of healthy leaves (500.3) was recorded from V_1 which was followed (480.5) by V_2 and the lowest number of healthy leaves (456.8) was recorded from V_3. In case of infested leaves, the lowest number (12.67) was observed from V_1 and the highest number (46.42) found in V_3. The lowest infestation (2.47%) was counted from V_1which was followed by (4.90%) from V_2.The highest infestation was recorded (9.22%) from V_3.

Table 6.Efficiency of variety and granular insecticides against leaf infestation caused by Rice hispa

Influence of variety			
Treatment	No. of healthy leaves	No. of infested leaves	Percentage of infested leaves
V_1	479.8 a	13.63 c	2.76 c
V_2	458.7 b	26.00 b	5.36 b
V_3	437.8 c	47.42 a	9.77 a
LSD $_{(0.05)}$	10.35	1.40	0.21
CV (%)	2.66	5.70	4.12
Influence of insecticide treatment			
Treatment	No. of healthy leaves	No. of infested leaves	Percentage of infested leaves
T_1	468.1 a	21.61 d	4.44 d
T_2	462.3 ab	26.33 c	5.407 c
T_3	455.0 bc	33.00 b	6.76 b
T_4	449.6 c	35.11 a	7.25 a
LSD $_{(0.05)}$	11.95	1.62	0.24
CV (%)	2.66	5.70	4.12
Influence of treatment combination			
Treatment	No. of healthy leaves	No. of infested leaves	Percentage of infested leaves
V_1T_1	488.3 a	11.17 h	2.23 i
V_1T_2	481.7 ab	13.00 gh	2.63 hi
V_1T_3	478.0 abc	14.67 g	2.97 gh
V_1T_4	471.0 abcd	15.67 g	3.22 g
V_2T_1	466.0 bcde	19.67 f	4.05 f
V_2T_2	460.3 cdef	24.00 e	4.95 e
V_2T_3	455.7 def	28.00 d	5.79 d
V_2T_4	452.7 def	32.33 c	6.67 c
V_3T_1	450.0 efg	34.00 c	7.04 c
V_3T_2	445.0 fgh	42.00 b	8.63 b
V_3T_3	431.3 gh	56.33 a	11.53 a
V_3T_4	425.0 h	57.33 a	11.88 a
LSD $_{(0.05)}$	20.70	2.80	0.41
CV (%)	2.66	5.70	4.12

V_1=BRRI dhan33, V_2=BRRI dhan49, V_3=BRRI dhan51

T_1=Furadan 5G, T_2=Diazinon 10G, T_3=Fifronil 3G,T_4=untreated control

4.2.5.2 Effect of insecticides

The effect of granular insecticides on leaves infestation caused by Grass hopper showed statistically significant variation (Table 7).Data recorded from 5 selected hills/plot observed that the highest number of healthy leaves (488.7) was recorded from T_1(applying Furadan 5G @ 10g/plot in two application) which was statistically similar with T_2. The lowest number of healthy leaves (469.4) was recorded in T_4 (untreated control) which was statistically similar with T_3.In case of infested leaves, the lowest number (22.67) was recorded in T_1 which was followed (25.44 and 27.89) from T_2 and T_3 respectively, Whereas the highest number of infested leaves (35.89) from T_4.The lowest infestation (4.44%) was observed from T_1, whereas the highest infestation (7.10%) was recorded from T_4. Similar kinds of results were also reported by Khan and Tarique (2011) and Mamun *et al.* (2011).

4.2.5.3 Interaction effect of variety and different insecticides

The interaction effect of variety and different insecticides had significant effect on the number of healthy leaves (Table 7).The highest number of healthy leaves (510.0) was recorded from V_1T_1 which was statistically similar with V_1T_2, V_1T_3 and V_1T_4.The lowest number of healthy leaves (443.3) observed from V_3T_4 which was statistically similar with V_3T_3.In case of infested leaves, The lowest number of infested leaves (11.00) was recorded from V_1T_1 which was statistically similar with V_1T_2 and V_1T_3. The highest number of infested leaves (60.67) was recorded from V_3T_4.The lowest infestation (2.10%) was observed from V_1T_1 which was statistically similar with V_1T_2 and V_1T_3.whereas the highest infestation (12.03%) was recorded from V_3T_4.

Table 7.Efficiency of variety and granular insecticides against leaf infestation caused by Grass hopper

Influence of variety			
Treatment	No. of healthy leaves	No. of infested leaves	Percentage of infested leaves
V_1	500.3 a	12.67 c	2.47 c
V_2	480.5 b	24.83 b	4.90 b
V_3	456.8 c	46.42 a	9.22 a
LSD (0.05)	9.64	1.70	0.23
CV (%)	2.38	7.19	4.88
Influence of insecticide treatment			
Treatment	No. of healthy leaves	No. of infested leaves	Percentage of infested leaves
T_1	488.7 a	22.67 d	4.447 d
T_2	482.8 ab	25.44 c	5.021 c
T_3	475.9 bc	27.89 b	5.561b
T_4	469.4 c	35.89 a	7.104 a
LSD (0.05)	11.13	1.97	0.26
CV (%)	2.38	7.19	4.88
Influence of treatment combination			
Treatment	No. of healthy leaves	No. of infested leaves	Percentage of infested leaves
V_1T_1	510.0 a	11.00 i	2.10 i
V_1T_2	503.3 ab	12.00 hi	2.33 i
V_1T_3	495.7 abc	13.00 hi	2.55 hi
V_1T_4	492.0 abcd	14.67 gh	2.89 h
V_2T_1	486.7 bcde	17.33 g	3.43 g
V_2T_2	482.0 cdef	23.00 f	4.55 f
V_2T_3	480.3 cdef	26.67 e	5.25 e
V_2T_4	473.0 def	32.33 d	6.38 d
V_3T_1	469.3 efg	39.67 c	7.79 c
V_3T_2	463.0 fg	41.33 bc	8.18 c
V_3T_3	451.7 gh	44.00 b	8.87 b
V_3T_4	443.3 h	60.67 a	12.03 a
LSD (0.05)	19.28	3.41	0.46
CV (%)	2.38	7.19	4.88

