EFFECT OF DIFFERENT LEVELS OF NPK ON INSECT PESTS OF TRANSPLANTED AMAN RICE (*Oryza sativa* L.)

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CERTIFICATE

This is to certify that the thesis entitled 'EFFECT OF DIFFERENT LEVELS OF NPK ON INSECT PESTS OF TRANSPLANTED AMAN RICE (*Oryza sativa* L.)' 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. Sakib Mahdi Aziz, Registration number: 11-04387 **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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Dedicated

To

My Beloved Parents

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EFFECT OF DIFFERENT LEVELS OF NPK ON INSECT PESTS OF TRANSPLANTED AMAN RICE (*Oryza sativa* L.)

ABSTRACT

The study was conducted in the experimental field of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh during the period from July to October 2016 to find out the effect of different levels of NPK in transplant Aman rice field on it`s insect pests. BRRI dhan33 were used as the test crop in this experiment. The experiment comprised of the different NPK fertilizer dose as treatment- T_0= Untreated control (no NPK fertilizers), T_1= NPK @ 45, 50, 40 $kgha^{-1}$, T_2= NPK @ 70, 25, 40 $kgha^{-1}$, T_3= NPK @ 70, 50, 20 $kgha^{-1}$, T_4= NPK @ 70, 50, 40 $kgha^{-1}$, T_5= NPK @ 70, 50, 60 $kgha^{-1}$, T_6= NPK @ 70, 75, 40 $kgha^{-1}$ and T_7= NPK @ 95, 50, 40 $kgha^{-1}$. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Data were recorded on different types of insect pests of rice those were identified recorded during the entire growing period with their number and incidence on rice plants and also different yield contributing characters and yield of rice and analized the statistical differences for different levels of NPK fertilizers. Among the observed insect pests, 2 species were belong to the family Pyralidae and only 1 species for each of Chrysomelidae, Acrididae, Delphacidae, Cicadellidae and Coreidae family. During the entire growing period 5 selected hills/plot were monitored with clean observation and yellow stem borer, leaf folder, rice hispa, grasshopper, brown plant hopper, green leaf hopper and rice bug were recorded the lowest number of those insect pests were observed in T_5 trteated plot whereas the highest number was found from T_7 trteated plot. In case of incidence of dead heart recorded at 25, 45 and 65 DAT, data recorded from each plot revealed that the lowest incidence of dead heart was observed from T_5 (3.64%, 4.23% and 4.47%, respectively), while the highest incidence of dead heart was found from T_7 (10.37%, 13.56% and 14.73%, respectively) treatment. In terms of white head incidence, at 60, 70 and 80 DAT, data recorded from each plot revealed that the lowest incidence of white head was found from T_5 (2.35%, 2.66% and 3.12%, respectively), whereas the highest incidence of white head was observed from T_7 (7.57%, 8.26% and8.64%) treatment. The highest grain yield was recorded from T_5 (4.54 ton), while the lowest grain yield was observed from T_0 (2.78 ton) treatment. Among the different levels of NPK fertilizers, NPK @ 70, 50, 60 $kgha^{-1}$ (T_5) was the better for the rice cultivation to support its insect pests.

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ABBREVIATIONS

And others (Co-workers)	=	*et al.*
Brown Plant Hopper	=	BPH
Centimeter	=	cm
Coefficient of Variation	=	CV
Dead Heart	=	DH
Degree centigrade	=	^{o}C
Degree of freedom	=	df
Electrical Conductivity	=	EC
Example	=	viz.
Green Leaf Hopper	=	GLH
Hydrogen ion conc.	=	pH
Least significant difference	=	LSD
Million tons	=	mt
Nitrogen	=	N
Non-significant	=	NS
Per Hectare	=	ha^{-1} Or, (/ha)
Percentage	=	%
Phosphorus	=	P
Potassium	=	K
Randomized Block Design	=	RBD
Relative humidity	=	% RH
Soil Organic Carbon	=	SOC
Standard Error	=	SE
that is	=	i.e.
tons	=	t
White ear head	=	WEH
Yellow Stem Borer	=	YSB

CHAPTER I

INTRODUCTION

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

Rice is more nutritious than any other cereal crops and is an ideal host for over 800 species of insect (Barr and Smith, 1975). In tropical Asia, more than 100 species of insects are persistent to rice. In Bangladesh, about 175 insect pest species have been reported, which cause damage to the rice plants (Mustafi *et al*., 2007), of these 20-30 species are economically important (Miah and Karim, 1984). The estimated loss of rice in Bangladesh due to insect pests and diseases amounts to 1.5 to 2.0 million tons (Siddique, 1992).

At high population density, crop loss may be 100% (Rahman *et al*., 2004). Major pests cause damage about 28% to Aman crops and the estimated annual loss of rice in Bangladesh due to insect pests and diseases amounts 1.5 to 2.0 million tons (BRRI, 1989).

Nutrient management is the most important practice in rice production system, but it may affects response of rice to insect pests. If there is positive interaction between nutrients and pest can be identified, can provide guidelines for optimizing total agro-ecosystem function (Magdoff *et al*. 2000). Some aman rice pests are green leaf hopper, rice hispa, green stink bug, rice leafroller, yellow stem borer and rice bug. The beneficial insects are categories as predator and parasitoids, collectively known as natural enemies which are able to interact with their prey and consequently regulate them at reasonably lower level. 99 species of parasitoids and 88 species of predator of rice insect pests have been recorded in Bangladesh (Wahiduzzaman, 1993). The application of nitrogen fertilizer in plants can normally increase herbivore's feeding preference, food consumption, survival, growth, reproduction, and population density, except few examples that nitrogen fertilizer reduces the herbivore performances.

Given the importance of NPK fertilization on the yield in grain from the rice plant, it is necessary to know what the best dose is for each variety as well as its influence on components of yield and other agronomic parameters such as the cycle, plant height, lodging and moisture content of the grain, in order to obtain better knowledge of said productive response. Higher nitrogen doses cause for higher sucking pests incidence.

Nitrogen (N) has been an important yield determinant of the flooded rice production systems. High prices, food shortages in developing world and the adverse effects of heavy N losses from flooded fields however necessitate optimal use of N. Nitrogen losses through ammonia volatilization, leaching and runoff have been recorded from 20-80% in the rice production (Singh *et al*., 1998; Griggs *et al*., 2007; Norman *et al*., 2009). Economic use of nitrogen fertilizer is especially important for small growers as urea prices are continuously on rise. The response of rice crop to nitrogen fertilizers have been well documented, however the effects of application rates on yield and quality of rice are lacking. Non-judicious uses of nitrogen fertilizer suppress paddy growth and yield (Rashid, 1996). They observed that higher N contents in plant tissues by urea application were due to better growth, increased N solubility and increased root efficiency for N uptake. Urea-N application lowers soil pH and it forms NH_3^-availability under alkaline conditions (Gao *et al.,* 2012).

Phosphorous fertilizer did not much affect rice growth, then there was not difference in plant height, number of tillers/ square foot at various P_2O_5 levels. Only the SPAD index was responded to P_2O_5 levels, higher dose of phosphorous made the rice leaves greener than as compared to control (recommended phosphorous application). When applying more phosphorous fertilizer, the number of panicles per m^2, number of filled grains/ panicle tended upward, however difference among the treatments was not significant. Application of 60 kg P_2O_5 obtained 723 panicles/ m^2 and 63 filled grains/ panicles. The more application of phosphorous fertilizer, the more unfilled grain percentage was observed, and the more reduced 1000 grain weight. The unfilled grain percentage was the highest unfilled grain was in the treatment of 60 kg P_2O_5/ ha (Gao *et al.*, 2012).

Potassium induced change in rice plant at profound effect on insect–host interactions. Increase of K in rice plant causes reduction in the feeding rate of BPH *Nilaparvata lugens* (Vaithilingan *et al.*, 1975) and *Nephotettix sp.* (Subramanian and Balasubramnian, 1976). Little information was available on the effects of K on growth, biomass and chemical composition of rice plant and the effects of K-induced changes on the interaction of rice plant and *S. furcifera* therefore some studies were carried out on these aspects.

Present study was aimed to identify optimum doses of NPK for lower incidence of insect pests and higher grain yields and better quality of rice. With due emphasis on above aspects in view, the present study was undertaken with following objectives;

- To study impact of graded levels of plant nutrient components (NPK) on growth, development and yield of rice plant associate with insect pest
- To ensure the minimum use of chemical nutrients and find out the proper dose of nutrient components (NPK) against these insect pests
- To assess the level of incidence caused by sucking insect pests such as brown plant hopper (BPH), rice green leaf hopper (GLH) and rice bug and
- To study yield-infestation relationship with special reference to yellow stem borer in transplanted aman rice cultivation.

CHAPTER II
REVIEW OF LITERATURE

Yield and yield contributing characteristics of rice are considerably depended on the manipulation of basic ingredients of agriculture. The basic ingredients include varieties of rice, environment, agronomic practices (planting time & density, fertilizer, irrigation etc.), and insect pest management etc. Among the mentioned factors different doses of Nitrogen, Phosphorous & Potassium on the incidence of insect pests in rice field are more responsible for the growth and yield of rice. Rice suffers heavy losses every year due to attack of many insect pests, among those, Rice Yellow Stem Borer, Rice Leaf Roller, Brown plant hopper (BPH), Green leaf hopper (GLH), Rice bug, Rice Hispa & Rice Grasshopper etc. Rice Yellow Stem Borer is the most important. They cause huge damage of grain, leaf, stem and ultimately yield. But research works related to these pests and their incidence on rice related with different Nitrogen, Phosphorous & Potassium doses. Optimum doses of Nitrogen, Phosphorous & Potassium result in minimum insect incidence are required for better rice production. That's limited in Bangladesh as well as the World. The research work so far done in Bangladesh and elsewhere is not adequate and conclusive.

In Bangladesh, the geographical, climatic and edaphic conditions are favorable for year round rice cultivation. However, in Bangladesh, the average yield of rice is about 2.92 t ha^{-1} (BBS, 2014) which is very low compared to other rice growing countries of the World, like China (6.30 t ha^{-1}), Japan (6.60 t ha^{-1}) and Korea (6.30 t ha^{-1}) (FAO, 2009). In Bangladesh, rice covers almost 84% of the total cultivable land and T. aman alone occupies 46.30% of rice cultivated land. The rest 26.85, 17.59 and 9.26 % of the lands are occupied by Boro, Aus and Sown Aman, respectively (BBS, 2004). Recently various rice varieties were developed and available as BRRI dhan and maximum of them is exceptionally high yielding had larger panicles, heavier seeds, resulting in an average yield increase of 7.27% (Bhuiyan *et al.,* 2014). These variety however, needs further evaluation under different adaptive condition to interact with different environmental conditions and investigation of optimum use of nitrogen and their infestation level is a major one.

In Bangladesh, rice dominates over all other crops and covers 75% of the total cropped area of which around 79% is occupied by high yielding rice varieties (BBS, 2014). In most of the rice growing areas in Asia, the great increases in populations of major insect pests of rice including plant hoppers (*Nilaparvata lugens* and *Sogatella furcifera*), leaf folder (*C. medinalis*), stem borers (*S. incertulas*, *C. polychrysus*) were closely related to the long-term excessive application of nitrogen fertilizers (Ghose *et al.,* 1960).
Management of rice insect pests, many options such as chemical, cultural, mechanical, biological etc. are available. Various control strategies have been adopted against rice pests, one common method being the use of synthetic insecticides, which can be environmentally disruptive and can result in the accumulation of residues in the harvested produce and creating health hazards (Chinniah *et al.,* 1998). The use of chemicals led to impose certain well known undesirable side effects including environmental pollution, resurgence, upset, resistance to pesticides, and develop high pesticide residues. On the other hand, non-chemical control plays an important role in evolving an ecologically sound and environmentally acceptable method.

The overuse and misuse of fertilizers created major environmental problems and soil degradation followed by the development of an integrated nutrient management (INM) and integrated pest management (IPM) approach to the soil and crop pests. This approach utilizes a combination of host plant resistance cultural, biological, nutritional and chemical control methods. To make the green revolution successful & to mitigate the adverse effects of fertilizers to the crop productive environment. Judicious use of fertilizers is considered as one of the important aspect of cultural practices in IPM which influence the activity of insect pests and ultimate effect on growth, development and yield of crop plant. Keeping in view, the present study was undertaken to assess the effect of different levels of fertilizers on incidence of arthropod fauna on rice. The relevant reference available in published literature pertaining to present investigation have been reviewed and described below.

Nevertheless, some of the important and informative works and research findings related so far been done at home and abroad have been reviewed in this chapter under the following headings-

4.1 Effect of NPK on incidence of insect pests on rice

Saha *et al*. (1970) studied on the combinations of five levels of nitrogen fertilization (0, 25, 50, 75 and 100 kg/ha of ammonium sulphate) with three transplanting dates (7th and 22nd August and 7th September), and observed the effects of nitrogen fertilization and transplanting date on the damage caused by *Scirpophaga incertulas* (Wlk.). The combined incidence of dead hearts, white ear heads and partly chaffy ear heads increased from 8.36% in plots without nitrogen fertilizer to 20.12% in treated with highest level and declined from 21.02% for the first transplanting date to 9.82% for the last, the greatest yields came from crop transplanted on 22nd August and treated with the two highest levels of nitrogen.

The field experiment conducted by Subramanian *et al.* (1976) in Annamalai-nagar to study the effect of potash fertilizer at different rates of 50, 100, 150, 200 and 250 kg/ha on incidence of *Baliothrips biformis* (Bagn.), *Nephotettix virescens* (Dist.) and *Nilaparvata lugens* (Stal), and damage by *Hydrellias asakii* and *Cnaphalocrocis medinalis* (Gnenee), revealed that the infestation of pest were significantly lower in plots treated at the 200 and 250 kg levels.

Ittya virah *et al.* (1979) reported that application of potash at a higher rate (equivalent to 135 kg of potassium oxide/ha) reduced the incidence of *Nilaparvatha lugens* on rice.

The field experiment conducted by Uhm (1985) to study on effects of different levels of nitrogen fertilizer levels with 7.5kg, 15kg, 30kg with planting spaces 10 x 20cm, 15 x 30cm and 20 x 40cm on the population of brown plant hopper concluded that density of the brown plant hopper increased with increased level of nitrogen fertilization at the planting spaces of 10 x 20cm and 15 x 30cm. Whereas, brown plant hopper density was greater at nitrogen level of 15kg than at level of 30kg nitrogen per ha in 20 x 40cm spacing plots.

Dhandapani (1990) investigated the effects of green manure and nitrogen fertilizer in rice on damage caused by *Scirpophaga incertulas*. Nitrogen fertilizer applied at 150-200 kg N/ha, increased dead heart incidence. Application of green manure did not show increase in damage. Numbers of white ears also increased at greater N concentration and at plant densities of 80 or 100 hills/m^2 as compared to 66 hills/m^2.

The field experiment conducted by Samiyyan *et al*. (1990) in clay loam soils of Maharashtra to study the effect of potash with different levels of nitrogen on the incidence of rice BPH, as BPH population was the lowest with potassium application at 200 kg+ nitrogen at 50 kg/ha and highest for nitrogen at 100 kg with potassium at 50 kg/ha.

The field experiment conducted by Singh *et al*. (1990) in Punjab indicated that the NPK at 120:60:60 kg/ha increased the susceptibility of rice to infestation by yellow stem borer *Scirpophagus incertulus* but, green manuring and plant spacing had no effect on the incidence of pest on rice.

High infestation of yellow stem borer is correlated with the high use of nitrogenous fertilizers, but split applications of nitrogen suggested as the most appropriate and successful strategy of pest management (Ramzan *et al*., 1992).

Sudhakar *et al*. (1993) studied the influence of levels and source of nitrogen on the incidence of *Cnaphalocrocis medinalis* in different rice varieties such as, IET 9746, IET 9188, IET 9572, Rajha, Rajshree and Salivahana and three levels of nitrogen (20, 40 and 60 kg/N/ha) each from two sources (urea and Urea Super Granule). It was observed that at 60 DAT, Salivahana was least susceptible (12.19 %), whereas IET 9572 with 25.01% leaf damage was found as most susceptible to leaf folder. There was a corresponding and significant increase in infestation with the increasing levels of fertilizer for both sources at 30 and 60 DAT.

The field experiment carried out by Mahadev *et al*. (1995) in the gangetic alluvial soil (Entisol) of West Bengal to study the effect of fertilizer treatments (80 kg N, 80 KG N+ 40 kg P and 80 kg N + 40 kg P + 40 kg K/ha) in rice cv. CR 222 MW 10 under rained conditions and concluded that the crop applied with N either alone or coupled with P exhibited a higher degree of incidence of green leaf hopper and yellow stem borer, but NPK lowered the incidence of rice bug, leaf folder and yellow stem borer.