V_1=BRRI dhan33, V_2=BRRI dhan49, V_3=BRRI dhan51

T_1=Furadan 5G, T_2=Diazinon 10G, T_3=Fifronil 3G,T_4=untreated control

4.2.6 Tiller infestation by brown plant hopper

4.2.6.1 Effect of variety

The effect of variety on tillers infestation caused by Brown plant hopper showed statistically significant variation (Table 8). Data was recorded from 5 selected hills/plot observed that the highest number of healthy tillers (47.33) was recorded from V_1 which was followed (43.38) by $V_2$and the lowest number of healthy tillers (39.21) was recorded from $V_{3.}$ In case of infested tillers, the lowest number (1.65) was observed from V_1 and the highest number of tillers (4.70) found in V_3. During infestation level the lowest infestation (3.38%) was counted from V_1which was followed by (6.00%) from V_2. The highest infestation was recorded (10.80%) from $V_{3.}$

4.2.5.2 Effect of insecticides

The effect of granular insecticides on leaf infestation caused by Brown plant hopper showed statistically significant variation (Table 8).Data recorded from 5 selected hills/plot observed that the highest number of healthy tillers (45.11) was recorded from T_1(applying Furadan 5G @ 10g/plot in two application) which was statistically similar with T_2. The lowest number of healthy tillers (41.33) was recorded in T_4 (untreated control).In case of infested tillers, the lowest number (2.27) was recorded in T_1 which was followed (2.73 and 23.24) from T_2 and T_3 respectively, Whereas the highest number of infested tillers (3.90) from T_4. The lowest infestation (4.90%) was observed from T_1, whereas the highest infestation (8.83%) was recorded from T_4.Bisne *et al.* (2006) and Jones *et al.* (1996) also found similar results.

4.2.5.3 Interaction effect of variety and different insecticides

The interaction effect of variety and different insecticides had significant effect on the number of healthy tillers (Table 8).The highest number of healthy tillers (49.33) was recorded from V_1T_1 which was statistically similar with V_1T_2. The lowest number of healthy tillers (36.33) observed from V_3T_4 which was statistically similar with V_3T_3.In case of infested tillers, The lowest number of infested tillers (1.30) was recorded from V_1T_1 which was statistically similar with V_1T_2 and the highest number of infested tillers (6.50) was recorded from V_3T_4.The lowest infestation (2.57%) was observed from V_1T_1 which was statistically similar with V_1T_2, whereas the highest infestation (15.22%) was recorded from V_3T_4.

4.2.7 Leaf infestation by green leaf hopper

4.2.7.1 Effect of variety

The effect of variety on leaves infestation caused by Green leaf hopper showed statistically significant variation (Table 9). Data was recorded from 5 selected hills/plot observed that the highest number of healthy leaves (520.00) was recorded from V_1 which was followed (468.8) by $V_2$and the lowest number of healthy leaves (432.1) was recorded from V_3. In case of infested leaves, the lowest number of infested leaves (29.25) was observed from V_1 and the highest number (61.58) found in V_3. The lowest infestation (5.37%) was counted from V_1which was followed by (8.25%) from V_2.The highest infestation was recorded (12.45%) from V_3.

Table 8 Efficiency of variety and granular insecticides against tiller infestation caused by Brown plant hopper

Influence of variety			
Treatment	No. of healthy tillers	No. of infested tillers	Percentage of infested tillers
V_1	47.33 a	1.64 c	3.38 c
V_2	43.38 b	2.75 b	6.00 b
V_3	39.21 c	4.70 a	10.80 a
LSD $_{(0.05)}$	1.18	0.18	0.34
CV (%)	3.21	7.08	6.01
Influence of insecticide treatment			
Treatment	No. of healthy tillers	No. of infested tillers	Percentage of infested tillers
T_1	45.11 a	2.27 d	4.90 d
T_2	44.06 ab	2.73 c	5.95 c
T_3	42.72 b	3.24 b	7.21 b
T_4	41.33 c	3.90 a	8.83 a
LSD $_{(0.05)}$	1.36	0.21	0.40
CV (%)	3.21	7.08	6.01
Influence of treatment combination			
Treatment	No. of healthy tillers	No. of infested tillers	Percentage of infested tillers
V_1T_1	49.33 a	1.30 h	2.57 h
V_1T_2	47.67 ab	1.36 h	2.79 h
V_1T_3	46.67 bc	1.86 g	3.83 g
V_1T_4	45.67 bcd	2.06 fg	4.33 fg
V_2T_1	44.33 cde	2.23 f	4.80 f
V_2T_2	44.00 def	2.80 e	5.98 e
V_2T_3	43.17 ef	2.86 e	6.25 e
V_2T_4	42.00efg	3.13 de	6.96 d
V_3T_1	41.67 fg	3.30 d	7.34 d
V_3T_2	40.50 gh	4.03 c	9.08 c
V_3T_3	38.33 hi	5.00 b	11.55 b
V_3T_4	36.33 i	6.50 a	15.22 a
LSD $_{(0.05)}$	2.35	0.36	0.69
CV (%)	3.21	7.08	6.01

V_1=BRRI dhan33, V_2=BRRI dhan49, V_3=BRRI dhan51

T_1=Furadan 5G, T_2=Diazinon 10G, T_3=Fifronil 3G,T_4=untreated control

4.2.7.2 Effect of insecticides

The effect of granular insecticides on leaves infestation caused by Green leaf hopper showed statistically significant variation (Table 9).Data was recorded from 5 selected hills/plot observed that the highest number of healthy leaves (497.8) was recorded from T_1(applying Furadan 5G @ 10g/plot in two application). The lowest number of healthy leaves (455.0) was recorded in T_4 (untreated control) which was statistically similar with T_3.In case of infested leaves, the lowest number (35.44) was recorded in T1 which was followed (41.00 and 46.00) from T_2 and T_3 respectively, Whereas the highest number of infested leaves (54.78) from T_4. During infestation level the lowest infestation (6.81%) was observed from T_1, whereas the highest infestation (10.81%) was recorded from T4. Similar kinds of results were also reported by Khan and Tarique (2011) and Mamun *et al.* (2011).

4.2.7.3 Interaction effect of variety and different insecticides

The interaction effect of variety and different insecticides had significant effect on the number of healthy leaves (Table 9).The highest number of healthy leaves (560.0) was recorded from V_1T_1 and the lowest number of healthy leaves (420.0) observed from V_3T_4 which was statistically similar with $V_3T_3$and V_3T_2.In case of infested leaves, The lowest number of infested leaves (22.00) was recorded from V_1T_1 and the highest number of infested leaves (83.33) was recorded from V_3T_4..During infestation level the lowest infestation (3.78%) was observed from V_1T_1 whereas the highest infestation (16.56%) was recorded from V_3T_4.

Table 9.Efficiency of variety and granular insecticides against leaves infestation caused by Green leaf hopper

Influence of variety			
Treatment	No. of healthy leaves	No. of infested leaves	Percentage of infested leaves
V_1	520.0 a	29.25 c	5.36 c
V_2	468.8 b	42.08 b	8.25 b
V_3	432.1 c	61.58 a	12.45 a
LSD $_{(0.05)}$	8.67	1.69	0.27
CV (%)	2.16	4.51	3.61
Influence of insecticide treatment			
Treatment	No. of healthy leaves	No. of infested leaves	Percentage of infested leaves
T_1	497.8 a	35.44 d	6.81 d
T_2	477.2 b	41.00 c	8.02 c
T_3	464.4 c	46.00 b	9.10 b
T_4	455.0 c	54.78 a	10.81a
LSD $_{(0.05)}$	10.01	1.95	0.31
CV (%)	2.16	4.51	3.61
Influence of treatment combination			
Treatment	No. of healthy leaves	No. of infested leaves	Percentage of infested leaves
V_1T_1	560.0 a	22.00 j	3.78 i
V_1T_2	523.3 b	27.67 i	5.02 h
V_1T_3	503.3 c	32.33 h	6.03 g
V_1T_4	493.3 c	35.00 gh	6.62 f
V_2T_1	486.7 cd	36.33 g	6.95 f
V_2T_2	473.3 de	42.00 f	8.14 e
V_2T_3	463.3 ef	44.00 ef	8.66 e
V_2T_4	451.7 fg	46.00 de	9.24 d
V_3T_1	446.7 fg	48.00 d	9.70 d
V_3T_2	435.0 gh	53.33 c	10.91c
V_3T_3	426.7 h	61.67 b	12.62 b
V_3T_4	420.0 h	83.33 a	16.56 a
LSD $_{(0.05)}$	17.34	3.38	0.53
CV (%)	2.16	4.51	3.61

V_1=BRRI dhan33, V_2=BRRI dhan49, V_3=BRRI dhan51

T_1=Furadan 5G, T_2=Diazinon 10G, T_3=Fifronil 3G,T_4=untreated control

4.2.8 Panicle infestation by rice bug

4.2.8.1 Effect of variety

The effect of variety on panicles infestation caused by Rice bug showed statistically significant variation (Table 10). Data was recorded from 5 selected hills/plot observed that the highest number of healthy panicles (45.83) was recorded from V_1 which was followed (43.92) by $V_2$and the lowest number of healthy panicles (40.42) was recorded from $V_{3.}$ In case of infested panicles, the lowest number of infested panicles (2.01) was observed from V_1 and the highest number (5.40) found in V_3. The lowest infestation (4.21%) was counted from V_1which was followed by (6.18%) from $V_{2.}$The highest infestation was recorded (11.77%) from $V_{3.}$

4.2.8.2 Effect of insecticides

The effect of granular insecticides on panicles infestation caused by Rice bug showed statistically significant variation (Table 10).Data was recorded from 5 selected hills/plot observed that the highest number of healthy panicles (44.33) was recorded from T_1(applying Furadan 5G @ 10g/plot in two application) which was statistically similar with T_2. The lowest number of healthy panicles (42.44) was recorded in T_4 (untreated control) which was statistically similar with T_3.In case of infested panicles, the lowest number (2.78) was recorded in T_1 which was statistically similar with T_2, whereas the highest number of infested panicles (4.41) from T_4. During infestation level the lowest infestation (5.93%) was observed from T_1, whereas the highest infestation (9.47%) was recorded from T4.Bisne *et al.* (2006) and Jones *et al.* (1996) also found similar results.