Raju *et al.* (1996) reported that the incidence of *Nephotettix virescens* on the rice variety ADT 38 was minimum when highest level of potassium 100kg/ha was applied. The maximum incidence of pest was noted in plots receiving no potassium. The combination of nitrogen and potassium at various levels had a significant effect on pest population. Nitrogen at 125 and 150 kg/ha with potassium at 50 and 100 kg/ha were most effective treatments, resulting in the lowest of *Nephotettix virescens.*

Navinkumar *et al*. (1998) concluded that pest incidence increased with a corresponding increase in nitrogen concentration. Applying N at $^{1}/_{4}$ th basal, ½ at active tillering and $^{1}/_{4}$ th at panicle initiation stage resulted in the lowest incidence of both Leaf folder *Cnaphalocrocis medinalis* and yellow stem borer compared to other two methods of nitrogen application like ½ as basal, 1/4th at active tillering and 1/4th at panicle initiation or ½ basal and ½ at panicle initiation.

Pathak *et al*. (1999) reported that minimum stem borer incidence in control plots and enhanced doses of N resulted in significant increase in borer incidence and caused (16.36 and 21.50 % DH) at nitrogen dose of 50 and 100kg/ha. While increasing the level of potassium and phosphorus decreased the incidence of stem borer and leaf folder. The fertilizer dose of N_0 P_{100} K_{60} Kg/ha had the minimum stem borer population (10.66% DH).

Das (2001) observed the highest infestation of leaf folder and low yield from the plot treated with 190 kg urea ha^{-1} and the minimum from 130 kg/ha.

Patro *et al*. (2000) reported linear increase of both brown plant hopper (BPH) and white backed plant hopper (WBPH) when NPK doses increased from 60: 30: 30 level to 90:50: 50, 120: 60: 60 and 150: 75: 75 kg/ha. The NPK fertilizer dose 90: 45:45 kg/ha seems to be realistic from both the point of economic and effective pest suppression.

Salim (2002) observed that at low level of K, plant height, number of tillers/hill, root growth and biomass of rice plants were significantly less than the plants grown in the standard culture solution (40 ppm K). Further, increase in the amount of K from 40 ppm to 200 ppm did not significantly increase the growth and biomass of rice plants. Increase in the application of K in the culture solution increased K but decreased N, P, Mg, Si, Zn and soluble proteins in the rice plant. Deficiency of k in rice plant increased intake and assimilation of food, honeydew excretion, growth index; adult longevity and population build-up of *S. furcifera*.

Chau (2003) reported that nitrogen fertilizer not only affected growth of plant, but also responsible for the outbreak of insect pests such as brown plant hopper, stem borer, leaf folder. Phosphorous fertilizer was less promoted to the plant growth than nitrogen, and not affect to insect pests. Balanced fertilizer application can help rice plant to become more resistant to pests effectively.

Ramprasad *et al*. (2004) observed significantly highest leaf folder population/sweep at 200 kg N/ha (27.3) followed by 120 kg N/ha (18.7) and 0kg N/ha (8.4). The dead heart and white ear head incidence was more at 200 kg N (6.2 % and 11.7 %) followed by 120 kg N/ha (5.4% and 9.5%) and the lowest being at 0 kg N/ha (4.8 % and 8.0%).

Zhong-xia *et al*. (2004) studied that rice plants damaged by brown plant hopper (BPH), resulted increased in both WC and RWC with the increase of nitrogen content in rice plants. RWC in rice plants applied with high nitrogen fertilizer decreased drastically by the injury of BPH nymphs, while the reduced survival duration of rice plants with the increase of nitrogen content was recorded and plant become susceptibility to BPH.

Zhong-xian (2006) reported that number of arthropod species significantly increased with rice growth and the diversity indices increased with the increase of nitrogen rate at the booting stage. The population density of brown plant hopper and the white-backed plant hoppers (WBPH) *Sogatella furcifera* Horváth, peaked during the booting stage, however, the number of BPH in rice field with 200 kg N/ha was considerably higher than those in other two rice fields with 100 kg N/ha and 0 kg N/ha at the booting as well as the milking stage. These results indicated that the rapid growth in populations of plant hopper due to excessive nitrogen might be attributed to the combination of reduction in control capacity of natural enemies and strong simulation of nitrogen to plant hoppers.

Sarwar (2012) reported that compared with the untreated control, K fertilizer significantly reduced the rate of rice borers' infestation and increased paddy yield and suggest that application of K fertilizer could be useful in the recovery of plants damage when attacked by larvae of borers which can be safely and successfully managed to contribute larger volume of yield and reduce the environmental pollution.

Rashid (2013) studied that interactions of N, P and K had no significant effect on population growth and weight of BPH. However, interaction of N and P showed significant effect on population growth of BPH. Fertilization with nitrogen increased population and dry weight of BPH. Phosphorus Fertilization markedly increased the population growth while high potassium application decreased Population build up and dry weight of BPH.

Kulagod *et al*. (2011) indicated that the leafhopper, leaf folder and yellow stem borer population was significantly high in treatments receiving only N and lower population was observed in treatments receiving only K and in control. Phosphorus alone, combinations of P with N and NPK treatments supported moderate leafhopper, leaf folder and stem borer population and low pest population in higher levels of Potash 100 and 200 kg 'K.' doses. The maximum incidence was noted in plots receiving no K.

Satpathi *et al.* (2012) in West Bengal assessed in Swarnamashuri (MTU- 7029) that maximum number of BPH with 1.70 individuals /hill was noted at 120 kg N/ha. While minimum number of BPH individuals (1.09/hill) was observed at 40 kg N/ha. Incidence BPH was inversely proportional to applied dose of P, highest being noted (1.60 individuals/hill) at no P condition and lowest (1.29/hill) at 40 kg P/ha situation. Similar to P application, maximum, BPH incidence was noted when no K was applied (1.33/hill) and minimum (0.92/hill) at 40 Kg K/ha.

Chakraborty (2011) observed that incidence of dead heart (DH) and white head (WH) was 175.74% and 206.72% higher than the control field when the field was fertilized by 140kg N/ha. Application of high dose K to rice plants decreased adult life and population build-up of the insect.

Randhawa *et al*. (2014) observed that highest incidence of rice leaf folder, *Cnaphalocrocis medinalis* (Guenee) and stem borer *Scripophaga incertulas* (Walker) on basmati variety Punjab Bas-2 and incidence increased with increase in nitrogen level.

The field experiment conducted by Mahapatra (2014) in Cuttack to study the effect of nitrogen fertilizer on the incidence of leaf folder in different rice varieties such as Daya, Birupa, Surendra, Indira, Pusa 44 and Vijetha at different levels of nitrogen viz., 0, 60, 120 and 180 kg N ha-1 revealed that higher level of nitrogenous fertilizer application results significantly higher leaf folder damage.

2.1 Rice Yellow Stem Borer

Scirpophaga incertulas, commonly known as the rice yellow stem borer. The rice stem borer is generally considered as the most serious pest of rice. They occur regularly and attack rice plants from seedling to majority stages. About 16 different stem borer species are found in rice fields.

Rahman *et al*., (2004) reported in Bangladesh that six species of rice stem borer cause damage on rice and among which the yellow stem borer, dark headed stripped borer and pink borer major economic significance.

Kapur (1967) reported that in Bangladesh, the most destructive and widely distributed species is yellow stem borer.

2.1.1 Systematic Position:

Phylum: Arthropoda

Class: Insecta

Order: Lepidoptera

Family: Pyralidae

Genus: Scirpophaga

Species: *S. incertulas*

2.1.3 Nature of Damage

The rice stem borers are generally considered as the most serious pest of rice. They occur regularly and attack plants from seedling to maturity stages. About 16 different stem borer species are found in rice fields and among them the yellow stem borer; dark headed striped borer and pink borer are of major borer and have great economic significance. (Kapur 1967; Rao and Israel, 2004).

Ragini *et al.* (2005) conducted a survey to evaluate the seasonal occurrence and relative abundance of 3 rice stem borer species, i.e. the yellow stem borer (YSB, *Scirpophaga incertulas)*, the pink stem borer (PSB, *Sesamia inferens*) and the dark headed borer (DHB, *Chilo polychrysus*). YSB was the most predominant species in June-September (60.0%) and October-January (48.43%). PSB was as abundant as YSB in October-January (48.43%). DSB was least abundant during either season (4.29-7.18%). YSB infestation was predominant from early tillering to maximum tillering stage and decreased gradually with increasing PSB infestation from the flowering stage.

Saha and Saharia (1970) reported that stem borer moths preferred to oviposit on rice plant grown with high rates of nitrogenous fertilizers. The larvae also grown better on heavily fertilized plants.

Kamran and Raros (1967) worked on seasonal fluctuations in abundance of various rice borers in Philippines, both during the wet and dry seasons. They also found that borer infestations were high during the wet season.

Scirpophaga incertulas could attack most of the growing stages of rice plant; begin Scanning with seedling through tillering and up to ear setting (Ranasinghe, 1992).

The caterpillars of *Scirpophaga incertulas* bore into the rice stem and hollow out the stem completely. The damage symptoms vary according to the stage of growth of the plant. During the very early stages of growth the larvae damage the growing point in the terminal shoot. This condition is known as 'Dead heart'. The larvae also feed internally within the leaf sheath and damage the vascular tissue by feeding inside the stem; The damage to stem results in the entry holes around. If the borer attack at the flowering stage resulting the panicles white and empty, a condition known as the 'white head'.

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

2.1.4 Management of stem borer

Naqvi (1973) suggested that an integrated pest management programme of rice, including use of pest resistant/tolerant variety, minimum one application of granular insecticide in water in paddy fields at the vulnerable stage of the crop, non-application of pesticides during the period when parasites were active and use of cultural practices has been evolved and has been practiced under an operational research project. This has helped in considerably reducing cost on crop protection and minimizing pesticide pollution.

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

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: Pyralidae
Genus: Cnaphalocrocis
Species: *C. medinalis*

2.2.2 Distribution of leaf roller

Das (1998) & Biswas *et al.,* (2001) observed that the leaf roller *Cnaphalocrocis medinalis* Guenée has appeared as the most damaging pest in recent years.

Khan *et al.,* (1988); Shanmugam *et al.,* (2006), 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.

Sato *et al*., (1978) observed that adult female moth is golden yellow in color with brown margins on both the wings. While resting, the body shape is like that of an equal-sided triangle. It has three bands traversing entire forewing. Middle band was short, comma like and curved outside. Male moths are smaller than female moths and have a prominent patch of dark brown andraconial scales along the mid costa of forewing. Adults usually emerge in the evening and mating occurs at night.

2.2.3 Nature of Damage

The destructive stage of this insect is the larval stage. At this stage they fold the leaves longitudinally before feeding. They tie the leaf margins with the threadlike silk. They feed the green mesophyll of leaf inside the folded leaf. They feed by scraping. At first and second instar larvae feed within the slightly folded areas of leaf. At late second instar feed and roll up the maximum area of a leaf. There is one larva in one leaf. After feeding one leaf, larva moves to another leaf. In this way one larva can damage a number of leaves. So, vegetative growth and finally yield is hampered. Yield losses are maximum when flag leaf is damaged. The larvae roll the leaves from tip downwards and then feed inside the young leaves and buds. Damaged leaves have a silvery-brown papery look and are noticeable from a distance. Fraenkel *et al*. (1981) observed that *C. medinalis* damages the rice plant throughout the crop growth period. The larvae fold the leaves longitudinally by stitching the leaf margins and feed by scraping the green mesophyll tissue from within the folded leaves. This feeding causes linear, pale white stripes that result in membranous patches.

2.2.4 Integrated management

Timely planting and wider spacing reduces the leaf folder incidence. Avoid excessive use of nitrogenous fertilizers. Keep the bunds clear by trimming them and remove the grassy weeds as they serve as alternate hosts. Avoid using chemicals like carbofuran, phorate that cause resurgence of leaf folder. Setting up of light traps at 4/ha to attract and kill adult moths. Release *Trichogramma chilonis,* 5- 6 times @ 1,00,000adults/ ha starting from 15 days after transplanting. High humidity and shady areas of the field favour their development. The presence of grassy weeds in rice fields and surrounding borders support continuous development of the pest. Expanded rice areas with irrigation systems, multiple rice cropping and insecticide induced resurgences are important factors in the leaf folder's abundance. The adults are nocturnal and during the day, they stay under shade to escape predation. They are active year-round and moths fly short distances when disturbed.

2.3 Brown plant hopper (BPH)

The pest, BPH belongs to the plant sucking group of insects called Homoptera. It has been a serious pest of rice in Japan for many years and in Taiwan since 1960. Until 1970, the insect was only a minor pest in the tropics, but now the BPH has greatly increased in abundance and caused heavy yield losses in many countries. Considering the unpredictable nature of infestations and the severe damage caused, the BPH is regarded as the most serious pest of rice in today's South, South-East Asia and the Far-east (Alam *et al*., 1988)..

2.3.1 Systematic position of brown plant hopper

Phylum: Arthropoda

Class: Insecta

Order: Homoptera

Family: Delphacidae

Genus: *Nilaparvata*

Species: *Nilaparvata lugens*

2.3.2 Nature of damage

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

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

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

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

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

2.3.3 Control measures

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

2.4 Green leaf hopper

Different species of leaf and plant hoppers infest rice in the Indian subornment. Of these, the green leafhopper, zigzag leafhopper, the white backed plant hopper and the brown plant hopper are considered economically important (Misra and Israel 1970). The several areas, they frequently occur in large number enough to cause hopper burn.

2.4.1 Systematic position of green leafhopper

Phylum: Arthropoda

Class: Insecta

Order: Homoptera

Family: Cicadellidae

Genus: *Nephotettix*

Species: *Nephotettix virescens*

2.4.2 Nature of damage

The green leafhoppers, *Nephotettix spp*. (Homoptera: Cicadellidae) are most devastating pests of rice throughout the rice growing areas of Asia (Razzaque *et al*. 1985). These have been reported from Bangladesh, Bhutan India, Indonesia, Kampuchea, Malaysia, Nepal, Philippines, Sri Lanka, Thailand, and Vietnam (Alam 1983; Alam and Catling 1976; Heinrichs *et al*. 1982; Reissing *et al*. 1985). They don't do only cause direct damage by sucking plant sap and by ovipositing on the leaf sheath but also act as efficient vector of rice tungro virus, one of the most menacing diseases of rice.

Misra *et al*. (1985) reported that the seasonal changes in population density of *Nephotettix virescens, N. nigropictus, Sogatella furcifera,* and *Nisiaatro venosa*, which are important pests of rice in India, Bangladesh during the kharif season.

Hibino (1979) and Chen & Chu (1981) reported that *N. lugens* is vector of the virus diseases-grassy stunt, ragged stunt, wilted stunt.

Soekhardjan *et al*. (1974) reported that in general there is an increase in the level of green leafhopper infestation with the increase of the age of the rice plants.

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

Alam (1971) found that at IRRI, *N. virescens* were more abundant during the late dry and wet season. Hiesh (1972) also found that green leafhoppers were generally more abundant on the wet season crops than on the dry season crops. Too much rain could suppress the insect abundance.

2.4.3 Control measures

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

2.5 Rice Bug

Rice bug, *Leptocorisa acuta* (Thunburg) and *Leptocorisa oratoria* (Fabricius) are important pests infesting the rice crop at the flowering stage. These are also known as Gandhi bugs because of the peculiar odour they emit. The insects were earlier identified as *Leptocorisa acuta* from India, but now called as *Leptocorisa oratoria* (Fabricius). These two closely related species may occur together in rice fields. They are most abundant at 27^0C to 28^0C and about 80 % relative humidity. Population usually increases at the end of a rainy season but declines rapidly during dry month.

2.5.1 Systematic position of rice bug

Phylum: Arthropoda
  Class: Insecta
    Order: Hemiptera
      Family: Alydidae
        Genus: *Leptocorisa*
          Species: *Leptocorisa acuta*

Singh and Chandra (1967) observed that rice bug migrates from alternate hosts to rice fields during the flowering stage. The hibernating adults become active with the onset of summer rains. Intermittent rains and high temperature during summer are conducive to terminating its aestivation. They also found that the rice bug reacts favorably to the higher humidity and rainfall prevailing from April to June in Bihar, India, which are the active season of the bugs.

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

2.5.2 Nature of damage

Rice bugs feed by inserting their needlelike mouthparts into new leaves, tender stems and developing grains. Consequently, the plant reacts to repair the tissue and seal the wound. When injuries accumulate, the plant becomes stressed, which can lead to growth retardation of the grains and some grain and plant deformation. Excessive feeding can cause yellow spots on the leaves. This reduces photosynthesis and, in extreme cases, can damage the vascular system of the plant. Puncture holes also serve as points of entry for several plant pathogens, such as the fungus that causes sheath rot disease. The most economically important damage is caused when the adults and nymphs feed on the developing grains. Such damage causes discoloration of the grains, which reduces market quality. The general nature and symptoms of damage in brief as reported by a number of workers are as follows.