Table 10.Efficiency of variety and granular insecticides against panicle infestation caused by Rice bug

Influence of variety			
Treatment	No. of healthy panicles	No. of infested panicles	Percentage of infested panicles
V_1	45.83 a	2.01 c	4.21 c
V_2	43.92 b	2.89 b	6.18 b
V_3	40.42 c	5.40 a	11.77 a
LSD $_{(0.05)}$	0.84	0.20	0.39
CV (%)	2.28	6.85	6.29
Influence of insecticide treatment			
Treatment	No. of healthy panicles	No. of infested panicles	Percentage of infested panicles
T_1	44.33 a	2.78 c	5.96 c
T_2	43.67 ab	2.95 c	6.38 c
T_3	43.11 bc	3.58 b	7.73 b
T_4	42.44 c	4.41 a	9.47 a
LSD $_{(0.05)}$	0.97	0.23	0.45
CV (%)	2.28	6.85	6.29
Influence of treatment combination			
Treatment	No. of healthy panicles	No. of infested panicles	Percentage of infested panicles
V_1T_1	46.33 a	1.83 h	3.81 h
V_1T_2	46.00 a	1.95 h	4.09 gh
V_1T_3	45.67 ab	2.06 gh	4.33 gh
V_1T_4	45.33 abc	2.20 fgh	4.62 fg
V_2T_1	45.00 abc	2.43 efg	5.13 ef
V_2T_2	44.00 bcd	2.56 ef	5.51 e
V_2T_3	43.67 cd	2.70 e	5.82 e
V_2T_4	43.00 de	3.86 d	8.25 d
V_3T_1	41.67 ef	4.10 cd	8.94 cd
V_3T_2	41.00 f	4.33 c	9.55 c
V_3T_3	40.00 fg	6.000 b	13.06 b
V_3T_4	39.00 g	7.167 a	15.54 a
LSD $_{(0.05)}$	1.68	0.40	0.79
CV (%)	2.28	6.85	6.29

V_1=BRRI dhan33, V_2=BRRI dhan49, V_3=BRRI dhan51

T_1=Furadan 5G, T_2=Diazinon 10G, T_3=Fifronil 3G,T_4=untreated control

4.2.8.3 Interaction effect of variety and different insecticides

The interaction effect of variety and different insecticides had significant effect on the number of healthy panicles (Table 10).The highest number of healthy panicles (46.33) was recorded from V_1T_1 which was statistically similar withV_1T_2,V_1T_3,V_1T_4 and V_2T_1.The lowest number of healthy panicles (39.00) observed from V_3T_4 which was statistically similar with V_3T_3.In case of infested panicles, The lowest number of infested panicles (1.83) was recorded from V_1T_1 which was statistically similar with$V_1T_2$and the highest number of infested panicles (7.16) was recorded from V_3T_4, The lowest infestation (3.81%) was observed from V_1T_1 which was statistically similar withV_1T_2,V_1T_3whereas the highest infestation (15.54%) was recorded from V_3T_4.

4.2.9 Tiller infestation by rice stink bug

4.2.9.1 Effect of variety

The effect of variety on tillers infestation caused by Stink bug showed statistically significant variation (Table 11). Data was recorded from 5 selected hills/plot observed that the highest number of healthy tillers (47.71) was recorded from V_1 which was followed (46.06) by $V_2$and the lowest number of healthy tillers (43.08) was recorded from V_3. In case of infested tillers, the lowest number of infested tillers (2.10) was observed from V_1 and the highest number (5.97) found in V_3. The lowest infestation (4.23%) was counted from V_1which was followed by (7.65%) from V_2.The highest infestation was recorded (12.17%) from V_3. Jones *et al.* (1996) also found significant variation of effective tiller hill-1 among different varieties.

4.2.9.2 Effect of insecticides

The effect of granular insecticides on tillers infestation caused by Stink bug showed statistically significant variation (Table 11).Data was recorded from 5 selected hills/plot observed that the highest number of healthy tillers (46.34) was recorded from T_1(applying Furadan 5G @ 10g/plot in two application) which was statistically similar with T_2. The lowest number of healthy tillers (44.78) was recorded in

T_4(untreated control).In case of infested tillers, the lowest number (3.18) was recorded in T1, whereas the highest number of infested tillers (4.76) from T4. During infestation level the lowest infestation (6.46%) was observed from T1, whereas the highest infestation (9.63%) was recorded from T4. Similar kinds of results were also reported by Khan and Tarique (2011) and Mamun *et al.* (2011).

4.2.9.3 Interaction effect of variety and different insecticides

The interaction effect of variety and different insecticides had significant effect on the number of healthy tillers (Table 11).The highest number of healthy tillers (48.00) was recorded from V_1T_1 which was statistically similar withV_1T_2,V_1T_3 and V_1T_4. The lowest number of healthy tillers (42.00) observed from V_3T_4 which was statistically similar with V_3T_3.In case of infested tillers, The lowest number of infested tillers (1.67) was recorded from V_1T_1 which was statistically similar with V_1T_2 and the highest number of infested tillers (7.17) was recorded from V_3T_4..During infestation level the lowest infestation (3.35%) was observed from V_1T_1 which was statistically similar with V_1T_2, whereas the highest infestation (14.59%) was recorded from V_3T_4.

Table 11 Efficiency of variety and granular insecticides against tillers infestation caused by Rice stink bug

Influence of variety

Treatment	No. of healthy tillers	No. of infested tillers	Percentage of infested tillers
V_1	47.71 a	2.10 c	4.23 c
V_2	46.06 b	3.81 b	7.65 b
V_3	43.08c	5.96 a	12.17 a
LSD $_{(0.05)}$	0.57	0.21	0.35
CV (%)	1.48	6.19	5.21
Influence of insecticide treatment			
Treatment	No. of healthy tillers	No. of infested tillers	Percentage of infested tillers
T_1	46.34 a	3.18 d	6.45 d
T_2	45.88 ab	3.74 c	7.58 c
T_3	45.47 b	4.16 b	8.41 b
T_4	44.78 c	4.75 a	9.62 a
LSD $_{(0.05)}$	0.66	0.24	0.41
CV (%)	1.48	6.19	5.21
Influence of treatment combination			
Treatment	No. of healthy tillers	No. of infested tillers	Percentage of infested tillers
V_1T_1	48.00 ab	1.66 i	3.35 j
V_1T_2	48.13 a	1.96 hi	3.93 ij
V_1T_3	47.50 ab	2.13 h	4.29 i
V_1T_4	47.20 abc	2.66g	5.35 h
V_2T_1	46.87 bcd	3.06 g	6.14 g
V_2T_2	46.33 cd	3.63 f	7.28 f
V_2T_3	45.90 de	4.13 e	8.27 e
V_2T_4	45.13 ef	4.43 de	8.94 e
V_3T_1	44.17 fg	4.83 d	9.88 d
V_3T_2	43.17 gh	5.63 c	11.54 c
V_3T_3	43.00 hi	6.23 b	12.68 b
V_3T_4	42.00 i	7.16 a	14.59 a
LSD $_{(0.05)}$	1.14	0.41	0.71
CV (%)	1.48	6.19	5.21

V_1=BRRI dhan33, V_2=BRRI dhan49, V_3=BRRI dhan51

T_1=Furadan 5G, T_2=Diazinon 10G, T_3=Fifronil 3G,T_4=untreated control

4.3 Yield contributing characters and yield

Yield contributing characters and yield of BRRI dhan33, BRRI dhan49 and BRRI dhan51 were showed statistically significant variation in terms of different yield contributing characters and yield (Table 12).

4.3.1 Length of panicle

4.3.1.1 Effect of variety

In consideration of length of panicle, the longest panicle (22.68 cm) was recorded from V_1 which was followed (21.27 cm) by V_2 and the shortest panicle (20.35 cm) was found from V_3 (Table 12). Wang *et al.* (2006) also found significant variation of panicle length in different rice varieties.

4.3.1.2 Effect of insecticides

The longest panicle (21.94 cm) was recorded from T_1, which was statistically similar with T_2.The shortest panicle (20.86 cm) was found from T_4which was statistically similar with T_3.Similar kinds of results were also reported by Khan and Tarique (2011) and Mamun *et al.* (2011).

4.3.1.3 Interaction effect of variety and different insecticides

The interaction effect of variety and different insecticides had significant effect on the panicle length (Table 12).The longest panicle (23.33 cm) was recorded from V_1T_1 which was statistically similar withV_1T_2, and V_1T_3.The shortest panicle (19.67 cm) was observed from V_3T_4 which was statistically similar with V_3T_3,V_3T_2 and V_3T_1.

4.3.2 Number of filled grains/panicle

4.3.2.1 Effect of variety

In consideration of length of panicle, the maximum number of filled grains (86.42) was recorded from V1 which was followed (82.42) by V2 and the minimum number of filled grains (80.23) was found from V3 (Table 12). Ashraf *et al.* (2006) also found highest filled grains $panicle^{-1}$

4.3.2.2 Effect of insecticides

The maximum number of filled grains (84.50) was recorded from T_1.The minimum number of filled grains (81.89) was found from T_4which was statistically similar with T_3.Chandra and Pandey (2001), Ahmed *et al.* (1997) and Alam *et al.* (1996) also reported that similar result.

4.3.2.3 Interaction effect of variety and different insecticides

The interaction effect of variety and different insecticides had significant effect on number of filled grains (Table 12).The highest number of filled grains (88.67) was recorded from V_1T_1 and the lowest number of filled grains (79.33) was observed from V_3T_4 which was statistically similar with $V_3T_3$and $V_3T_{2.}$

4.3.3 Number of unfilled grains/panicle

4.3.3.1 Effect of variety

The effect of variety on number of unfilled grains was showed statistically significant variation (Table 12).The maximum number of unfilled grains (8.44) was recorded from V_1 which was followed (13.35) by V_2 and the minimum number of unfilled grains (16.52) was found from V_3.

4.3.3.2 Effect of insecticides

The effect of granular insecticides on number of unfilled grains was showed statistically significant variation (Table 12).The highest number of unfilled grains (11.68) was recorded from T_1.The lowest number of unfilled grains (13.92) was found from T_4.Similar kinds of results were also reported by Khan and Tarique (2011) and Mamun *et al.* (2011).

4.3.3.3 Interaction effect of variety and different insecticides

The interaction effect of variety and different insecticides had significant effect on number of unfilled grains (Table 12).The highest number of filled grains (7.37) was recorded from V_1T_1 and the lowest number of unfilled grains (17.67) was observed from V_3T_4 .

4.3.4 Weight of 1000-grains (g)

4.3.4.1 Effect of variety

The effect of variety on weight of 1000-grains was showed statistically significant variation (Table 12).The maximum weight (21.02 g) was recorded from V_1 which was followed (18.83 g) by V_2 and the minimum weight (17.75 g) was found from V3. Hossain *et al.* (2007) also found similar kind of results.

4.3.4.2 Effect of insecticides

The effect of granular insecticides on weight of 1000-grains was showed statistically significant variation (Table 12).The highest weight (19.96 g) was recorded from T1which was statistically similar with T_2.The lowest weight (18.49) was found from T4 which was statistically similar with $T_{3.}$Chandra and Pandey (2001), Ahmed *et al.* (1997) and Alam *et al.* (1996) also reported that similar result.