According to Rai (1989) both nymphs and adults of rice earhead bugs sucked the milky juice from developing grains, there by prevented grain formation and such grains later shriveled. The earheads in badly infested fields showed numerous empty grains, which turned brown and dried.

Lee *et al*. (1986) reported that *L. oratorius* was the most dominant species associated with grain discolouration in association with fungal pathogen *Fusarium solani* causing “Dirty panicle” disease of rice.

Morrill (1997) observed that, when given the choice on plants in the laboratory, adults strongly preferred (pre) flowering spikelets to milky or dough spikelets. Attack of (pre) flowering spikelets causes empty or partially filled seed (van der Goot 1949; Rothschild 1970b; Morrill 1997), or causes dislodge-ment of spikelets (W.L. Morrill, personal communication). Attack of milky spikelets reduces seed weight. (Morrill 1997) and feeding on dough-stage spikelet may cause stained seed. However, farmers are concerned about grain yield, seed ripeness and the proportion of empty seed, not about stained seed. The influence of feeding by *L. oratorius* on rice yield has been examined in several studies.

2.5.3 Control measures

Remove weeds from fields and surrounding areas to prevent the multiplication of rice bugs during fallow periods. Level fields with even applications of fertilizer and water encourage rice to grow and develop is at the same rate**.** a**s** a preventive measure, the removal of alternate hosts, especially graminaceous weeds, can prevent rice bug populations from reaching damaging levels. This is because the bug requires a wild host to feed and reproduce upon before moving into the rice field in early spring. The use of late-maturing cultivars can reduce feeding damage from the rice bug, as their activity corresponds with warm weather and the flowering stage of host grasses.

Planting fields, within a village, at the same time (synchronous planting) also helps reduce rice bug problems. Capturing rice bugs, in the early morning or late afternoon, by net can be effective at low rice bug densities, though labor intensive.

2.6 Rice hispa

Rice hispa, *Dicladispa armigera* (Oliver) frequently causes extensive damage to lowland rice crops in Bangladesh, China (including Taiwan), India, Indonesia, Japan, Myanmar, Nepal, Pakistan, West Malaysia, and southern Thailand. The pest is not reported on upland rice and prefers more aquatic habitats. In Central Africa, a species of rice hispa, *Dicladispa viridicyanea* (Kraatz) attacks upland rice in the vegetative stage as well as in lowland seedbeds. *Trichispa sericea* (Guerin), an African species, damages upland rice in West Africa and Madagascar.

Three other hispid insects— *Dactylispa dilaticornis, Rhadinosa lebongensis* Maulik, and *Leptista pygmaea* Baly—damage the rice crop in several states of India. *Dicladispa gestroi* (Chapuis) is another important hispid insect reported from the Malagasy Republic.

2.6.1 Systematic Position:

Phylum: Arthropoda

Class: Insecta

Order: Coleoptera

Family: Chrysomelidae

Genus: *Dicladispa*

Species: *Dicladispa armigera*

2.6.2 Nature of Damage

Both adults and grubs feed on and damage rice plants. The adults scrape the upper surface of the leaf blade, often leaving only the lower epidermis. The damaged areas appear as white streaks parallel to the midrib. The tunneling of the grubs between the two epidermal layers results in irregular translucent white patches starting from ovipositional sites near the leaf tip and extending toward the base of the leaf blades. The affected parts of the leaves usually wither off. In severe infestations, the leaves turn whitish and membranous and finally dry off. In Kenya, *Trichispa sericea* can transmit rice yellow mottle virus. Infested plants have reduced leaf area, become less vigorous, and are often stunted. In recent years, hispa has been a perpetual problem in Bangladesh, infesting several thousand hectares annually and causing affected areas to suffer a significant yield loss. The insect also attacks sugarcane and some wild grasses.

2.6.3 Control Measure

Close plant spacing results in greater leaf densities that can tolerate higher hispa numbers. Bunds and vicinities should be kept free from grassy weeds on which these beetles can maintain their population. Stubble should be uprooted after harvest to avoid ratooning. In some countries, leaf tips are clipped off before transplanting to eliminate early stages of the pest. Excess N application should be avoided. Planting early at the beginning of the monsoon allows a field to escape hispa build up. Hand picking damaged leaves removes larvae from the field and prevents hispa build up. Damaged leaves can be removed up until booting.

2.7 Rice grasshopper

Rice grasshopper is an important pest of rice. It causes heavy damage to nurseries and reduces yield. Adults are about the size of your little finger. The body is a shiny greenish yellow colour with three black lines on its upper side. In the early stages, the young are yellowish, with many reddish brown spots. They become greenish as they grow older. Adults and their young are mostly found near grasses, water channels, ditches and rice fields.

2.7.1 Systematic Position:

Phylum: Arthropoda
Class: Insecta
Order :Orthoptera
Family: Acrididae
Genus: *Hieroglyphus*
Species: *Hieroglyphus banian*

2.7.2 Nature of Damage

The adults and young eat leaves at the sides first. You can see large chunks of the leaves being damaged. During August and September they cause heavy damage and leaf shedding may occur. Rice grasshoppers also feed on grains, resulting in empty panicles.

Rice grasshoppers feed throughout the year on rice, maize, millet, sugarcane and other grasses. They lay eggs from September to November in soil at the depth of your little finger. Eggs are laid in pods and each pod contains many eggs. It sleeps between November and March and the eggs hatch at the end of June or in early July (during the monsoon) and start feeding on the leaves. They can travel long distances when they come out of the ground.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to evaluate the effect of different doses of Nitrogen, Phosphorous & Potassium on the incidence of insect pests of rice. Materials and method Includes location of experiment, soil and climate condition of the experimental plot, materials used, design of the experiment, data collection procedure and procedure of data analysis that followed in this experiment has been presented under the following headings:

3.1 Description of the experimental site

3.1.1 Experimental period

The experiment was conducted during the period from July 2016 to October 2016.

3.1.2 Site description

The present piece of research work was conducted in the experimental area of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh. The location of the site is 23^{0}74/N latitude and 90^{0}035/E longitude with an elevation of 8.2 meter from sea level.

3.1.3 Climatic condition

The geographical location of the experimental site was under the subtropical climate and its climatic conditions is characterized by heavy rainfall during the month of April to September and scanty rainfall during the rest period of the year. Details of meteorological data in respect of average temperature 27 (^{0}C), rainfall 231.3 (cm), relative humidity 77.5 (%) and sunshine hour 12:46 during the period of the experiment has been presented in Appendix II.

3.1.4 Soil characteristics of the experimental plot

The soil belonged to “The Modhupur Tract”, AEZ-28 (FAO, 1988). Top soil was Silty Clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and had organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land. The details have been presented in Appendix 1.

3.2 Experimental details

3.2.1 Planting material

BRRI dhan33 were used as the test crop in this experiment.

3.2.2 Treatments of the experiment

The experiment comprised of the following NPK dose as treatment.

T_0 = Untreated control, no NPK fertilizers,

T_1 = NPK @ 45, 50, 40 kg/ha

T_2 = NPK @ 70, 25, 40 kg/ha

T_3 = NPK @ 70, 50, 20 kg/ha

T_4 = NPK @ 70, 50, 40 kg/ha

T_5 = NPK @ 70, 50, 60 kg/ha

T_6 = NPK @ 70, 75, 40 kg/ha

T_7 = NPK @ 95, 50, 40 kg/ha

3.2.2.1 Details of the treatment

T_0= Untreated Control (No NPK fertilizer application)

T_1= Top dressing of Nitrogen @ 45 kg/ha from urea at three equal splitting

Phosphorous @ 50kg/ha from TSP at single dose &

Potassium @ 40kg/ha from MoP at single dose as basal

T_2 = Top dressing of Nitrogen @ 70 kg/ha from urea at three equal splitting

Phosphorous @ 25 kg/ha from TSP at single dose as basal &

Potassium @ 40 kg/ha from MoP at single dose as basal

T_3 = Top dressing of Nitrogen @ 70 kg/ha from urea at three equal splitting

Phosphorous @ 50 kg/ha from TSP at single dose as basal &

Potassium @ 20 kg/ha from MoP at single dose as basal

.T_4 = Top dressing of Nitrogen @ 70k g/ha from urea at three equal splitting

Phosphorous @ 50 kg/ha from TSP at single dose as basal &

Potassium @ 40 kg/ha from MoP at single dose as basal

.T_5 = Top dressing of Nitrogen @ 70 kg/ha from urea at three equal splitting

Phosphorous @ 50 kg/ha from TSP at single dose as basal &

Potassium @ 60 kg/ha from MoP at single dose as basal

T_6 = Top dressing of Nitrogen @ 70 kg/ha from urea at three equal splitting

Phosphorous @ 75 kg/ha from TSP at single dose as basal &

Potassium @ 40 kg/ha from MoP at single dose as basal

T_7= Top dressing of Nitrogen @ 95 kg/ha from urea at three equal splitting

Phosphorous @ 50 kg/ha from TSP at single dose as basal &

Potassium @ 40 kg/ha from MoP at single dose as basal

3.2.3 Experimental design and layout

The experiment was laid out in a randomized complete block design (RCBD) with three replications, where the experimental area was divided into three blocks representing the replications to reduce soil hetero-genic effects. Each block was divided into 8 unit plots as treatments marked with raised bunds. Thus the total numbers of plots were 24. The unit plot size was 4.0 m × 2.5 m. The distance maintained between two blocks and two plots were 0.5 m and 0.5 m, respectively. (Figure 1).

3.3 Growing of crops

3.3.1 Seed collection and sprouting

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

3.3.2 Raising of seedlings

The nursery bed was prepared by puddling with repeated ploughing followed by laddering. The sprouted seeds were sown on beds as uniformly as possible. Irrigation was gently provided to the bed as and when needed. No fertilizer was used in the nursery bed.

3.3.3 Land preparation

The plot selected for conducting the experiment was opened in the 2^{nd} week of June 2016 with a power tiller, and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good puddle condition. Weeds and stubbles were removed. The experimental plot was partitioned into unit plots in accordance with the experimental design. Organic and inorganic manures as indicated below were mixed with the soil of each unit plot.

3.3.4 Fertilizers and manure application

The fertilizers N, P, K in the form of USG, TSP, MP respectively were applied as per treatment & S, Zn and B in the form of Gypsum, Zinc sulphate and Borax were applied as recommended for BRRI dhan 33 (BRRI, 2013). Urea was applied as granule. The entire amount of TSP, MP, gypsum, zinc sulphate and borax were applied during the final preparation of land. The USG was applied in three equal installments at Basal, tillering and panicle initiation stages.

Doses and times of fertilizer application in experimental rice field

Fertilizers and Manures	Dose/ha	Application (%) at DAT		
		Basal	15	30
Cowdung	10 tonnes	100	--	--
Urea (N=46%)	As per treatment	33.33	33.33	33.33
TSP (P_2O_5=48%)	As per treatment	100	--	--
MoP (K_2O =60%)	As per treatment	100	--	--
Gypsum	12 kg (S: 12 Kg)	100	--	--
Zinc sulphate	2.0 kg (Zn: 0.7 kg)	100	--	--
Boric acid	10 (B: 1.3 kg)	100	--	--

3.3.5 Transplanting of seedling

Twenty five days old seedlings were carefully uprooted from the seedling nursery and transplanted on 30 July, 2016 in well puddled plot. Three seedlings $hill^{-1}$ were used following spacing as per treatment. After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings of the same source whenever required.

3.3.6 Intercultural operations

Intercultural operations were done to ensure normal growth of the crop. Plant protection measures were followed as and when necessary. The following intercultural operations were done.

3.3.6.1 Irrigation and drainage

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

3.3.6.2 Weeding

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

3.4 Harvesting, threshing and cleaning

The crop was harvested at full maturity at 31 October, 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 from10 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 were recorded from each plot 10 m^2 (4.0 m × 2.5 m) and converted to t ha^{-1}.

3.5 Data collection and calculation

The infestation was expressed as percent ‘dead heart’ and ‘white head’ calculated by using the formula as suggested by Shafiq *et al*. (2000).

3.5.1 Infestation level

Five hills were selected at random per replicate for each treatment. The dead heart tiller and white head infested tiller were counted. In case of dead heart, it was counted in vegetative growth stage and white head infested infected tillers was counted at reproductive stage converted into per plant. Hopper burn was counted in tillering, panicle initiation, before ripening and after ripening stage and tungro infested infected tillers was counted at seedling, tillering, and panicle initiation stage converted into per plant. The observation was recorded at the first observation of symptom and was continued up to maturity at 7 days interval.

3.5.1.1 Percent dead heart infestation

Number of dead hurt infested tillers will counted at tillering to before panicle initiation from total tillers per five hills and converted into percent dead hurt was calculated by using the following formula:

No. of dead hurt infested tiller

% dead hurt infested tillers = --x 100

Total no. of tiller per five hills

3.5.1.2 Percent white head infestation

Number of white head infested tillers will counted at dough stage to before grain maturity stage from total tillers per five hills and converted into percent white head was calculated by using the following formula:

No. of white head infested tiller

% white head infested tillers = --x 100

Total no. of tiller per five hills

3.5.1.3 Percent Hopper burn infestation

Number of Hopper burn infested tillers will counted at tillering, panicle initiation, before ripening stages from total tillers per five hills and converted into percent Hopper burn was calculated by using the following formula:

No. of hopper burn infested plant

% Hopper burn infested tillers = --x 100

Total no. of plant per five hills

3.5.1.4 Percent tungro infestation

Number of tungro infested tillers will counted at seedling, tillering, and panicle initiation stage from total tillers per five hills and percent tungro infestation calculated by using the following formula:

No. of tungro infested plant

% tungro infested tillers=---x 100

Total no. of plants per five hills

3.5.2 Yield contributing characters and yield of rice

3.5.2.1 Panicle length

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

3.5.2.2 Filled grains panicle^{-1}

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

3.5.2.3 Unfilled grains panicle^{-1}

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

3.5.2.4 Weight of 1000-grains

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

3.5.2.5 Grain yield

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

3.6 Statistical analysis

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

Plate 1: The experimental field of the present study at SAU, Dhaka

Plate 2: **The experimental field of the present study at SAU, Dhaka**

4.0 m × 2.5 m

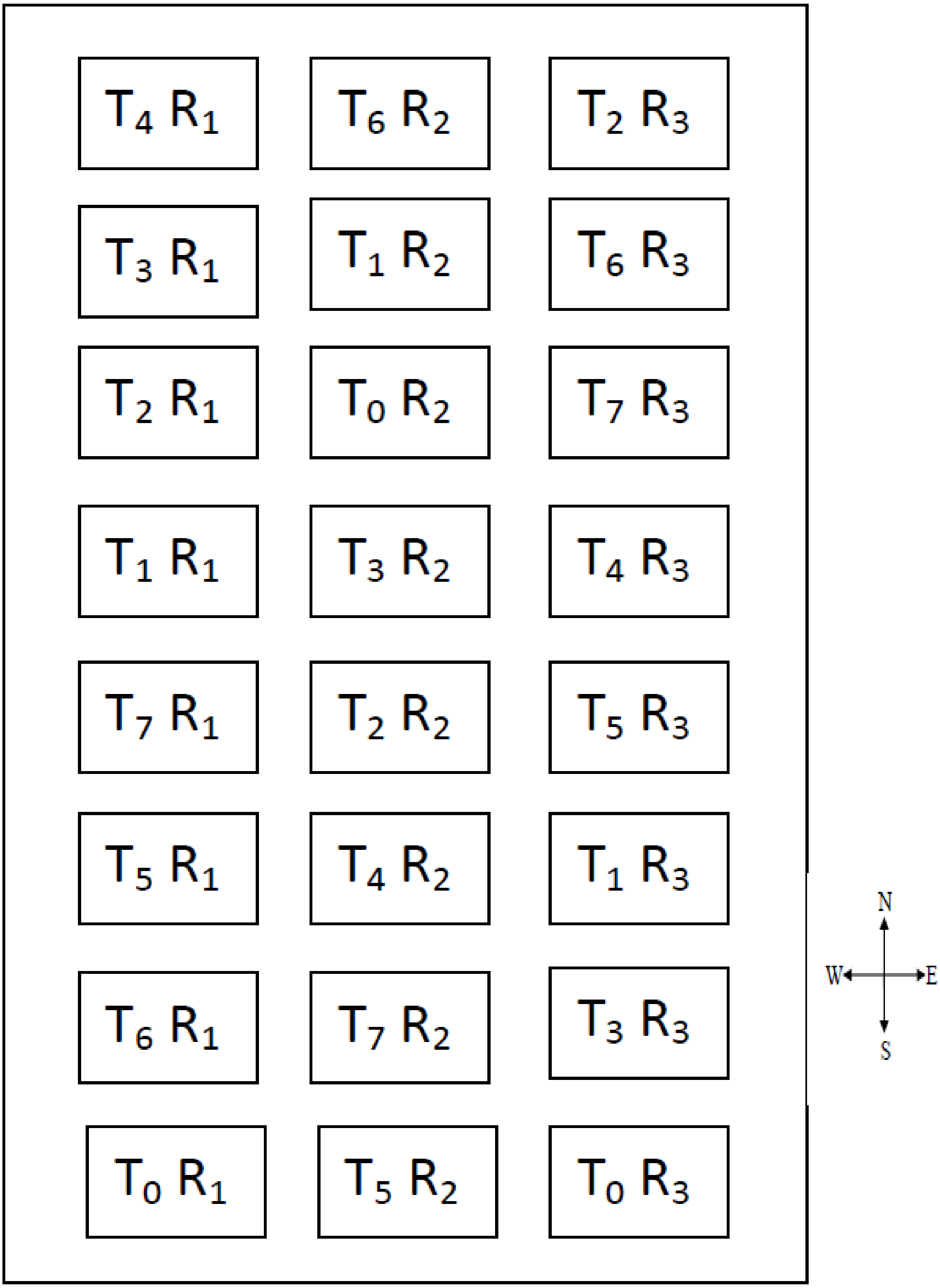

FIgure 1. **Layout of experimental field of the present study at SAU**

CHAPTER IV

RESULTS AND DISCUSSION

The study was conducted to find out the effect of different levels of NPK on insect pests in transplant aman rice. Different types of insect pests were identified for the entire growing period with their number and incidence on rice plants and also recorded the data on different yield contributing characters and yield of rice. The analysis of variance (ANOVA) of the data on the different recorded parameters has been presented in Appendix III-XII. The results have been presented and discussed, and possible interpretations have been given under the following headings and sub-headings:

4.1 Identification of different insect pests of rice

4.1.1 Different species of insect pests

There were numerous insect pests of rice under favorable condition which is the common phenomenon of rice cultivation and rice plants compete with these insect pests throughout the entire growing period. In the entire growing period of rice 8 major common species of insect pests were observed and they were belongs to the 6 family under 5 orders. The common name, scientific name, order, family and nature of damage as rice insect pests are presented in Table 1. Among the observed insect pests 2 species belong to the family Pyralidae and only 1 species for each of Chrysomelidae, Acrididae, Delphacidae, Cicadellidae and Coreidae family. Most of the insect pests were more destructive in nymphal and adult stages and caterpillars were in the larval stage. The identified insect pests also presented in Table 1. Different report represents so far there are total 175 species of rice insect pests in Bangladesh and among them 20-30 species are economically important (Miah and Karim, 1984). Major pests cause damage about 28% to aman crops and the estimated approximately 1.5 to 2.0 million tons annual loss of rice in Bangladesh due to different insect pests and diseases (BRRI, 1985). Mustafi *et al.* (2007) reported that there are about 175 insect pest species which cause damage to the rice plants in Bangladesh.

Table 1. List of different insect pests that were observed in the experimental rice field during entire growing period with their common name, scientific name, order, family and nature of damage

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

4.1.2 Number of different insect population

During the entire growing period 5 selected hills/plot were monitored with clean observation and yellow stem borer, leaf folder, rice hispa, grasshopper, brown plant hopper, green leaf hopper and rice bug insect pests were observed in different growth stage as insect populations of rice plants. The number of these identified insects were recorded and presented in Table 2. For different levels of NPK fertilizers number of different insect pests showed statistically significant differences under the present trial.

4.1.2.1 Yellow stem borer

In consideration of yellow stem borer, it was revealed that the number of yellow stem borer in 5 selected hills vary from 1.67 to 9.33 for different levels of NPK fertilizers. The lowest number (1.67) of yellow stem borer was observed from T_5 (NPK @ 70, 50, 60 kg/ha) treatment which was followed (3.13) by T_1 (NPK @ 45, 50, 40 kg/ha) treatment and then (5.27) by T_6 (NPK @ 70, 75, 40 kg/ha) and (5.80) by T_4 (NPK @ 70, 50, 40 kg/ha) treatment, whereas the highest number (9.33) was found from T_7 (NPK @ 95, 50, 40 kg/ha) treatment which was followed (7.67) by T_0 (Untreated control, no NPK fertilizers) and then (6.87) by T_2 (NPK @ 70, 25, 40 kg/ha) and (6.33) by T_3 (NPK @ 70, 50, 20 kg/ha) treatment. Data reveal that optimum doses of NPK fertilizers was more effective in controlling of yellow stem borer, whereas in excessive application of NPK fertilizers increased the incidence of yellow stem borer compare to the untreated control condition. So the application of appropriate doses of NPK fertilizers is the pre-requisite for attaining highest yield of rice. Rao and Israel (2004) reported from their earlier experiment that rice stem borers are generally considered as the most serious of insect pest of rice and about 16 different species of stem borer are commonly found in rice fields and among them the yellow stem borer, dark headed striped borer and pink borer are of major borer and have a great economic significance in rice cultivation. Ragini *et al.* (2005) reported that yellow stem borer (YSB) infestation was extensively occurred early tillering to maximum tillering stage.

Table 2. Number of major insect pests in BRRI dhan33 during the growing period at different levels of NPK fertilizers

Treatments	Number of different insect pests in 5 selected hills						
	Yellow stem borer	Leaf folder	Rice hispa	Grasshopper	Brown plant hopper	Green leaf hopper	Rice bug
T_0	7.67 b	10.27 b	3.27 b	11.13 b	7.27 b	9.27 b	6.33 b
T_1	3.13 g	2.73 f	1.60 f	4.27 f	2.47 g	2.87 fg	2.60 f
T_2	6.87 c	8.13 c	2.87 c	8.33 c	5.87 c	7.87 c	5.53 c
T_3	6.33 d	7.33 d	2.47 d	6.33 d	5.33 d	6.13 d	4.80 d
T_4	5.80 e	5.33 e	2.13 e	5.47 de	4.87 e	4.87 e	4.13 e
T_5	1.67 h	1.13 g	1.13 g	3.33 g	1.93 h	2.47 g	1.73 g
T_6	5.27 f	4.93 e	1.67 f	4.93 ef	4.27 f	3.07 f	3.80 e
T_7	9.33 a	12.67 a	3.67 a	12.73 a	9.47 a	11.67 a	8.60 a
$LSD_{(0.05)}$	0.470	0.751	0.293	0.899	0.467	0.522	0.495
CV(%)	4.65	6.52	7.07	7.26	5.13	4.95	6.04

In a column, numeric data represents the mean value of 3 replications; each replication is derived from each plot of each treatment
In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_0 = Untreated control, no NPK fertilizers
T_1 = NPK @ 45, 50, 40 kg/ha
T_2 = NPK @ 70, 25, 40 kg/ha
T_3 = NPK @ 70, 50, 20 kg/ha
T_4 = NPK @ 70, 50, 40 kg/ha
T_5 = NPK @ 70, 50, 60 kg/ha
T_6 = NPK @ 70, 75, 40 kg/ha
T_7 = NPK @ 95, 50, 40 kg/ha

4.1.2.2 Leaf folder

In case of leaf folder, the numbers of leaf folder differ from 1.13 to 12.67 per 5 selected hills due to different levels of NPK fertilizers. The lowest number of leaf folder was recorded from T_5 (1.13) treatment which was followed by T_1 (2.73) treatment, while the highest number was observed from T_7 (12.67) treatment which was followed by T_0 (10.27) treatment. Kaushik (2010) reported that the rice leaf folder is the most widely distributed and commonly found foliage feeder in all the rice growing areas of Southeast Asia (Table 2).

4.1.2.3 Rice hispa

For rice hispa, in 5 selected hills the range was 1.13 to 3.27 for different levels of NPK fertilizers under the study. The lowest number of rice hispa was recorded from T_5 (1.13) treatment which was followed by T_1 (1.60) and T_6 (1.67) treatment and they were statistically similar, while the highest number was observed from T_7 (3.67) treatment which was followed by T_0 (3.27) treatment. Singh *et al*. (1990) in Punjab indicated that the NPK at 120:60:60 kg/ha increased the susceptibility of rice to infestation by rice hispa (Table 2).

4.1.2.4 Grasshopper

In consideration of grasshopper, data revealed that the number of grasshopper in 5 selected hills vary from 3.33 to 12.73 for different levels of NPK fertilizers. The lowest number of grass hopper was recorded from T_5 (3.33) treatment which was followed by T_1 (4.27) and T_6 (4.93) treatment and they were statistically similar, while the highest number was observed from T_7 (12.73) treatment which was followed by T_0 (11.13) treatment. Similar findings also reported earlier by Mahadev *et al*. (1995) in the gangetic alluvial soil (Entisol) of West Bengal when studied the effect of fertilizer treatments on rice (Table 2).

4.1.2.5 Brown plant hopper

In case of brown plant hopper, the numbers of brown plant hopper differ from 1.93 to 7.27 per 5 selected hills due to different levels of NPK fertilizers. The lowest number of brown plant hopper was found from T_5 (1.93) treatment which was followed by T_1 (2.47) treatment, whereas the highest number was recorded from T_7

(9.47) treatment which was followed by T_0 (7.27) treatment. Data revealed that optimum doses of NPK fertilizers was more effective in controlling of brown plant hopper, whereas in excessive application of NPK fertilizers increased the incidence of brown plant hopper compare to the untreated control condition. So the application of appropriate doses of NPK fertilizers is the pre-requisite for attaining highest yield of rice by controlling brown plant hopper. Alam *et al*. (1988) reported that the BPH is regarded as the most serious pest of rice in today's South, South-East Asia and the Fareast considering the unpredictable nature of infestations and the severe damage (Table 2).

4.1.2.6 Green leaf hopper

In consideration of green leaf hopper, data revealed that the number of green leaf hopper in 5 selected hills vary from 2.47 to 11.67 for different levels of NPK fertilizers. The lowest number of green leaf hopper was recorded from T_5 (2.47) treatment which was statistically similar to T_1 (2.87) and followed by T_6 (3.07) treatment, while the highest number was observed from T_7 (11.67) treatment which was followed by T_0 (9.27) treatment. Nath and Bhagabati (2005) reported that the green leaf hopper population was first appeared in the rice seedbed during June-July, reaching the peak in October -November in the main rice field and disappeared from field from December to May (Table 2).

4.1.2.7 Rice bug

In case of rice bug, the numbers of rice bug differ from 1.73 to 8.60 per 5 selected hills due to different levels of NPK fertilizers. The lowest number of rice bug was observed from T_5 (1.73) treatment which was followed by T_1 (2.60) treatment, whereas the highest number was found from T_7 (8.60) treatment which was followed by T_0 (6.33) treatment. Tsueda *et al.* (2002) studied on the occurrence of rice bugs, a total of 22 species, in rice fields. They also observed that *Stenotusrubro vittatus* was the important species and the peak occurrence of it coincided with the date of heading of early-ripening rice (Table 2).

4.2 Infestation of rice by different insect pests in different stages

4.2.1 Dead heart incidence caused by yellow stem borer

Dead heart incidence caused by yellow stem borer at 25, 45 and 60 DAT (days after transplanting) showed statistically significant differences for different levels of NPK fertilizers (Table 3). At 25 DAT, data recorded from each plot revealed that the lowest incidence of dead heart was observed from T_5 (3.64%) which was closely followed by T_1 (4.24%) and T_6 (4.66%) and they were statistically similar, while the highest incidence of dead heart was found from T_7 (10.37%) which was followed by T_0 (9.42%). In case of incidence of dead heart decrease/increase over control, the highest decrease was observed in T_5 (-61.36) and the lowest was found in T_2 (-22.82), whereas the increase of dead heart incidence was found from T_7 (+10.08) treatment.

At 45 DAT, data recorded from each plot revealed that the lowest incidence of dead heart was observed from T_5 (4.23%) which was closely followed by T_1 (5.16%) and T_6 (5.48%) and they were statistically similar, while the highest incidence of dead heart from T_7 (13.56%) which was followed by T_0 (10.36%). In case of incidence of dead heart decrease/increase over control, the highest decrease was observed in T_5 (-59.17) and the lowest was found in T_2 (-18.24), whereas the increase of dead heart incidence was found from T_7 (+30.89) treatment.

At 65 DAT, data recorded from each plot revealed that the lowest incidence of dead heart was observed from T_5 (4.47%) which was closely followed by T_1 (5.66%), T_6 (6.10%), T_4 (6.41%) and T_3 (6.57%) and they were statistically similar, while the highest incidence of dead heart was found from T_7 (14.73%) which was followed by T_0 (11.06%). In case of incidence of dead heart decrease/increase over control, the highest decrease was observed in T_5 (-59.58) and the lowest was found in T_2 (-17.90), whereas the increase of dead heart incidence was found from T_7 (+33.18) treatment. Ramzan *et al*. (1992) reported that high infestation of yellow stem borer is correlated with the high use of nitrogenous fertilizers in rice field.

Table 3. Incidence of rice yellow stem borer (dead heart) infestation in BRRI dhan33 at different levels of NPK fertilizers

Treatments	Incidence of rice yellow stem borer infestation (dead heart/plot) at different days after transplanting (DAT)					
	1st observation (25 DAT)		2nd observation (45 DAT)		3rd observation (65 DAT)	
	Dead heart (%)	Decrease/increase over control (%)	Dead heart (%)	Decrease/increase over control (%)	Dead heart (%)	Decrease/increase over control (%)
T_0	9.42 b	--	10.36 b	--	11.06 b	--
T_1	4.24 e	-54.99	5.16 e	-50.19	5.66 d	-48.82
T_2	7.27 c	-22.82	8.47 c	-18.24	9.08 c	-17.90
T_3	6.08 d	-35.46	6.24 d	-39.77	6.57 d	-40.60
T_4	5.77 d	-38.75	5.96 de	-42.47	6.41 d	-42.04
T_5	3.64 f	-61.36	4.23 f	-59.17	4.47 e	-59.58
T_6	4.66 e	-50.53	5.48 de	-47.10	6.10 d	-44.85
T_7	10.37 a	+10.08	13.56 a	+30.89	14.73 a	+33.18
$LSD_{(0.05)}$	0.517	--	0.810	--	1.124	--
CV(%)	4.59	--	6.22	--	8.01	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from each plot of each treatment
In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_0 = Untreated control, no NPK fertilizers
T_1 = NPK @ 45, 50, 40 kg/ha
T_2 = NPK @ 70, 25, 40 kg/ha
T_3 = NPK @ 70, 50, 20 kg/ha
T_4 = NPK @ 70, 50, 40 kg/ha
T_5 = NPK @ 70, 50, 60 kg/ha
T_6 = NPK @ 70, 75, 40 kg/ha
T_7 = NPK @ 95, 50, 40 kg/ha

4.2.2 White head incidence caused by yellow stem borer

Statistically significant variation was observed in terms of white head incidence caused by yellow stem borer at 60, 70 and 80 DAT due to different levels of NPK fertilizers (Table 4). At 60 DAT, data recorded from each plot revealed that the lowest incidence of white head was found from T_5 (2.35%) which was closely followed by T_1 (3.08%) and T_6 (3.19%) and they were statistically similar, while the highest incidence of white head was observed from T_7 (7.57%) which was followed by T_0 (5.13%) and T_2 (4.69%) and they were statistically similar. In case of incidence of white head decrease/increase over control, the highest decrease was observed in T_5 (-54.19) and the lowest was recorded in T_2 (-8.58), whereas the increase of white head incidence was attained from T_7 (+47.56) treatment.

At 70 DAT, data recorded from each plot revealed that the lowest incidence of white head was observed from T_5 (2.66%) which was statistically similar to T_1 (2.97%) and T_6 (3.24%) and closely followed by T_4 (3.83%), whereas the highest incidence of white head from T_7 (8.26%) which was followed by T_0 (5.84%) and T_2 (5.16%) and they were statistically similar. In case of incidence of white head decrease/increase over control, the highest decrease was observed in T_5 (-54.45) and the lowest was found in T_2 (-11.64), whereas the increase of white head incidence was found from T_7 (+41.44) treatment (Plate 3).

At 80 DAT, data recorded from each plot revealed that the lowest incidence of white head was observed from T_5 (3.12%) which was statistically similar to T_1 (3.45%) and closely followed by T_6 (3.99%), while the highest incidence of white head was found from T_7 (8.64%) which was followed by T_0 (5.95%) and T_2 (5.67%) and they were statistically similar. In case of incidence of white head decrease/increase over control, the highest decrease was observed in T_5 (-47.56) and the lowest was found in T_2 (-4.71), whereas the increase of white head incidence was found from T_7 (+45.21) treatment. Chakraborty (2011) observed that incidence of white head (WH) was 206.72% higher than the control field when the field was fertilized by 140 kg N/ha (Plate 4).