4.3.4.3 Interaction effect of variety and different insecticides

The interaction effect of variety and different insecticides had significant effect on weight of 1000-grains (Table 12).The highest weight (22.33 g) was recorded from V_1T_1 which was statistically similar with V_1T_2.The lowest weight (17.33) was observed from V_3T_4 which was statistically similar with $V_3T_{3,}V_3T_2,V_3T_{1,}V_2T_4$ and $V_2T_{3.}$

Table 12. Efficiency of variety and granular insecticides on yield contributing characters and yield of (BRRI dhan33, BRRI dhan49 and BRRI dhan51)

Influence of variety					
Treatment	Panicle length (cm)	No. of filled grain $panicle^{-1}$	No. of unfilled grain $panicle^{-1}$	1000 grain weight (g)	Grain yield ($t\ ha^{-1}$)
V_1	22.68 a	86.42 a	8.44 c	21.02 a	5.07 a
V_2	21.27 b	82.42 b	13.35 b	18.83 b	3.82 b
V_3	20.35 c	80.23 c	16.52 a	17.75 c	2.77 c
$LSD_{(0.05)}$	0.56	0.74	0.42	0.53	0.18
CV (%)	3.09	1.06	3.88	3.24	5.53
Influence of insecticide treatment					
Treatment	Panicle length (cm)	No. of filled grain $panicle^{-1}$	No. of unfilled grain $panicle^{-1}$	1000 grain weight (g)	Grain yield ($t\ ha^{-1}$)
T_1	21.94 a	84.50 a	11.68 d	19.96 a	4.36 a
T_2	21.61 a	83.06 b	12.44 c	19.56 a	4.01 b
T_3	21.33 ab	82.64 bc	13.04 b	18.81 b	3.71 c
T_4	20.86 b	81.89 c	13.92 a	18.49 b	3.47 d
$LSD_{(0.05)}$	0.65	0.86	0.48	0.61	0.21
CV (%)	3.09	1.06	3.88	3.24	5.53
Influence of treatment combination					
Treatment	Panicle length (cm)	No. of filled grain $panicle^{-1}$	No. of unfilled grain $panicle^{-1}$	1000 grain weight (g)	Grain yield ($t\ ha^{-1}$)
V_1T_1	23.33 a	88.67 a	7.36 i	22.33 a	5.50 a
V_1T_2	22.77 ab	86.67 b	8.43 h	21.33 ab	5.33 a
V_1T_3	22.63 ab	85.53 bc	8.53 h	20.33 bc	4.93 b
V_1T_4	22.00 bc	84.80 cd	9.43 g	20.10 c	4.53 c
V_2T_1	21.77 bcd	83.93 d	12.00 f	19.53 c	4.33 c
V_2T_2	21.40 cde	81.97 ef	12.90 e	19.43 c	3.86 d
V_2T_3	21.03 cde	82.23 e	13.83 d	18.33 d	3.63 de
V_2T_4	20.90 cde	81.53 efg	14.67 d	18.03 d	3.46 ef
V_3T_1	20.73 def	80.90 efg	15.67 c	18.00 d	3.26 f
V_3T_2	20.67 def	80.53 fgh	16.00 bc	17.90 d	2.83 g
V_3T_3	20.33 ef	80.17 gh	16.77 b	17.77 d	2.56 gh
V_3T_4	19.67 f	79.33 h	17.67 a	17.33 d	2.43 h
$LSD_{(0.05)}$	1.12	1.49	0.84	1.05	0.36
CV (%)	3.09	1.06	3.88	3.24	5.53

V_1=BRRI dhan33, V_2=BRRI dhan49, V_3=BRRI dhan51

T_1=Furadan 5G, T_2=Diazinon 10G, T_3=Fifronil 3G,T_4=untreated control

4.3.5 Grain yield

4.3.5.1 Effect of variety

The effect of variety on grain yield was showed statistically significant variation (Table 12).The highest grain yield (5.07 t/ha) was recorded from V_1 which was followed (3.82 t/ha) by V_2 and the lowest grain yield (2.78 t/ha) was found from V_3.

4.3.5.2 Effect of insecticides

The effect of granular insecticides on grain yield was showed statistically significant variation (Table 12).The highest yield (4.38 t/ha) was recorded from T_1which was followed (4.01 t/ha and 3.71 t/ha) by $T_2$and T_3. The lowest yield (3.48 t/ha) was found from T_4.Chandra and Pandey (2001), Ahmed *et al.* (1997) and Alam *et al.* (1996) also reported that similar result.

4.3.5.3 Interaction effect of variety and different insecticides

The interaction effect of variety and different insecticides had significant effect on grain yield (Table 12).The maximum yield (5.50 t/ha) was recorded from V_1T_1 which was statistically similar with V_1T_2 and the lowest grain yield (2.43 t/ha) was observed from V_3T_4 which was statistically similar with V_3T_3

CHAPTER V

SUMMARY AND CONCLUSION

A field experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during August to December, 2016 in *aman* season with a view to find out the performance of three transplanted aman rice varieties under different granular insecticides.

The experiment was laid out two factorial a randomize complete block design with three replications. The size of the individual plot was 3.0 m x 2.0 m and total numbers of plots were 36. There were 12 treatment combinations. The experiment was carried out with three transplanted aman rice varieties *i.e*. BRRI dhan33 (V_1), BRRI dhan49 (V_2), BRRI dhan51 and four treatments viz. Furadan 5G (T_1), Diazinon 10G (T_2), Fifronil 3G (T_3), Untreated control (T_4).

Under the present experiment 8 species of insects were recorded affiliated to 7 family and 6 orders 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 were observed and the highest number of theses insect pests were recorded from V_3T_4 treatment combination and whereas the lowest number of these insect pests were observed from V_1T_1.

In case dead heart symptoms caused by yellow stem borer at vegetative stages. The lowest infestation level (1.37%),(5.54%) and (2.89%) were recorded from V_1T_1, T_1 and V_1 respectively whereas the highest infestation level (14.42%), (9.61%) and (12.04%) were observed from V_3T_4, T_4 and V_3respectively.In white head infestation of rice due to yellow stem borer the lowest infestation level (1.42%), (5.76%) and(2.89%) were recorded from V_1T_1,T_1 and V_1 respectively whereas the highest infestation level (15.30%), (9.96%) and (12.92%) were observed from V_3T_4, T_4 and V_3. In leaf infestation of rice caused by leaf folder the lowest leaf infestation level (1.42%), (3.84%) and (2.33%) were recorded from V_1T_1, $T_1$and V_1whereas the highest leaf infestation level (8.66%), (6.05%) and (7.44%) were observed from V_3T_4, T_4 and V_3.In case of leaf infestation of rice caused by rice hispa, the lowest leaf infestation le(2.33%), (4.44%) and (2.76%) were recorded from V_1T_1, T_1 and V_1, whereas the highest leaf infestation level (11.88%), (7.25%) and (9.77%) were observed from V_3T_4, T_4 and V_3.In tillers infestation of rice caused by brown plant hopper the lowest infestation level (2.57%), (4.90%)and (3.38%) were recorded from V_1T_1, T_1 and V_1 respectively whereas the highest infestation level (15.22%),(8.83%) and (10.80%) were observed from V_3T_4, T_4 and V_3.For leaf infestation of rice caused by green leaf hopper, the lowest number (3.78%), (6.81%) and (5.36%) were found from V_1T_1, T_1 and V_1 respectively, while the highest number (10.81%) and (12.45%) were from T_4 and V_3. In case of tillers infestation of rice caused by rice bug the lowest infestation (5.96%) and (4.21%) were recorded from T_1 and V_1 respectively, whereas the highest infestation (9.47%) and (11.77%) were observed from T_4 and V_3. The highest grain yield (5.50 t/ha), (4.36 t/ha) and (5.07 t/ha) were recorded from V_1T_1,T_1 and V_1 respectively while the lowest grain yield (2.43t/ha), (3.47 t/ha) and (2.77 t/ha) from V_3T_4, T_4 and V_3.

Based on this experiment the following conclusion can be drawn:

1. Furadan 5G is an effective granular insecticide for controlling insect pests in transplanted aman rice

2. Insect pests control played an important role for the growth and yield of transplanted aman rice.

3. BRRI dhan33 (V1) produced highest grain yield (5.07 t ha^{-1}), panicle length (22.68 cm), number of filled grain/panicle (86.42), 1000 grain weight (21.02 g) with better granular insecticide..

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APPENDICES

Appendix I. Monthly records of air temperature, relative humidity, rainfall and sunshine during the period from August to December 2016

Month	Air temperature (ºc)		*Relative humidity (%)	Total Rainfall (mm)	Average Sunshine hours
	Maximum	minimum			
August	35.5	28.7	80	514	4.7
September	32.7	26.4	75	183	5.5
October	30.8	23.5	74	341	4.9
November	29.8	20.2	68	107	5.2
December	24.3	16.5	66	o	5.4

Appendix II. Characteristics of soil of experimental field

Morphological features	Characteristics
Location	Agronomy 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

Appendix III. Analysis of variance of the data on incidence of different rice insect pests

Source of variation	df	Mean square of value of			
		Yellow stem borer	Leaf folder	Rice hispa	Grasshopper
Replication	2	0.51	1.82	1.57	4.00
Variety (A)	2	32.88*	124.50*	102.61*	245.46*
Insecticide (B)	3	1.76*	7.73*	6.37*	19.66*
Variety (A) X Insecticide (B)	6	0.04*	0.33*	0.17*	0.35*
Error	22	0.06	0.11	0.08	0.19

*Significant at 5% level of significance

NS Non significant

Appendix III. (Continued)

Source of variation	df	Mean square of value of			
		Brown plant hopper	Green leaf hopper	Rice bug	Rice stink bug
Replication	2	3.32	1.93	1.57	1.18
Variety (A)	2	192.98*	105.85	63.73*	67.67*
Insecticide (B)	3	13.75*	6.93	6.34*	4.40*
Variety (A) X Insecticide (B)	6	0.07*	0.24	0.19*	0.16*
Error	22	0.10	0.07	0.05	0.051

*Significant at 5% level of significance

NS Non significant

Appendix IV. Analysis of variance of the data on healthy tiller, infected tiller and % of infected tiller of rice as affected by Yellow stem borer (dead heart)

Source of variation	df	Mean square of value of		
		Healthy tiller	Infected tiller	Percentage of infected tiller
Replication	2	74.96	0.72	0.35
Variety (A)	2	249.46*	31.72*	246.50*
Insecticide (B)	3	29.08*	3.57*	28.92*
Variety (A) X Insecticide (B)	6	2.67*	0.06*	0.84*
Error	22	1.99	0.05	0.26

*Significant at 5% level of significance

^{NS} Non significant

Appendix V. Analysis of variance of the data on healthy tiller, infected tiller and % of infected tiller of rice as affected by Yellow stem borer (White head)

Source of variation	df	Mean square of value of		
		Healthy tiller	Infected tiller	Percentage of infected tiller
Replication	2	92.00	0.54	0.07
Variety (A)	2	188.03*	44.92*	301.82*
Insecticide (B)	3	35.25*	3.53*	27.79*
Variety (A) X Insecticide (B)	6	0.31*	0.03*	0.42*
Error	22	0.88	0.06	0.16

*Significant at 5% level of significance

^{NS} Non significant

Appendix VI. Analysis of variance of the data on healthy leaves, infected leaves and % of infected leaves of rice as affected by leaf folder

Source of variation	df	Mean square of value of		
		Healthy leaves	Infected leaves	Percentage of infected leaves
Replication	2	21970.08	37.47	0.56
Variety (A)	2	5291.08*	1790.67*	78.53*
Insecticide (B)	3	1051.88*	170.28*	8.29*
Variety (A) X Insecticide (B)	6	26.04*	2.36*	0.12*
Error	22	415.38	1.84	0.14