Table 4. Incidence of rice yellow stem borer (white head) infestation in BRRI dhan33 for different levels of NPK fertilizers

Treatments	Incidence of rice yellow stem borer infestation (white head/plot) at different days after transplanting (DAT)					
	1st observation (60 DAT)		2nd observation (70 DAT)		3rd observation (80 DAT)	
	White head (%)	Reduction over control (%)	White head (%)	Reduction over control (%)	White head (%)	Reduction over control (%)
T_0	5.13 b	--	5.84 b	--	5.95 b	--
T_1	3.08 d	-39.96	2.97 e	-49.14	3.45 de	-42.02
T_2	4.69 b	-8.58	5.16 b	-11.64	5.67 b	-4.71
T_3	3.96 c	-22.81	4.06 c	-30.48	4.38 c	-26.39
T_4	3.66 c	-28.65	3.83 cd	-34.42	4.08 c	-31.43
T_5	2.35 e	-54.19	2.66 e	-54.45	3.12 e	-47.56
T_6	3.19 d	-37.82	3.24 de	-44.52	3.99 cd	-32.94
T_7	7.57 a	+47.56	8.26 a	+41.44	8.64 a	+45.21
$LSD_{(0.05)}$	0.436	--	0.731	--	0.559	--
CV(%)	5.92	--	9.25	--	6.49	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from each plot of each treatment
In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_0 = Untreated control, no NPK fertilizers
T_1 = NPK @ 45, 50, 40 kg/ha
T_2 = NPK @ 70, 25, 40 kg/ha
T_3 = NPK @ 70, 50, 20 kg/ha
T_4 = NPK @ 70, 50, 40 kg/ha
T_5 = NPK @ 70, 50, 60 kg/ha
T_6 = NPK @ 70, 75, 40 kg/ha
T_7 = NPK @ 95, 50, 40 kg/ha

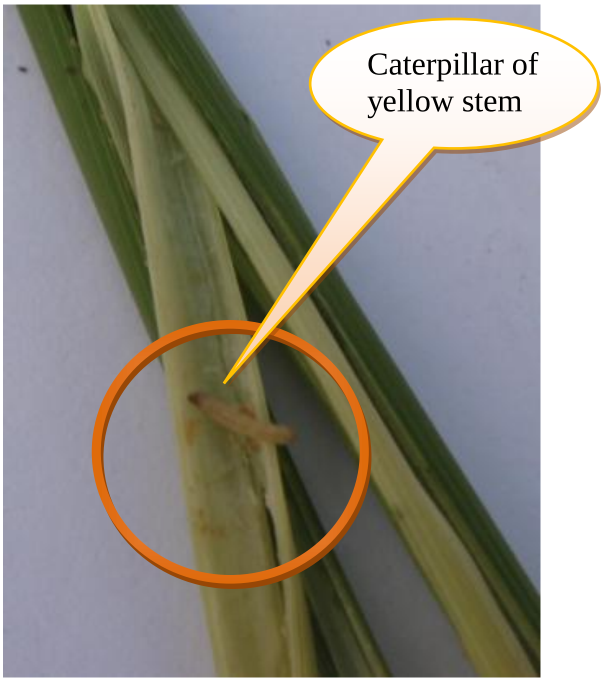

Plate 3 . Adult yellow stem borer & infested rice sheath with caterpillar of yellow stem borer in the rice plants of the experimental field

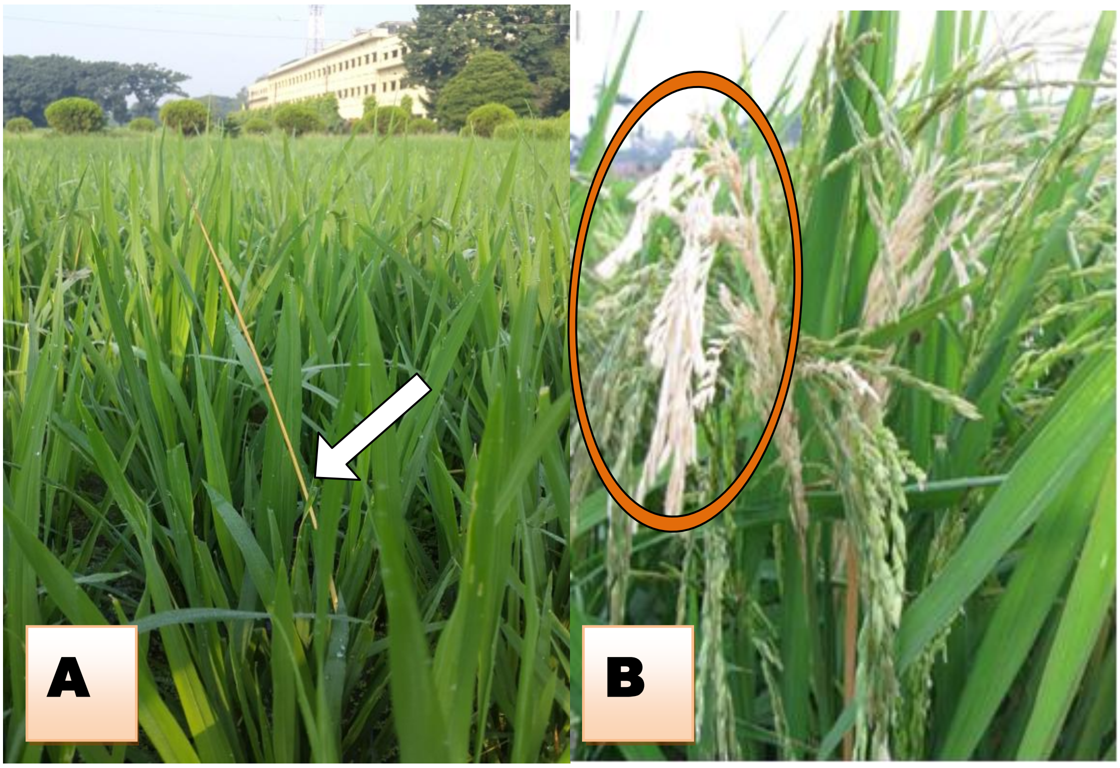

Plate 4 . The rice plants showing dead heart (A) & white head (B) symptom in the experimental field during the study period

4.2.3 Leaf folder incidence in leaf

Different levels of NPK fertilizers showed statistically significant differences in terms of leaf folder incidence as % of leaf infestation at 30, 45 and 60 DAT (Table 5). At 30 DAT, data recorded from each plot revealed that the lowest incidence of leaf folder was found from T_5 (3.47%) which was statistically similar with T_1 (3.84%) and closely followed by T_6 (4.05%), while the highest incidence of leaf folder was observed from T_7 (8.05%) which was followed by T_0 (6.12%). In case of incidence of leaf folder decrease/increase over control, the highest decrease was observed in T_5 (-43.30) and the lowest was recorded in T_2 (-10.62), whereas the increase of leaf folder head incidence was attained from T_7 (+31.54) treatment.

At 45 DAT, data recorded from each plot revealed that the lowest incidence of leaf folder was observed from T_5 (3.94%) which was closely followed by T_1 (4.56%), T_6 (4.67%) and T_4 (4.91%) and they were statistically similar, whereas the highest incidence of leaf folder from T_7 (8.56%) which was followed by T_0 (6.64%). In case of incidence of leaf folder decrease/increase over control, the highest decrease was observed in T_5 (-40.66) and the lowest was recorded in T_2 (-10.69), whereas the increase of leaf folder incidence was found from T_7 (+28.92) treatment (Plate 5).

At 60 DAT, data recorded from each plot revealed that the lowest incidence of leaf folder was observed from T_5 (4.04%) which was closely followed by T_1 (4.72%), T_6 (4.91%) and T_4 (5.23%) and they were statistically similar, while the highest incidence of leaf folder was found from T_7 (9.18%) which was followed by T_0 (6.94%). In case of incidence of leaf folder decrease/increase over control, the highest decrease was observed in T_5 (-41.79) and the lowest was found in T_2 (-11.82), whereas the increase of leaf folder incidence was found from T_7 (+32.28) treatment. Mahadev *et al*. (1995) reported that the crop applied with N either alone or coupled with P exhibited a lowered the incidence of leaf folder in rice field at vegetative stage.

Table 5. Incidence of leaf folder infestation in BRRI dhan33 for different levels of NPK fertilizers

Treatments	Incidence of leaf folder at different days after transplanting (DAT)					
	1st observation (30 DAT)		2nd observation (45 DAT)		3rd observation (60 DAT)	
	Leaf infestation (%)	Reduction over control (%)	Leaf infestation (%)	Reduction over control (%)	Leaf infestation (%)	Reduction over control (%)
T_0	6.12 b	--	6.64 b	--	6.94 b	--
T_1	3.84 ef	-37.25	4.56 e	-31.33	4.72 e	-31.99
T_2	5.47 c	-10.62	5.93 c	-10.69	6.12 c	-11.82
T_3	4.92 d	-19.61	5.34 d	-19.58	5.64 cd	-18.73
T_4	4.57 d	-25.33	4.91 de	-26.05	5.23 de	-24.64
T_5	3.47 f	-43.30	3.94 f	-40.66	4.04 f	-41.79
T_6	4.05 e	-33.82	4.67 e	-29.67	4.91 e	-29.25
T_7	8.05 a	+31.54	8.56 a	+28.92	9.18 a	+32.28
$LSD_{(0.05)}$	0.403	--	0.502	--	0.643	--
CV(%)	4.57	--	5.15	--	6.29	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from each plot of each treatment
In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_0 = Untreated control, no NPK fertilizers
T_1 = NPK @ 45, 50, 40 kg/ha
T_2 = NPK @ 70, 25, 40 kg/ha
T_3 = NPK @ 70, 50, 20 kg/ha
T_4 = NPK @ 70, 50, 40 kg/ha
T_5 = NPK @ 70, 50, 60 kg/ha
T_6 = NPK @ 70, 75, 40 kg/ha
T_7 = NPK @ 95, 50, 40 kg/ha

4.2.4 Rice hispa incidence in leaf

At 25, 40 and 55 DAT, statistically significant differences was observed in terms of rice hispa incidence as % of leaf infestation due to different levels of NPK fertilizers (Table 6). At 25 DAT, data recorded from each plot revealed that the lowest incidence of rice hispa was found from T_5 (1.15%) which was closely followed by T_1 (1.90%) and T_6 (1.85%) and they were statistically similar, whereas the highest incidence of rice hispa was observed from T_7 (4.86%) which was followed by T_0 (3.17%). In case of incidence of rice hispa decrease/increase over control, the highest decrease was observed in T_5 (-63.72) and the lowest was recorded in T_2 (-8.83), whereas the increase of rice hispa incidence was attained from T_7 (+53.31) treatment.

At 40 DAT, data recorded from each plot revealed that the lowest incidence of rice hispa was observed from T_5 (1.46%) which was statistically similar with T_1 (1.67%) and closely followed by T_6 (2.05%), while the highest incidence of rice hispa from T_7 (5.14%) which was followed by T_0 (3.55%). In case of incidence of rice hispa decrease/increase over control, the highest decrease was observed in T_5 (-58.87) and the lowest was recorded in T_2 (-14.65), whereas the increase of rice hispa incidence was found from T_7 (+44.79) treatment (Plate 6).

At 55 DAT, data recorded from each plot revealed that the lowest incidence of rice hispa was observed from T_5 (1.66%) which was statistically similar to T_1 (1.86%) and closely followed by T_6 (2.24%), while the highest incidence of rice hispa was found from T_7 (5.83%) which was closely followed by T_0 (3.78%). In case of incidence of rice hispa decrease/increase over control, the highest decrease was observed in T_5 (-56.08) and the lowest was found in T_2 (-14.02), whereas the increase of rice hispa incidence was found from T_7 (+54.23) treatment. Pathak *et al*. (1999) reported that minimum rice hispa incidence in control plots and enhanced doses of N resulted in significant increase in rice hispa incidence in rice field.

Table 6. Incidence of rice hispa infestation in BRRI dhan33 for different levels of NPK fertilizers

Treatments	Incidence of rice hispa at different days after transplanting (DAT)					
	1st observation (25 DAT)		2nd observation (40 DAT)		3rd observation (55 DAT)	
	Leaf infestation (%)	Reduction over control (%)	Leaf infestation (%)	Reduction over control (%)	Leaf infestation (%)	Reduction over control (%)
T_0	3.17 b	--	3.55 b	--	3.78 b	--
T_1	1.90 e	-40.06	1.67 g	-52.96	1.86 f	-50.79
T_2	2.89 bc	-8.83	3.03 c	-14.65	3.25 c	-14.02
T_3	2.56 cd	-19.24	2.74 d	-22.82	2.85 d	-24.60
T_4	2.34 d	-26.18	2.43 e	-31.55	2.67 d	-29.37
T_5	1.15 f	-63.72	1.46 g	-58.87	1.66 f	-56.08
T_6	1.85 e	-41.64	2.05 f	-42.25	2.24 e	-40.74
T_7	4.86 a	+53.31	5.14 a	+44.79	5.83 a	+54.23
$LSD_{(0.05)}$	0.443	--	0.254	--	0.355	--
CV(%)	9.80	--	5.26	--	6.69	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from each plot of each treatment
In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_0 = Untreated control, no NPK fertilizers
T_1 = NPK @ 45, 50, 40 kg/ha
T_2 = NPK @ 70, 25, 40 kg/ha
T_3 = NPK @ 70, 50, 20 kg/ha
T_4 = NPK @ 70, 50, 40 kg/ha
T_5 = NPK @ 70, 50, 60 kg/ha
T_6 = NPK @ 70, 75, 40 kg/ha
T_7 = NPK @ 95, 50, 40 kg/ha

Plate 5. Infested leaf (A) by Rice leaf folder & larvae (B) of Leaf folder in a leaf

Plate 6. The rice plant showing white streak symptom (A) due to scrapping of adult Rice hispa & infested leaf blade (B) by larvae of Rice hispa

4.2.5 Grasshopper incidence

Different levels of NPK fertilizers showed statistically significant differences in terms of grasshopper incidence as % of leaf infestation at 25, 40 and 55 DAT (Table 7). At 25 DAT, data recorded from each plot revealed that the lowest incidence of grasshopper was recorded from T_5 (0.59%) which was statistically similar with T_1 (0.91%) and T_6 (1.05%) and closely followed by T_4 (1.85%), while the highest incidence of grasshopper was observed from T_7 (4.63%) which was followed by T_0 (3.06%), T_3 (2.57%) and T_2 (2.85%) and they were statistically similar. In case of incidence of grasshopper decrease/increase over control, the highest decrease was observed in T_5 (-80.72) and the lowest was recorded in T_2 (-6.86), whereas the increase of grasshopper head incidence was attained from T_7 (+51.31) treatment.

At 40 DAT, data recorded from each plot revealed that the lowest incidence of grasshopper was observed from T_5 (0.75%) which was statistically similar with T_1 (1.14%) and T_6 (1.32%) and closely followed by T_4 (1.95%), whereas the highest incidence of grasshopper from T_7 (5.07%) which was followed by T_0 (3.83%). In case of incidence of grasshopper decrease/increase over control, the highest decrease was observed in T_5 (-80.42) and the lowest was recorded in T_2 (-20.37), whereas the increase of grasshopper incidence was found from T_7 (+32.38) treatment (Plate 7).

At 55 DAT, data recorded from each plot revealed that the lowest incidence of grasshopper was observed from T_5 (0.92%) which was closely followed by T_1 (1.65%), T_6 (1.82%) and T_4 (2.23%) and they were statistically similar, while the highest incidence of grasshopper was found from T_7 (5.78%) which was followed by T_0 (4.14%) and T_2 (3.75%) and they were statistically similar. In case of incidence of grasshopper decrease/increase over control, the highest decrease was observed in T_5 (-77.78) and the lowest was found in T_2 (-9.42), whereas the increase of grasshopper incidence was found from T_7 (+39.61) treatment. Patro *et al.* (2000) reported that excess N fertilizer increase the incidence of grasshopper.

Table 7. Incidence of grasshopper infestation in BRRI dhan33 at different levels of NPK fertilizers

Treatments	Incidence of grasshopper at different days after transplanting (DAT)					
	1st observation (25 DAT)		2nd observation (40 DAT)		3rd observation (55 DAT)	
	Leaf infestation (%)	Reduction over control (%)	Leaf infestation (%)	Reduction over control (%)	Leaf infestation (%)	Reduction over control (%)
T_0	3.06 b	--	3.83 b	--	4.14 b	--
T_1	0.91 d	-70.26	1.14 e	-70.23	1.65 d	-60.14
T_2	2.85 b	-6.86	3.05 c	-20.37	3.75 b	-9.42
T_3	2.57 b	-16.01	2.73 c	-28.72	2.94 c	-28.99
T_4	1.85 c	-39.54	1.95 d	-49.09	2.23 d	-46.14
T_5	0.59 d	-80.72	0.75 e	-80.42	0.92 e	-77.78
T_6	1.05 d	-65.69	1.32 de	-65.54	1.82 d	-56.04
T_7	4.63 a	+51.31	5.07 a	+32.38	5.78 a	39.61
$LSD_{(0.05)}$	0.520	--	0.767	--	0.557	--
CV(%)	6.88	--	9.52	--	6.32	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from each plot of each treatment
In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_0 = Untreated control, no NPK fertilizers
T_1 = NPK @ 45, 50, 40 kg/ha
T_2 = NPK @ 70, 25, 40 kg/ha
T_3 = NPK @ 70, 50, 20 kg/ha
T_4 = NPK @ 70, 50, 40 kg/ha
T_5 = NPK @ 70, 50, 60 kg/ha
T_6 = NPK @ 70, 75, 40 kg/ha
T_7 = NPK @ 95, 50, 40 kg/ha

4.2.6 Rice bug incidence

Different levels of NPK fertilizers showed statistically significant differences in terms of rice bug incidence as % of panicle infestation at 45, 55 and 65 DAT (Table 10). At 45 DAT, data recorded from each plot revealed that the lowest incidence of rice bug was found from T_5 (1.78%) which was statistically similar with T_1 (2.15%) and closely followed by T_6 (2.56%), T_4 (2.84%) and T_3 (2.95%) and they were statistically similar, while the highest incidence of rice bug was observed from T_7 (4.22%) which was followed by T_0 (3.48%) and T_2 (3.14%) and they were statistically similar. In case of incidence of rice bug decrease/increase over control, the highest decrease was observed in T_5 (-48.85) and the lowest was recorded in T_2 (-9.77), whereas the increase of rice bug head incidence was attained from T_7 (+21.26) treatment.

At 55 DAT, data recorded from each plot revealed that the lowest incidence of rice bug was observed from T_5 (1.96%) which was statistically similar with T_1 (2.22%) and closely followed by T_6 (2.64%), whereas the highest incidence of rice bug from T_7 (4.75%) which was followed by T_0 (3.65%) and T_2 (3.42%) and they were statistically similar. In case of incidence of rice bug decrease/increase over control, the highest decrease was observed in T_5 (-46.30) and the lowest was recorded in T_2 (-6.30), whereas the increase of rice bug incidence was found from T_7 (+30.14) treatment (Plate 8).

At 65 DAT, data recorded from each plot revealed that the lowest incidence of rice bug was observed from T_5 (2.04%) which was closely followed by T_1 (2.45%) and T_6 (2.67%) and they were statistically similar, while the highest incidence of rice bug was found from T_7 (5.08%) which was followed by T_0 (3.82%) and T_2 (3.68%) and they were statistically similar. In case of incidence of rice bug decrease/increase over control, the highest decrease was observed in T_5 (-46.60) and the lowest was recorded in T_2 (-3.66), whereas the increase of rice bug incidence was found from T_7 (+32.98) treatment. Mahadev *et al*. (1995) reported that the crop applied with N either alone or coupled with P exhibited a lowered the incidence of rice bug.

Table 8. Incidence of rice bug infestation in BRRI dhan33 at different levels of NPK fertilizers

Treatments	Incidence of rice bug at different days after transplanting (DAT)					
	1st observation (45 DAT)		2nd observation (55 DAT)		3rd observation (65 DAT)	
	Panicle infestation (%)	Reduction over control (%)	Panicle infestation (%)	Reduction over control (%)	Panicle infestation (%)	Reduction over control (%)
T_0	3.48 b	--	3.65 b	--	3.82 b	--
T_1	2.15 e	-38.22	2.22 ef	-39.18	2.45 e	-35.86
T_2	3.14 bc	-9.77	3.42 bc	-6.30	3.68 bc	-3.66
T_3	2.95 cd	-15.23	3.13 bcd	-14.25	3.34 cd	-12.57
T_4	2.84 cd	-18.39	2.97 cd	-18.63	3.12 d	-18.32
T_5	1.78 e	-48.85	1.96 f	-46.30	2.04 f	-46.60
T_6	2.56 d	-26.44	2.64 de	-27.67	2.67 e	-30.10
T_7	4.22 a	+21.26	4.75 a	+30.14	5.08 a	+32.98
$LSD_{(0.05)}$	0.403	--	0.514	--	0.367	--
CV(%)	7.66	--	9.14	--	6.19	--

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

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

T_0 = Untreated control, no NPK fertilizers
T_1 = NPK @ 45, 50, 40 kg/ha
T_2 = NPK @ 70, 25, 40 kg/ha
T_3 = NPK @ 70, 50, 20 kg/ha
T_4 = NPK @ 70, 50, 40 kg/ha
T_5 = NPK @ 70, 50, 60 kg/ha
T_6 = NPK @ 70, 75, 40 kg/ha
T_7 = NPK @ 95, 50, 40 kg/ha

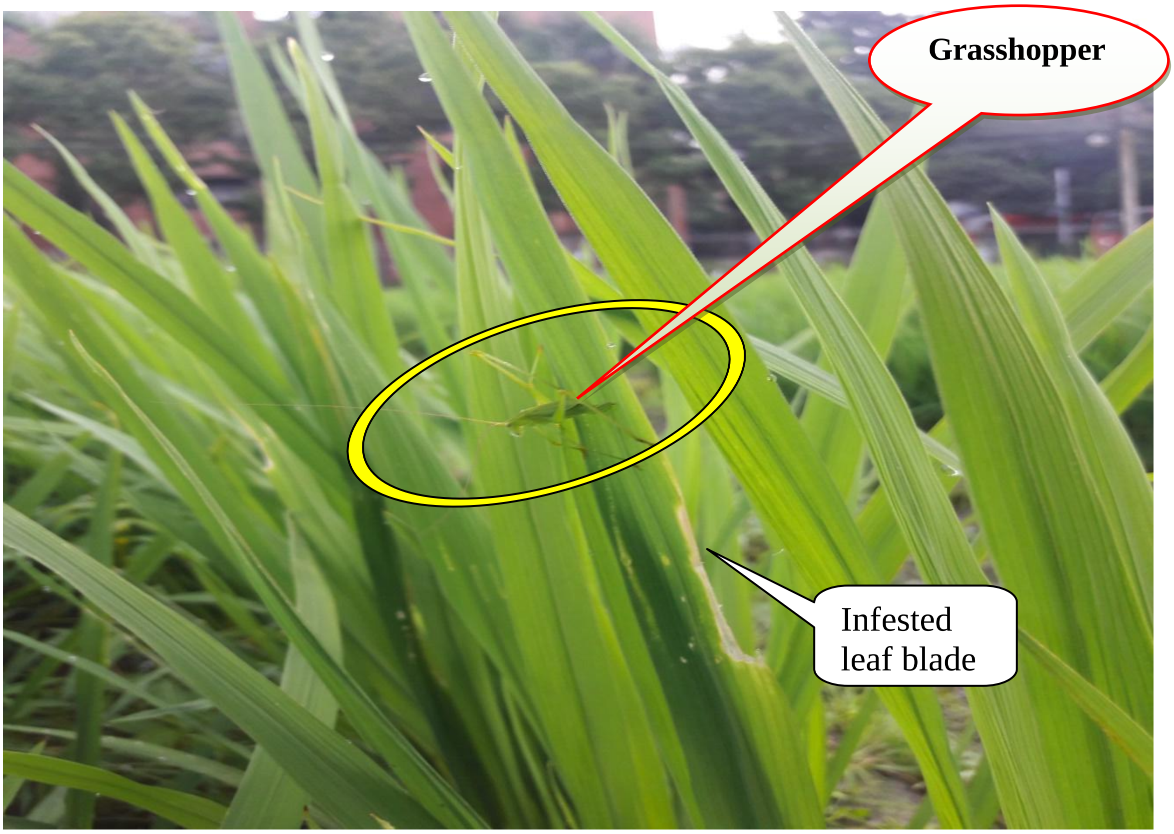

Plate 7. Grasshopper & infested leaf blade in the experimental rice field

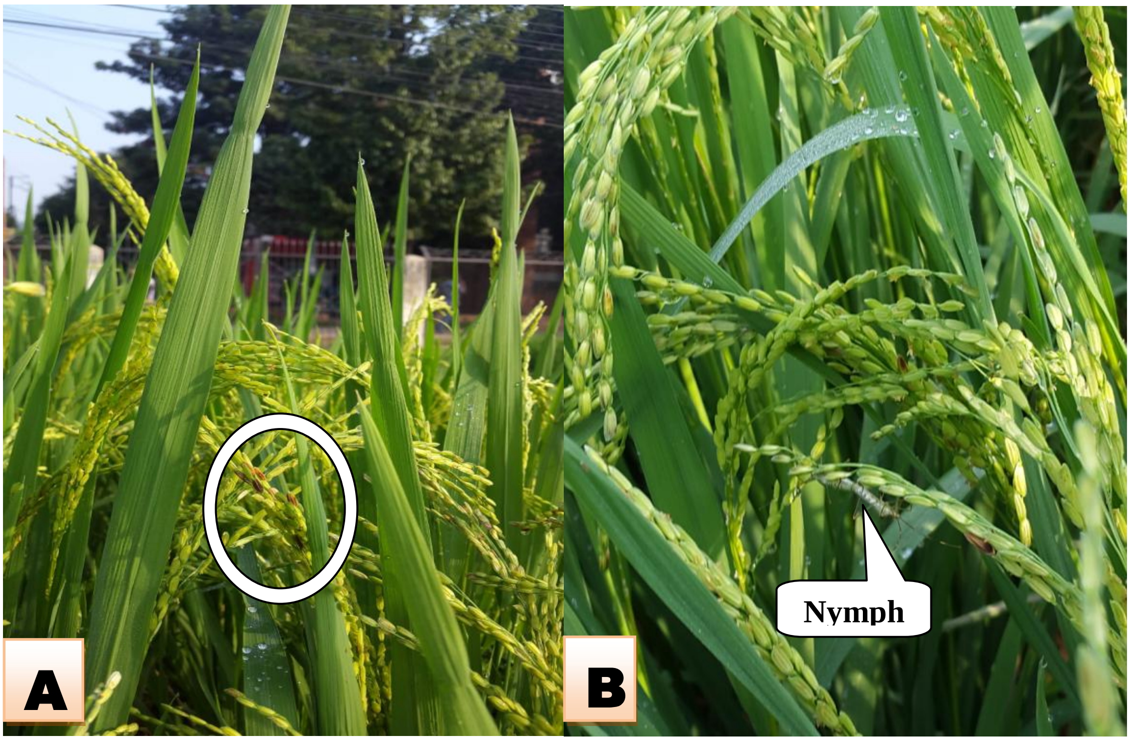

Plate 8. Infested rice grain (A) by Rice bug & Nymph of Rice bug (B) in field

4.2.7 Brown plant hopper incidence

Different levels of NPK fertilizers showed statistically significant differences in terms of brown plant hopper incidence as % of tiller infestation at 35, 50 and 65 DAT (Table 8). At 35 DAT, data recorded from each plot revealed that the lowest incidence of brown plant hopper was found from T_5 (4.23%) which was statistically similar with T_1 (4.78%) and closely followed by T_6 (4.93%) and T_4 (5.22%), while the highest incidence of brown plant hopper was observed from T_7 (7.88%) which was followed by T_0 (6.34%), T_3 (5.86%) and T_2 (6.12%) and they were statistically similar. In case of incidence of brown plant hopper decrease/increase over control, the highest decrease was observed in T_5 (-33.28) and the lowest was recorded in T_2 (-3.47), whereas the increase of brown plant hopper head incidence was attained from T_7 (+24.29) treatment.

At 50 DAT, data recorded from each plot revealed that the lowest incidence of brown plant hopper was observed from T_5 (4.55%) which was statistically similar with T_1 (4.94%) and T_6 (5.23%) and closely followed by T_4 (5.34%) and T_3 (5.78%) they were statistically similar, whereas the highest incidence of brown plant hopper from T_7 (7.12%) which was followed by T_0 (6.164%). In case of incidence of brown plant hopper decrease/increase over control, the highest decrease was observed in T_5 (-26.14) and the lowest was recorded in T_2 (-6.17), whereas the increase of brown plant hopper incidence was found from T_7 (+15.58) treatment.

At 65 DAT, data recorded from each plot revealed that the lowest incidence of brown plant hopper was observed from T_5 (4.78%) which was statistically similar with T_1 (5.03%) and closely followed by T_6 (5.55%), T_4 (5.78%) and T_3 (5.94%) and they were statistically similar, while the highest incidence of brown plant hopper was found from T_7 (7.95%) which was followed by T_0 (6.78%). In case of incidence of brown plant hopper decrease/increase over control, the highest decrease was observed in T_5 (-29.50) and the lowest was recorded in T_2 (-9.44), whereas the increase of brown plant hopper incidence was found from T_7 (+17.26) treatment. Similar findings also reported by Sarwar (2012) earlier.

Table 9. Incidence of brown plant hopper infestation in BRRI dhan33 at different levels of NPK fertilizers

Treatments	Incidence of brown plant hopper at different days after transplanting (DAT)					
	1st observation (35 DAT)		2nd observation (50 DAT)		3rd observation (65 DAT)	
	Tillers infestation (%)	Reduction over control (%)	Tillers infestation (%)	Reduction over control (%)	Tillers infestation (%)	Reduction over control (%)
T_0	6.34 b	--	6.16 b	--	6.78 b	--
T_1	4.78 cd	-24.61	4.94 de	-19.81	5.03 de	-25.81
T_2	6.12 b	-3.47	5.78 bc	-6.17	6.14 bc	-9.44
T_3	5.86 b	-7.57	5.56 bcd	-9.74	5.94 c	-12.39
T_4	5.22 c	-17.67	5.34 cd	-13.31	5.78 c	-14.75
T_5	4.23 d	-33.28	4.55 e	-26.14	4.78 e	-29.50
T_6	4.93 c	-22.24	5.23 cde	-15.10	5.55 cd	-18.14
T_7	7.88 a	+24.29	7.12 a	+15.58	7.95 a	+17.26
$LSD_{(0.05)}$	0.578	--	0.726	--	0.667	--
CV(%)	5.69	--	7.26	--	6.22	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from each plot of each treatment
In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_0 = Untreated control, no NPK fertilizers
T_1 = NPK @ 45, 50, 40 kg/ha
T_2 = NPK @ 70, 25, 40 kg/ha
T_3 = NPK @ 70, 50, 20 kg/ha
T_4 = NPK @ 70, 50, 40 kg/ha
T_5 = NPK @ 70, 50, 60 kg/ha
T_6 = NPK @ 70, 75, 40 kg/ha
T_7 = NPK @ 95, 50, 40 kg/ha

4.2.8 Green leaf hopper incidence

At 35, 50 and 65 DAT, statistically significant differences was observed in terms of green leaf hopper incidence as % of leaf infestation due to different levels of NPK fertilizers (Table 9). At 35 DAT, data recorded from each plot revealed that the lowest incidence of green leaf hopper was found from T_5 (1.12%) which was closely followed by T_1 (1.58%) and T_6 (1.84%) and they were statistically similar, whereas the highest incidence of green leaf hopper was observed from T_7 (3.96%) which was followed by T_0 (2.78%) and T_2 (2.59%) and they were statistically similar. In case of incidence of green leaf hopper decrease/increase over control, the highest decrease was observed in T_5 (-59.71) and the lowest was recorded in T_2 (-6.83), whereas the increase of green leaf hopper incidence was attained from T_7 (+42.45) treatment.

At 50 DAT, data recorded from each plot revealed that the lowest incidence of green leaf hopper was found from T_5 (1.34%) which was closely followed by T_1 (1.88%), T_6 (1.94%) and T_4 (2.14%) and they were statistically similar, while the highest incidence of green leaf hopper from T_7 (4.18%) which was followed by T_0 (2.96%) and T_2 (2.78%) treatment and they were statistically similar. In case of incidence of green leaf hopper decrease/increase over control, the highest decrease was observed in T_5 (-54.73) and the lowest in T_2 (-6.08), whereas the increase of green leaf hopper incidence was found from T_7 (+41.22) treatment.

At 65 DAT, data recorded from each plot revealed that the lowest incidence of green leaf hopper was observed from T_5 (1.56%) which was followed by to T_1 (1.94%) and T_6 (2.12%) and they were statistically similar, while the highest incidence of green leaf hopper was found from T_7 (4.34%) which was followed by T_0 (3.13%), T_2 (2.97%) and T_3 (2.81%) and they were statistically similar. In case of incidence of green leaf hopper decrease/increase over control, the highest decrease was found in T_5 (-50.16) and the lowest was found in T_2 (-5.11), whereas the increase of green leaf hopper incidence from T_7 (+38.66) treatment. Mahadev *et al.* (1995) reported that the crop applied with N either alone or coupled with P exhibited a higher degree of incidence of green leaf hopper.