*Significant at 5% level of significance

NS Non significant

Appendix VII. Analysis of variance of the data on healthy leaves, infected leaves and % of infected leaves of rice as affected by Rice hispa

Source of variation	df	Mean square of value of		
		Healthy leaves	Infected leaves	Percentage of infected leaves
Replication	2	17263.08	72.00	0.10
Variety (A)	2	5271.08*	3507.38*	150.55*
Insecticide (B)	3	597.21*	345.15*	14.84*
Variety (A) X Insecticide (B)	6	33.82*	70.97*	2.90*
Error	22	149.44	2.73	0.06

*Significant at 5% level of significance

NS Non significant

Appendix VIII. Analysis of variance of the data on healthy leaves, infected leaves and % of infected leaves of rice as affected by Grass hopper

Source of variation	df	Mean square of value of		
		Healthy leaves	Infected leaves	Percentage of infected leaves
Replication	2	13331.44	68.77	0.11
Variety (A)	2	5670.36*	3505.86*	140.28*
Insecticide (B)	3	625.65*	291.65*	11.73*
Variety (A) X Insecticide (B)	6	33.88*	57.60*	2.16*
Error	22	129.62	4.05	0.07

*Significant at 5% level of significance

^{NS} Non significant

Appendix IX. Analysis of variance of the data on healthy tiller, infected tiller and % of infected tiller of rice as affected by Brown plant hopper

Source of variation	df	Mean square of value of		
		Healthy tiller	Infected tiller	Percentage of infected tiller
Replication	2	163.75	0.56	0.49
Variety (A)	2	198.09*	28.79*	169.79*
Insecticide (B)	3	24.15*	4.36*	25.82*
Variety (A) X Insecticide (B)	6	1.58*	1.10*	6.86*
Error	22	1.93	0.04	0.16

*Significant at 5% level of significance

^{NS} Non significant

Appendix X. Analysis of variance of the data on healthy leaves, infected leaves and % of infected leaves of rice as affected by Green leaf hopper

Source of variation	df	Mean square of value of		
		Healthy leaves	Infected leaves	Percentage of infected leaves
Replication	2	16796.52	174.11	0.11
Variety (A)	2	23400.69*	3180.77*	152.21*
Insecticide (B)	3	3082.40*	605.95*	25.86*
Variety (A) X Insecticide (B)	6	288.65*	134.70*	4.22*
Error	22	104.86	3.99	0.09

*Significant at 5% level of significance

NS Non significant

Appendix XI. Analysis of variance of the data on healthy panicle, infected panicle and % of infected panicle of rice as affected by Rice bug

Source of variation	df	Mean square of value of		
		Healthy panicle	Infected panicle	Percentage of infected panicle
Replication	2	188.86	1.04	0.20
Variety (A)	2	90.52*	37.05*	184.43*
Insecticide (B)	3	5.81*	4.88*	22.53*
Variety (A) X Insecticide (B)	6	0.45*	1.40*	6.29*
Error	22	0.98	0.05	0.21

*Significant at 5% level of significance

NS Non significant

Appendix XII. Analysis of variance of the data on healthy tiller, infected tiller and % of infected tiller of rice as affected by Rice stink bug

Source of variation	df	Mean square of value of		
		Healthy tiller	Infected tiller	Percentage of infected tiller
Replication	2	444.66	26.25	1.10
Variety (A)	2	65.92*	44.85*	190.35*
Insecticide (B)	3	3.97*	3.95*	16.12*
Variety (A) X Insecticide (B)	6	0.28*	0.28*	1.11*
Error	22	0.45	0.06	0.17

*Significant at 5% level of significance

^{NS} Non significant

Appendix XIII. Analysis of variance of the data on yield contributing characters and yield of BRRI dhan33, BRRI dhan49 and BRRI dhan51

Source of variation	df	Mean square of value of				
		Length of panicle (cm)	Number of filled grains panicle^{-1}	Number of unfilled grains panicle^{-1}	Weight of 1000 grains (g)	Grain yield (t ha^{-1})
Replication	2	41.09	504.94	62.85	29.29	0.96
Variety (A)	2	16.56*	118.00*	199.02*	33.40*	15.91*
Insecticide (B)	3	1.91*	10.83*	8.10*	4.06*	1.33*
Variety (A) X Insecticide (B)	6	0.08*	1.17*	0.20*	0.53*	0.03*
Error	22	0.43	0.77	0.24	0.38	0.04

*Significant at 5% level of significance

^{NS} Non significant

LIST OF ACRONYMS

AEZ	=Agro Ecological Zone
BCR	=Benefit Cost Ratio
BARC	= Bangladesh Agricultural Research Council
BBS	= Bangladesh Bureau of Statistics
BINA	= Bangladesh Institute of Nuclear Agriculture
BARI	= Bangladesh Agricultural Research Institute
BRRI	= Bangladesh Rice Research Institute
Cm	= Centi meter
cv.	= Cultivar
DAT	= Days After Transplanting
DF	= Degrees of Freedom
EC	= Emulsifiable Concentrate
et al.	= and others
etc.	= Etcetera
FAO	= Food and Agricultural Organization
g	= Gram
HI	= Harvest Index
HYV	= High Yielding Variety
IRRI	= International Rice research Institute
Kg	= Kilogram
LSD	= Least Significant Difference
m	= Meter
m^2	= meter square
mm	= Millimeter
viz.	= namely
%	= Percent
CV %	= Percentage of Coefficient of Variance
SAU	= Sher-e-Bangla Agricultural University
T. aman	= Transplanted aman
t ha^{-1}	= Tons per hectare