Table 10. Incidence of green leaf hopper infestation in BRRI dhan33 for different levels of NPK fertilizers

Treatments	Incidence of green leaf hopper at different days after transplanting (DAT)					
	1st observation (35 DAT)		2nd observation (50 DAT)		3rd observation (65 DAT)	
	Leaf infestation (%)	Reduction over control (%)	Leaf infestation (%)	Reduction over control (%)	Leaf infestation (%)	Reduction over control (%)
T_0	2.78 b	--	2.96 b	--	3.13 b	--
T_1	1.58 f	-43.17	1.88 e	-36.49	1.94 d	-38.02
T_2	2.59 bc	-6.83	2.78 bc	-6.08	2.97 b	-5.11
T_3	2.24 cd	-19.42	2.46 cd	-16.89	2.81 b	-10.22
T_4	2.03 de	-26.98	2.14 de	-27.70	2.45 c	-21.73
T_5	1.12 g	-59.71	1.34 f	-54.73	1.56 e	-50.16
T_6	1.84 ef	-33.81	1.94 e	-34.46	2.12 cd	-32.27
T_7	3.96 a	+42.45	4.18 a	+41.22	4.34 a	+38.66
$LSD_{(0.05)}$	0.380	--	0.367	--	0.332	--
CV(%)	9.51	--	8.53	--	6.94	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from each plot of each treatment
In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_0 = Untreated control, no NPK fertilizers
T_1 = NPK @ 45, 50, 40 kg/ha
T_2 = NPK @ 70, 25, 40 kg/ha
T_3 = NPK @ 70, 50, 20 kg/ha
T_4 = NPK @ 70, 50, 40 kg/ha
T_5 = NPK @ 70, 50, 60 kg/ha
T_6 = NPK @ 70, 75, 40 kg/ha
T_7 = NPK @ 95, 50, 40 kg/ha

4.3 Yield attributes and yield of rice

Statistically significant variation was recorded in terms of different yield attributes and yield of BRRI dhan33 due to the application of different levels of NPK fertilizers (Table 11).

4.3.1 Plant height

Data revealed that different levels of NPK fertilizers produced different plant height (Table 11). The longest plant was recorded from T_5 (99.64 cm) which was statistically similar with other treatment except T_0 and the shortest plant was found from T_0 (95.50 cm) treatment.

4.3.2 Effective tillers/hill

Effective tillers/hill varied from 11.33 to 16.27 for different levels of NPK fertilizers (Table 11). The maximum number of effective tillers/hill was recorded from T_5 (16.27) which was statistically similar with other treatment except T_0 and T_7, whereas the minimum number was found from T_0 (11.33) treatment which was followed by T_7 (14.40) treatment.

4.3.3 Non-effective tillers/hill

Different levels of NPK fertilizers produced different number of non-effective tillers/hill which varied from 2.07 to 4.53 (Table 11). The minimum number of non-effective tillers/hill was recorded from T_5 (2.07) which was statistically similar to T_1 (2.27) and closely followed by T_6 (2.73) and T_4 (3.07) treatment and they were statistically similar, while the maximum number was found from T_0 (4.53) treatment which was followed by T_7 (4.00) and T_2 (3.87) treatment and they were statistically similar.

4.3.4 Panicle length

Data revealed that different levels of NPK fertilizers produced different length of panicle (Table 11). The longest panicle was recorded from T_5 (24.57 cm) which was statistically similar with other treatment except T_0 and the shortest panicle was found from T_0 (17.52 cm) treatment.

Table 11. Yield attributes and yield of BRRI dhan33 different levels of NPK fertilizers

Treatments	Plant height (cm)	Non-effective tillers/hill (No.)	Unfilled grains/panicle (No.)	Grain yield (t/ha)
T_0	81.48 b	4.53 a	17.60 a	2.78 d
T_1	98.97 a	2.27 e	4.80 ef	4.14 abc
T_2	96.05 a	3.87 b	6.07 bc	3.96 bc
T_3	96.77 a	3.33 c	5.60 cd	4.04 bc
T_4	97.33 a	3.07 cd	5.33 de	4.11 abc
T_5	99.64 a	2.07 e	4.27 f	4.54 a
T_6	98.46 a	2.73 d	5.13 de	4.36 ab
T_7	95.50 a	4.00 b	6.33 b	3.86 c
$LSD_{(0.05)}$	9.386	0.411	0.658	0.443
CV(%)	5.61	7.27	5.44	6.27

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 selected hills/plot of each treatment

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

T_0 = Untreated control, no NPK fertilizers

T_1 = NPK @ 45, 50, 40 kg/ha

T_2 = NPK @ 70, 25, 40 kg/ha

T_3 = NPK @ 70, 50, 20 kg/ha

T_4 = NPK @ 70, 50, 40 kg/ha

T_5 = NPK @ 70, 50, 60 kg/ha

T_6 = NPK @ 70, 75, 40 kg/ha

T_7 = NPK @ 95, 50, 40 kg/ha

4.3.5 Filled grains/panicle

Filled grains/panicle varied from 93.40 to 68.60 for different levels of NPK fertilizers (Table 11). The maximum number of filled grains/panicle was recorded from T_5 (93.40) which was statistically similar with other treatment except T_0 and the minimum number was recorded from T_0 (68.60) treatment.

4.3.6 Unfilled grains/panicle

Different levels of NPK fertilizers produced different number of unfilled grains/panicle which varied from 4.27 to 17.60 (Table 11). The minimum number of unfilled grains/panicle was observed from T_5 (4.27) which was statistically similar to T_1 (4.80) and closely followed by T_6 (5.13) and T_5 (5.33) treatment and they were statistically similar, while the maximum number was found from T_0 (17.60) treatment which was followed by T_7 (6.33) and T_2 (6.07) treatment and they were statistically similar.

4.3.7 Weight of 1000-grains

Weight of 1000-grains varied from 22.47 g to 18.42 g for different levels of NPK fertilizers (Table 11). The highest weight of 1000-grains was attained from T_5 (22.47 g) which was statistically similar with other treatment except T_0, whereas the minimum weight was recorded from T_0 (18.42 g) treatment.

4.3.8 Grain yield

Different levels of NPK fertilizers produced different grain yield which varied from 4.54 ton to 2.78 ton (Table 11). The highest grain yield was recorded from T_5 (4.54 ton) which was statistically similar to T_1 (4.42 ton), T_6 (4.36 ton) and T_4 (4.22 ton) and closely followed by T_4 (4.04 ton) and T_3 (3.96 ton) treatment and they were statistically similar, while the lowest grain yield was observed from T_0 (2.78 ton) treatment which was followed by T_7 (3.86 ton) treatment. Das (2001) observed the low yield from the plot treated with 190 kg urea/ha and the minimum from 130 kg/ha.

Plate 9. An Experimental plot (T_3R_1) with low Potassium application showing the defficiency symptoms in rice plants.

Plate 10. An Experimental plot (T_5R_1) with high Potassium application showing the low insect incidence & high yield of BRRI dhan33.

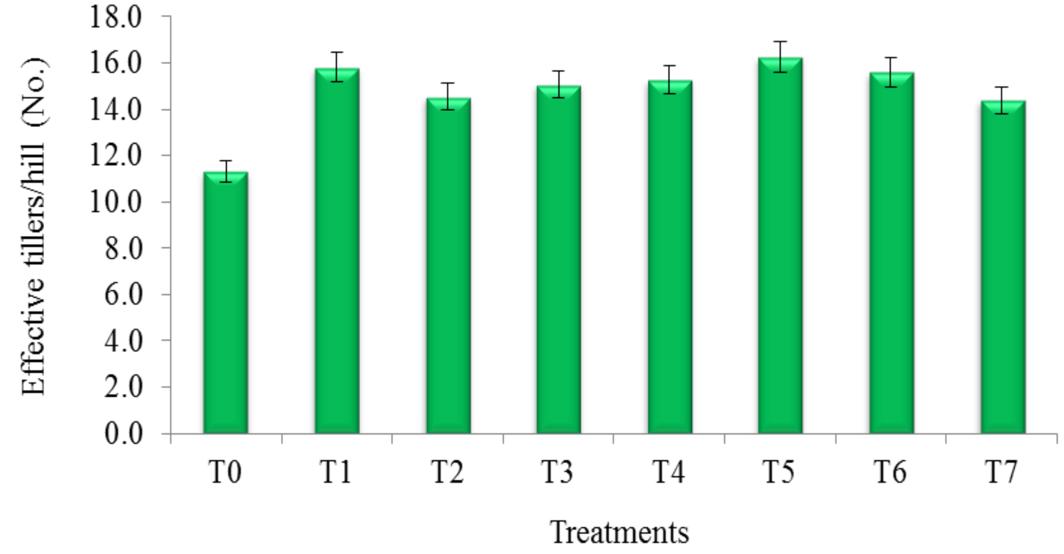

Figure 2. Effect of differentlevels of NPK fertilizers on number of effective tillers/hill of BRRI dhan33. (Vertical bars represent LSD value at 5% level of probability)

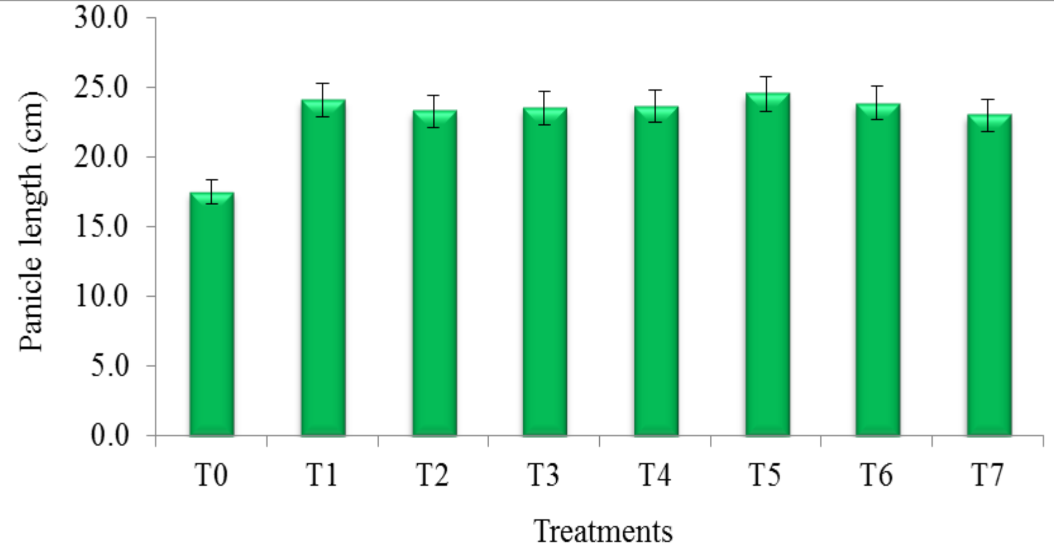

Figure 3. Effect of different levels of NPK fertilizers on panicle length of BRRI dhan33. (Vertical bars represent LSD value at 5% level of probability

T_0 = Untreated control, no NPK fertilizersl T_1 = NPK @ 45, 50, 40 kg/ha

T_2 = NPK @ 70, 25, 40 kg/ha T_3 = NPK @ 70, 50, 20 kg/ha

T_4 = NPK @ 70, 50, 40 kg/ha T_5 = NPK @ 70, 50, 60 kg/ha

T_6 = NPK @ 70, 75, 40 kg/ha T_7 = NPK @ 95, 50, 40 kg/ha

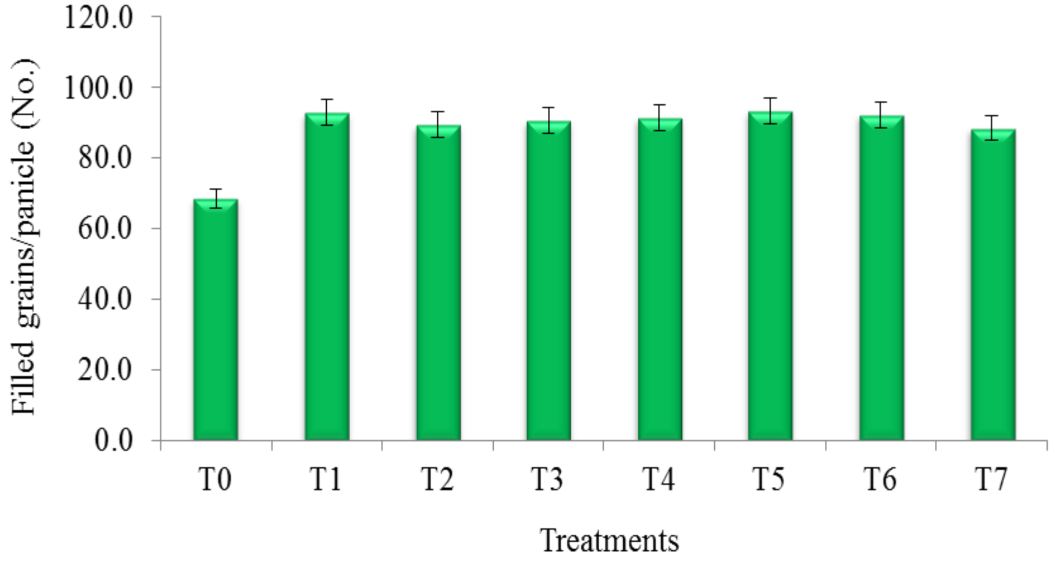

Figure 4. Effect of differentlevels of NPK fertilizers on number of filled grans/panicle of BRRI dhan33. (Vertical bars represent LSD value at 5% level of probability)

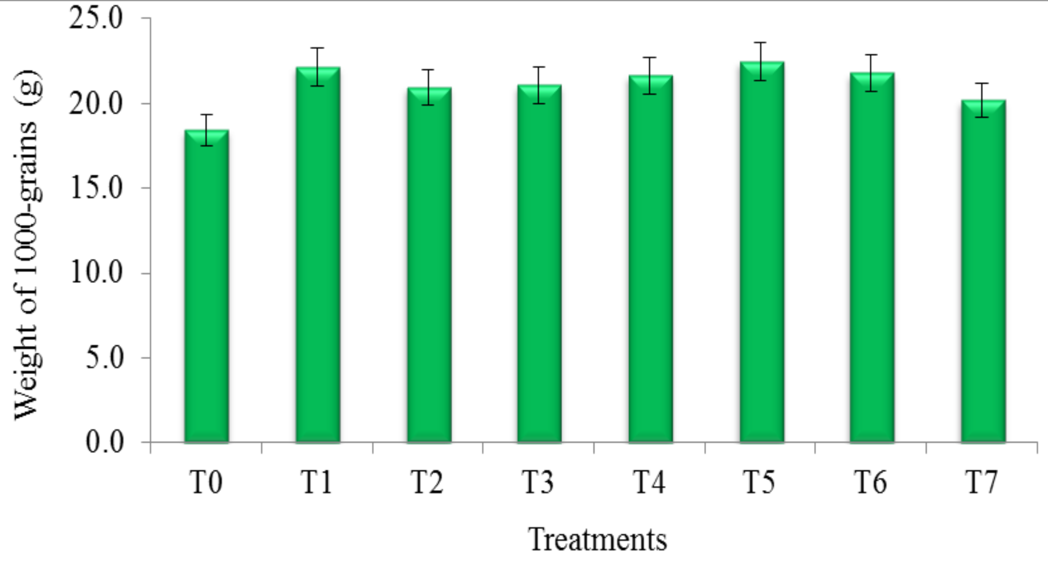

Figure 5. Effect of different levels of NPK fertilizers on weight of 1000-grains of BRRI dhan33. (Vertical bars represent LSD value at 5% level of probability

T_0 = Untreated control, no NPK fertilizersl

T_1 = NPK @ 45, 50, 40 kg/ha

T_2 = NPK @ 70, 25, 40 kg/ha

T_3 = NPK @ 70, 50, 20 kg/ha

T_4 = NPK @ 70, 50, 40 kg/ha

T_5 = NPK @ 70, 50, 60 kg/ha

T_6 = NPK @ 70, 75, 40 kg/ha

T_7 = NPK @ 95, 50, 40 kg/ha

CHAPTER V

SUMMARY AND CONCLUSION

The study was conducted in the experimental area of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh during the period from July to October 2016 to find out the effect of different levels of NPK on insect pests in transplant aman rice. BRRI dhan33 was used as the test crop in this experiment. The experiment comprised the different NPK fertilizer dose as treatment- T_0 = Untreated control, no NPK fertilizers, T_1 = NPK @ 45, 50, 40 kg/ha, T_2 = NPK @ 70, 25, 40 kg/ha, T_3 = NPK @ 70, 50, 20 kg/ha, T_4 = NPK @ 70, 50, 40 kg/ha, T_5 = NPK @ 70, 50, 60 kg/ha, T_6 = NPK @ 70, 75, 40 kg/ha and T_7 = NPK @ 95, 50, 40 kg/ha. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Data were recorded on different types of insect pests that were identified for the entire growing period with their number and incidence on rice plants and also different yield contributing characters and yield of rice and found statistical differences for different levels of NPK fertilizers.

Among the observed insect pests 2 species belong to the family Pyralidae and only 1 species for each of Chrysomelidae, Acrididae, Delphacidae, Cicadellidae and Coreidae family. Most of the insect pests were more destructive at nymphal and adult stages and caterpillars were in the larval stage. During the entire growing period 5 selected hills/plot were monitored with clean observation and yellow stem borer, leaf folder, rice hispa, grasshopper, brown plant hopper, green leaf hopper and rice bug insect pests was observed. The lowest number (1.67) of yellow stem borer was observed from T_5, whereas the highest number (9.33) was found from T_7 treatment. The lowest number of leaf folder was recorded from T_5 (1.13), while the highest number was observed from T_7 (12.67) treatment. The lowest number of rice hispa was recorded from T_5 (1.13), while the highest number was observed from T_7 (3.67) treatment. The lowest number of grass hopper was recorded from T_5 (3.33), while the highest number was observed from T_7 (12.73) treatment. The lowest number of brown plant hopper was found from T_5 (1.93), whereas the highest number was recorded from T_7 (9.47) treatment. The lowest number of green leaf hopper was recorded from T_5 (2.47), while the highest number was observed from T_7 (11.67) treatment. The lowest number of rice bug was observed from T_5 (1.73), whereas the highest number was found from T_7 (8.60) treatment.

In case of incidence of dead heart, at 25 DAT, data recorded from each plot revealed that the lowest incidence of dead heart was observed from T_5 (3.64%), while the highest incidence of dead heart was found from T_7 (10.37%) treatment. At 45 DAT, from each plot it was revealed that the lowest incidence of dead heart was observed from T_5 (4.23%), while the highest incidence of dead heart from T_7 (13.56%) treatment. At 65 DAT, data recorded from each plot revealed that the lowest incidence of dead heart was observed from T_5 (4.47%), while the highest incidence of dead heart was found from T_7 (14.73%) treatment.

In terms of white head incidence, at 60 DAT, 70 DAT and 80 DAT, data revealed that the lowest incidence of white head was found from T_5 (2.35%, 2.66% and 3.12% respectively), while the highest incidence of white head was observed from T_7 (7.57%, 8.26% and8.64% respectively) treatment.

In consideration of leaf folder incidence, at 30 DAT, 45 DAT and 60 DAT revealed that the lowest incidence of leaf folder was found from T_5 (3.47%, 3.94% and 4.04% respectively), while the highest incidence of leaf folder was observed from T_7 (8.05% , 8.56% and 9.18% respectively) treatment.

For rice hispa incidence, at 25 DAT, 40 DAT and 55 DAT data recorded from each plot revealed that the lowest incidence of rice hispa was found from T_5 (1.15%, 1.46% and1.66% respectively), whereas the highest incidence of rice hispa was observed from T_7 (4.86%, 5.14% and 5.83% respectively) treatment. In terms of grasshopper incidence, at 25 DAT, 40 DAT and 55 DAT data recorded from each plot revealed that the lowest incidence of grasshopper was recorded from T_5 (0.59%, 0.75% and 0.92% respectively), while the highest incidence of grasshopper was observed from T_7 (4.63%, 5.07% and 5.78% respectively) treatment.

In consideration of brown plant hopper incidence, at 35 DAT, 50 DAT and 65 DAT data recorded from each plot revealed that the lowest incidence of brown plant hopper was found from T_5 (4.23%, 4.55% and 4.78% respectively), while the highest incidence of brown plant hopper was observed from T_7 (7.88%, 7.12% and 7.95% respectively) treatment.

For green leaf hopper incidence, at 35 DAT, 50 DAT and 65 DAT, data recorded from each plot revealed that the lowest incidence of green leaf hopper was found from T_5 (1.12%, 1.34% and1.56% respectively), whereas the highest incidence of green leaf hopper was observed from T_7 (3.96%, 4.18% and4.34% respectively) treatment.

In case of rice bug incidence, at 45 DAT, 55 DAT and 65 DAT data recorded from each plot revealed that the lowest incidence of rice bug was found from T_5 (1.78%,1.96% and 2.04% respectively), while the highest incidence of rice bug was observed from T_7 (4.22%,4.75% and 5.08% respectively) treatment.

In terms of different yield attributes and yield of rice, the longest plant was recorded from T_5 (99.64 cm) and the shortest plant was found from T_0 (95.50 cm) treatment. The maximum number of effective tillers/hill was recorded from T_5 (16.27), whereas the minimum number was found from T_0 (11.33) treatment which was followed by T_7 (14.40) treatment. The minimum number of non-effective tillers/hill was recorded from T_5 (2.07), while the maximum number was found from T_0 (4.53) treatment which was followed by T_7 (4.00) and T_2 (3.87) treatment. The longest panicle was recorded from T_5 (24.57 cm) and the shortest panicle was found from T_0 (17.52 cm) treatment.

The maximum number of filled grains/panicle was recorded from T_5 (93.40) and the minimum number was recorded from T_0 (68.60) treatment. The minimum number of unfilled grains/panicle was observed from T_5 (4.27), while the maximum number was found from T_0 (17.60) treatment. The highest weight of 1000-grains was attained from T_5 (22.47 g), whereas the minimum weight was recorded from T_0 (18.42 g) treatment. The highest grain yield was recorded from T_5 (4.54 ton), while the lowest grain yield was observed from T_0 (2.78 ton) treatment.

CONCLUSION

Considering the above finding it was revealed that, if the nitrogen dose increases, the incidence of insect pest also increased. In the term of percent of infestation, Yield attributes such as number of effective tillers/hill, number of panicle, number of filled grains/panicle etc. and yield, among the tested measure applying NPK @ 70, 50, 60 kg/ha (T_5) was the better for the incidence of insect pest and controlling of insect pest of BRRI dhan33 than all other treatments.

However, imbalanced nutrition like 100% N, 100% P, 100% K etc. induced more insect incidence, whereas balanced nutrients supplemented with micronutrients resulted in lower incidence of insect pests.

RECOMMENDATION

Among the different levels of NPK fertilizers, NPK @ 70, 50, 60 kg/ha was the better for the rice cultivation.

Considering the situation of the present study, further research in the following areas may be suggested:

- ♦ Different pest management practices and rice variety may be used in future study.
- ♦ This study should be carried out in different agro-ecological zones (AEZ) of Bangladesh for confirmation of the results.

CHAPTER VI

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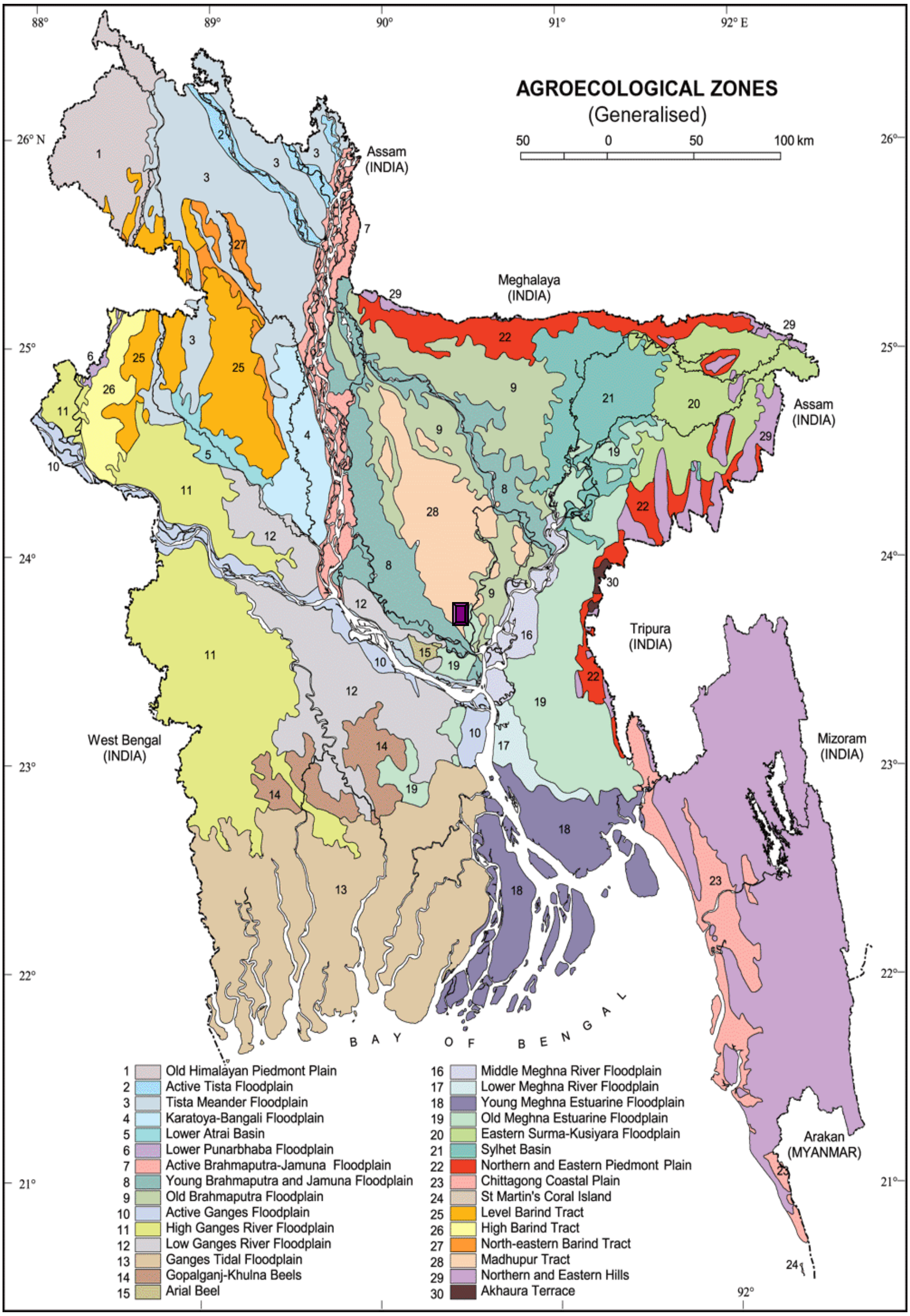
APPENDICES

Appendix I. The Map of the experimental site in Bangladesh



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

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

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

Appendix III. Characteristics of the soil of experimental field

A. Morphological characteristics of the experimental field

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

B. Physical and chemical properties of the initial soil

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

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

Appendix IV. Analysis of variance of the data on number of major insect pests in BRRI dhan33 during the growing period as influenced by different levels of NPK fertilizers

Source of variation	Degrees of freedom	Mean square			
		Number of different insect pests in 5 selected hills			
		Yellow stem borer	Leaf folder	Rice hispa	Grasshopper
Replication	2	0.032	0.062	0.012	0.102
Treatments	7	17.939**	43.863**	18.026**	34.149**
Error	14	0.072	0.184	0.071	0.264

**: Significant at 0.01 level of significance

Appendix IV. Analysis of variance of the data on number of major insect pests in BRRI dhan33 during the growing period as influenced by different levels of NPK fertilizers (contd')

Source of variation	Degrees of freedom	Mean square		
		Number of different insect pests in 5 selected hills		
		Brown plant hopper	Green leaf hopper	Rice bug
Replication	2	0.020	0.045	0.052
Treatments	7	2.319**	33.630**	14.110**
Error	14	0.028	0.089	0.080

**: Significant at 0.01 level of significance

Appendix V. Analysis of variance of the data on incidence of rice yellow stem borer (dead heart) infestation in BRRI dhan33 as influenced by different levels of NPK fertilizers

Source of variation	Degrees of freedom	Mean square		
		Incidence (%) of rice yellow stem borer infestation (dead heart/plot) at different days after transplanting (DAT)		
		1st observation (25 DAT)	2nd observation (45 DAT)	3rd observation (65 DAT)
Replication	2	0.062	0.010	0.141
Treatments	7	17.781**	29.995**	35.125**
Error	14	0.087	0.214	0.412

**: Significant at 0.01 level of significance

Appendix VI. Analysis of variance of the data on incidence of rice yellow stem borer (white head) infestation in BRRI dhan33 as influenced by different levels of NPK fertilizers

Source of variation	Degrees of freedom	Mean square		
		Incidence (%) of rice yellow stem borer infestation (white head /plot) at different days after transplanting (DAT)		
		1st observation (60 DAT)	2nd observation (70 DAT)	3rd observation (80 DAT)
Replication	2	0.037	0.0001	0.016
Treatments	7	7.931**	10.419**	9.738**
Error	14	0.062	0.174	0.102

**: Significant at 0.01 level of significance

Appendix VII. Analysis of variance of the data on incidence of leaf folder infestation in BRRI dhan33 as influenced by different levels of NPK fertilizers

Source of variation	Degrees of freedom	Mean square		
		Incidence (%) of leaf folder at different days after transplanting (DAT)		
		1st observation (30 DAT)	2nd observation (45 DAT)	3rd observation (60 DAT)
Replication	2	0.009	0.009	0.053
Treatments	7	6.655**	6.491**	7.800**
Error	14	0.053	0.082	0.135

**: Significant at 0.01 level of significance

Appendix VIII. Analysis of variance of the data on incidence of rice hispa infestation in BRRI dhan33 as influenced by different levels of NPK fertilizers

Source of variation	Degrees of freedom	Mean square		
		Incidence (%) of rice hispa at different days after transplanting (DAT)		
		1st observation (25 DAT)	2nd observation (40 DAT)	3rd observation (55 DAT)
Replication	2	0.013	0.009	0.028
Treatments	7	3.751**	4.225**	5.355**
Error	14	0.064	0.021	0.041

**: Significant at 0.01 level of significance

Appendix IX. Analysis of variance of the data on incidence of grasshopper infestation in BRRI dhan33 as influenced by different levels of NPK fertilizers

Source of variation	Degrees of freedom	Mean square		
		Incidence (%) of grasshopper at different days after transplanting (DAT)		
		1st observation (25 DAT)	2nd observation (40 DAT)	3rd observation (55 DAT)
Replication	2	0.0001	0.019	0.006
Treatments	7	8.011**	9.143**	10.396**
Error	14	0.088	0.192	0.101

**: Significant at 0.01 level of significance

Appendix X. Analysis of variance of the data on incidence of brown plant hopper infestation in BRRI dhan33 as influenced by different levels of NPK fertilizers

Source of variation	Degrees of freedom	Mean square		
		Incidence (%) of brown plant hopper at different days after transplanting (DAT)		
		1st observation (35 DAT)	2nd observation (50 DAT)	3rd observation (65 DAT)
Replication	2	0.006	0.135	0.136
Treatments	7	6.205**	3.567**	5.109**
Error	14	0.109	0.172	0.145

**: Significant at 0.01 level of significance

Appendix XI. Analysis of variance of the data on incidence of green leaf hopper infestation in BRRI dhan33 as influenced by different levels of NPK fertilizers

Source of variation	Degrees of freedom	Mean square		
		Incidence (%) of green leaf hopper at different days after transplanting (DAT)		
		1st observation (35 DAT)	2nd observation (50 DAT)	3rd observation (65 DAT)
Replication	2	0.008	0.020	0.035
Treatments	7	2.251**	2.260**	3.057**
Error	14	0.047	0.044	0.036

**: Significant at 0.01 level of significance

Appendix XII. Analysis of variance of the data on incidence of rice bug infestation in BRRI dhan33 as influenced by different levels of NPK fertilizers

Source of variation	Degrees of freedom	Mean square		
		Incidence (%) of rice bug at different days after transplanting (DAT)		
		1st observation (45 DAT)	2nd observation (55 DAT)	3rd observation (65 DAT)
Replication	2	0.006	0.003	0.029
Treatments	7	3.260**	4.117**	4.626**
Error	14	0.053	0.086	0.044

**: Significant at 0.01 level of significance

Appendix XIII. Analysis of variance of the data on yield attributes and yield of BRRI dhan33 as influenced by different levels of NPK fertilizers

Source of variation	Degrees of freedom	Mean square			
		Plant height (cm)	Effective tillers/hill (No.)	Non-effective tillers/hill (No.)	Panicle length (cm)
Replication	2	0.009	0.062	0.027	2.119
Treatments	7	102.687*	6.997**	2.255**	15.163**
Error	14	28.728	0.812	0.055	2.122

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix XIII. Analysis of variance of the data on yield attributes and yield of BRRI dhan33 as influenced by different levels of NPK fertilizers (Cont'd)

Source of variation	Degrees of freedom	Mean square			
		Filled grains/panicle (No.)	Unfilled grains/panicle (No.)	Weight of 1000-grains (g)	Grain yield (t/ha)
Replication	2	2.555	0.122	1.264	0.012
Treatments	7	200.575**	57.478**	5.053*	0.919**
Error	14	16.296	0.141	1.433	0.064

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance