INFLUENCE OF NITROGEN AND PHOSPHORUS LEVELS ON YIELD AND SEED QUALITY OF RICE

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CERTIFICATE

This is to certify that the thesis entitled **"INFLUENCE OF NITROGEN AND PHOSPHORUS LEVELS ON YIELD AND SEED QUALITY OF RICE"** *submitted to the Institute of Seed Technology, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of* ***MASTER OF SCIENCE (M.S.)*** *in* ***SEED TECHNOLOGY,*** *embodies the results of a piece of bona fide research work carried out by* ***MD. JUBYDUR RAHMAN VASHANI,*** *Registration. No. 11-04443 under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information as has been availed of during the course of this investigation has duly been acknowledged.

Dated:

Dhaka, Bangladesh

(Prof. Dr. A. K. M. Ruhul Amin)
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ABSTRACT

The experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during Boro season from December 2016 to May 2017 to study the influence of nitrogen and phosphorus levels on yield and seed quality of rice. The experiment comprised as two factors, i.e. different fertilizer doses i.e. F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer**,** F_3 = Recommended dose of fertilizer**,** F_4 =25% more than recommended dose of fertilizer**,** F_5 = 50% more than recommended dose of fertilizer, F_6= 75% higher than recommended dose of chemical fertilizer; and two varieties i.e. V_1 = BRRI dhan28, V_2 = BRRI dhan74. The experiment was conducted following split plot design with three replications. The result revealed that fertilizer dose F_4 (25% higher than recommended dose) gave highest plant height (91.24 cm), effective tillers hill^{-1} (11.96), panicle length (19.70 cm), 1000 grains weight (29.42 g) and grain yield (6.91 t ha^{-1}). On the other hand, V_1 (BRRI dhan28) was superior by producing tallest plant (90.58 cm) which may be attribute the highest grain yield (5.96 t ha^{-1}). Interaction of F_4V_1 was also superior in producing the highest yield (7.53 t ha-1). In case of seeds quality aspect, F_4 (25% higher than recommended dose) fertilizer dose gave the highest germination percentage (92.66%), shoot length (17.55 cm), root length (8.80 cm), shoot dry weight (20.86 mg) and root dry weight (14.60 mg). The variety V_2 gave highest germination percentage (87.42%), shoot length (16.58 cm), root length (8.75 cm), shoot dry weight (18.95 mg) and root dry weight (16.56 mg). From the result, it can be concluded that F_4 (25% higher than recommended dose) and V_2 (BRRI dhan28) most suitable for yield and seed quality.

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LIST OF ACRONYMS

AEZ	Agro-Ecological Zone
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
CV%	Percentage of coefficient of variance
cv.	Cultivar
DAE	Department of Agricultural Extension
DAS	Days after sowing
^{0}C	Degree Celsius
et al	And others
FAO	Food and Agriculture Organization
g	gram(s)
ha^{-1}	Per hectare
HI	Harvest Index
kg	Kilogram
mg	Milligram
MP	Muriate of Potash
N	Nitrogen
No.	Number
NS	Not significant
%	Percent
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources and Development Institute
TSP	Triple Super Phosphate
Wt.	Weight

CHAPTER I

INTRODUCTION

Rice (*Oryza sativa L.*) is one of the most important cereal crops of the world, grown in wide range of climatic zones, to nourish the mankind. Rice is cultivated in Bangladesh throughout the year as Aus, Aman and Boro. Aman (broadcast and transplanted) is generally cultivated in July-August, Aus in March-May, and Boro in December-January cropping seasons. Among these cropping transplanted Boro is most important and occupied about 46% of the rice cultivated land. About 40 percent of the world's population derives most of their calories from rice. Almost 90 percent of the population of Bangladesh, Myanmar, Sri Lanka, Vietnam and Kampuchea are rice eaters. Total rice production in Bangladesh is 34.5 m mton (FAO, 2016) and total world rice production is over 700 million tons (Ricepedia, 2017).

Rice is most important food crop and a major food grain for more than a third of the world’s population (Zhao *et al*., 2011). Judicious and proper use of fertilizers can markedly increase the yield and improve the quality of rice (Alam *et al*., 2009). Fertilizer is very important input for intensive rice production the profitability of rice production systems depends on yield and input quantities. So, the appropriate fertilizer input that is not only for getting high grain yield but also for attaining maximum profertility (Khuang *et al*., 2008). Nitrogen and phosphorus fertilizer is a major essential plant nutrient and key input for increasing crop yield (Dastan *et al*., 2012; Alinajoati and Mirshekari, 2011; Alam *et al*., 2009). Nitrogen deficiency generally results in stunted growth and chlorotic leaves caused by poor assimilate formation that leads to premature flowering and shortening of the growth cycle. The presence of N in excess promotes development of the above ground aground organs with abundant dark green (high chlorophyll) tissues of soft consistency and relatively poor root growth. This increases the risk of loding and reduces the plants resistance to brash climatic condition and foliar diseases (Roshan *et al*., 2011). Nitrogen contributes to carbohydrate accumulation in culms and leaf sheaths during the pre-heading stage and in the grain during the ripening stage of rice (Swin *et al*., 2010).

Under field conditions, the application of nitrogen (N) fertilizer is the most common and effective way to enhance the tiller population, as it increases the cytokinin content within tiller nodes and further enhances the germination of the tiller primordium (Liu *et al.*, 2011). Additionally, N evokes a significant effect on the promotion of tiller development (Sakakibara *et al.*, 2006). Although many tillers may be generated subsequent to a sufficient supply of N, not every tiller contributes equally to the overall yield. Typically, late emerging tillers do not contribute significantly to the grain yield of rice (Wang *et al.*, 2007); however, theoretically, they possess the potential for high productivity, due to the totipotency of rice coleoptile tissue (Oinam and Kothari, 1995). Rice requires N in larger quantities than any other nutrient, and it is the most critical limiting factor that influences grain yields (Siddiqui *et al.*, 2008), but no obvious decline in straw N concentration was discovered in late emerging tillers (Sparkes *et al.*, 2006; Wang *et al.*, 2016). Hence, elucidating the adverse effects on N accumulation and transport may assist in identifying the mechanisms underlying the low production of late emerging rice tillers.

Phosphorus deficit is a most important restrictive factor in plant growth and recognition of mechanisms that increase plant phosphorus use efficiency is important (Alinajoati and Mirshekari, 2011). Phosphorus is a major component in ATP, the molecule that provides energy to that plant for such processes as photosynthesis, protein synthesis, nutrient translocation, nutrient uptake and respiration. Phosphorus is also a component of other compounds necessary for protein synthesis and transfer of genetic material DNA, RNA (Wilson *et al*., 2006). Phosphorus application to rice increased P accumulation but did not consistently increase rice yields because flooding decreased soil P sorption and increased P diffusion. Resulting in higher P supply to rice relative to wheat (Dong *et al*., 2015). Rice crops require about 3-4 kg P for the production of one ton of rough rice including straw (Sahrawat, 2000). This element is involved in the supply and transfer of energy for biochemical processes in the rice plant. Phosphorus deficiency exists in rice soils elsewhere in the world (Kawaguchi and Kyuma, 1977; Goswami and Banerjee, 1978). In addition, continuous rice cropping without P fertilization causes depletion of the soil P level even in the fertile soils in the long run (BRRI, 2016). So, fertilizer P application is essential to meet the crop demand as well as for the maintenance of soil P level. The amount of P fertilizer to be applied depends on soil P status, P adsorption in soils, environmental conditions and crop management practices

On the basis of above discussion and importance of nitrogen and phosphorus on growth and yield, this study was conducted to determine the effects of nitrogen and phosphorus fertilizer on yield and seed quality of rice.

Objective

- To observe the different doses of Nitrogen and Phosphorus on the yield and yield attributes of rice.
- To select the suitable nitrogen and phosphorus level for producing better quality seed of rice.

CHAPTER II

REVIEW OF LITERATURE

Rice is one of the common and most important cereal crops of Bangladesh and as well as many countries of the world. The growth and yield of rice are largely controlled by the environmental variables notably moisture regimes, temperature and varieties. The growth and yield also influenced by fertilizer management and agronomic practice. Research works have been done by various workers in many parts of the globe to study the effect of fertilizer dose and spacing on the yield of rice. Many studies on the growth and yield have been carried out in many countries of the world. The work so far done in Bangladesh is not adequate and conclusive. Nevertheless, some of the important and informative works and research findings so far been done at home and abroad on this aspect have been reviewed in this chapter under the following headings:

2.1 Effect of nitrogen

Lemraski *et al*. (2017) carried out an experiment as a split factorial in randomized complete blocks design with three replications in Sari, Iran during 2013 and 2014. Rice cultivars were chosen as the main factor including Tarom Mahalli and Tarom Hashemi. Nitrogen rates (34 and 69 kg N ha^{-1} and nitroxin) with nano-particle (nano-potassium, nano-silicon and control) selected as the subfactor. The results indicated that the amount of total tiller per hill and fertile tiller per hill for Tarom Hashemi was more than Tarom Mahalli in both years. The highest paddy yield in both years was observed for Tarom Hashemi, the main reason behind it is increasing panicle length and fertile tiller number for this cultivar. For Tarom Hashemi, the highest paddy yield (5000 kg·ha^{-1}) was produced with 34 kg N ha^{-1} and nano potassium application. For Tarom Mahalli, the highest paddy yield 4657 kg·ha^{-1} was obtained with nitroxin and nano potassium consumption. The highest harvest index was achieved with nitroxin and nano-silicon consumption. Therefore, nano particle consumption in both cultivars resulted in improved yield.

Malav and Ramani (2017) conducted a field experiment during kharif seasons of 2014 and 2015 on loamy sands soil at Agriculture Research Station, Anand Agricultural University, Jabugam, Gujarat (India) to assess the effects of silicon on nitrogen use efficiency, rice yield and nutrient status at harvest of rice (*Oryza sativa* L.). The experiment encompassed four levels of nitrogen viz. 0, 75, 100 and 125 kg N ha^{-1} from ammonium sulphate and four levels of silicon viz. 0, 200, 400 and 600 kg Si ha^{-1} from calcium silicate. The experiment was laid out in randomized block design (Factorial) with three replications. Results revealed that individual application of nitrogen at 125 kg ha^{-1} and Si at 600 kg ha^{-1} produced the highest grain and straw yields of rice. With respect to N and its use efficiency, 100 kg N ha^{-1} was found optimum. Silicon reduced the agronomic efficiency as well as apparent N recovery while physiological efficiency was higher at 400 kg Si ha^{-1}. The effect of N and Si and their interaction was found to be significant for available N and Si content in grain and straw at harvest of rice crops under loamy sand soils.

Wang *et al*. (2017) reported that, the increasing food demands from an expanding population necessitate global efforts to increase crop production and ensure food security. The rate of nitrogen (N) fertilizer application is strongly related to crop yield. However, although the application of N fertilizer significantly increases the number of tillers in rice, late emerging tillers usually produce lower yields compared with early emerging tillers. Understanding the physiological constraints of late emerging rice tillers is critical for further increasing rice grain yields. Two-year field experiments, consisting of four nitrogen fertilizer levels, were conducted in order to study variations in the physiological characteristics of different types of tillers. The results revealed that the contributions of late emerging tillers to population rice grain yields improved with increased N levels. However, spikelets per panicle and the grain filling of late emerging tillers were significantly lower than that of the main stems or early emerging tillers under all N levels. The nitrogen harvest index of late emerging tillers was lower than that of main stems and early emerging tillers, and differences gradually increased under higher N rates. Nutrient source deficiency was a primary factor for the low productivity of late emerging tillers. Additionally, rapid malondialdehyde accumulation and delayed emergence determined the short growth duration of late emerging tillers. Further, low actual photochemistry efficacy (Φ_{PSII}) resulted in insufficient photosynthetic assimilate supply in late emerging tillers, whereas highly constitutive non-photochemical energy dissipation (Φ_{NO}) might damage the photosynthetic system. Moreover, the low activity of SuSase and spikelets per panicle revealed both inadequate sink activities and storage sites. The identification of these limiting factors in late emerging rice tillers will assist in closing the 'yield gap' between late emerging tillers and early emerging tillers and contribute to further increasing rice grain yields.

Liu *et al*. (2016) stated that, high N loss and low N use efficiency (NUE), caused by high N fertilizer inputs and inappropriate fertilization patterns, have become important issues in the rice (*Oryza sativa* L.) growing regions of southern China. Changing current farmer fertilizer practice (FFP, 225 kg ha^{-1} N as three applications, 40% as basal fertilizer, 30% as tillering fertilizer and 30% as jointing fertilizer) to one—time root—zone fertilization (RZF, 225 kg ha^{-1} N applied once into 10 cm deep holes positioned 5 cm from the rice root as basal fertilizer) will address this problem. A two—year field experiment covering two rice growing regions was conducted to investigate the effect of urea one—time RZF on rice growth, nutrient uptake, and NUE. The highest NH_4^+–N content for RZF at fertilizer point at 30 d and 60 d after fertilization were 861.8 and 369.9 mg kg^{-1} higher than FFP, respectively. Rice yield and total N accumulation of RZF increased by 4.3–44.9% and 12.7–111.2% compared to FFP, respectively. RZF reduced fertilizer—N loss by 56.3–81.9% compared to FFP. The NUEs following RZF (mean of 65.8% for the difference method and 43.7% for the labelled method) were significantly higher than FFP (mean of 35.7% for the difference method and 14.4% for the labelled method). In conclusion, RZF maintained substantial levels of fertilizer—N in the root—zone, which led to enhanced rice biomass and N uptake during the early growth stages, increased fertilizer—N residual levels and reduced fertilizer—N loss at harvest. RZF produced a higher yield increment and showed an increased capacity to resist environmental threats than FFP in sandy soils. Therefore, adopting suitable fertilizer patterns plays a key role in enhancing agricultural benefits.

Dong *et al*. (2015) reported that, excessive nitrogen (N) fertilizer application is common in the central Zhejiang Province area, China. A three-year (2009–11) experiment was conducted to determine the optimum N application rate for this area by studying the effects of various N rates on rice (*Oryza sativa* L.) yield, N-use efficiency (NUE), and quality of paddy field water. Results showed that no significant yield differences were observed under N rates from 180 to 315 kg ha^{-1}. The NUE could be improved by reducing N application rates without significantly decreasing yield. Due to high ammonia (NH_4^+-N) and nitrate (NO_3^-—N) concentrations, 5–7 days after N application was a critical stage for reducing N pollution. The N rate for the greatest yield was 176 kg ha^{-1}, accounting for 65 percent of the conventional N rate (270 kg ha^{-1}). The N-rate reduction in this area may be necessary for maintaining high yield, improving NUE, and reducing environmental pollution.

Moro *et al*. (2015) reported that, nitrogen is not only a major nutrient but most often the most limiting nutrient element in lowland ecologies. With the introduction of improved soil and water management ('sawah system) for lowland rice production, a study was conducted to determine the optimum nitrogen rate required. A randomized complete block design arranged in a split plot consisting of five levels of nitrogen as main treatments and three improved rice varieties as sub-treatments was adopted. Results showed that total number of tillers per m^2 increased significantly with increasing levels of N as was total dry matter production. However, total number of panicles did not show the same relationship. Total biomass yield increased significantly and linearly with increasing levels of N. Paddy yield significantly increased from 1.7t ha^{-1} (control) to a maximum of 9.4t ha^{-1} (90 kg N ha^{-1}) before declining to 5.8 t ha^{-1} (150 kg N ha^{-1}) in the order: 0 < 30 < 60 < 150 < 120 < 90 kg N ha^{-1} respectively. This result significantly and positively reflected on grain harvest index (GHI) in the order: 0.27 < 0.38 < 0.46 < 0.47 < 0.57 < 0.68 for 0, 30, 60, 150, 120 and 90 kg N ha^{-1} respectively. Nitrogen at 90 kg N ha^{-1} was therefore recommended.

Rao *et al*. (2014) was conducted a field experiment during three consecutive Kharif seasons of 2009-10, 2010-11 and 2011-12 at Agricultural Research Station, Seethampeta, Andhra Pradesh on sandy clay loam soil with three varieties (RGL 2537, RGL 2332 and MTU 7029) and four nitrogen levels (60, 80,100 and 120 kg/ ha) with an objective to find out suitable variety with optimum nitrogen level for high altitude areas of Andhra Pradesh. Among the varieties RGL 2537 recorded higher number of tillers and panicles m-2 with lengthy panicles, higher grain yield, harvest index, partial factor productivity, gross returns, net returns and rupee per rupee invested compared to RGL 2332 and MTU 7029. MTU 7029 recorded noticeably higher number of dead hearts, white ears/m2, per cent leaf folder, per cent silver shoots and BPH/hill compared to RGL 2332 and RGL 2537. Tiller production, days to 50 per cent flowering, dry matter production at harvest, yield attributes, yields and harvest index, gross returns, net returns and rupee per rupee invested, protein content of grain, soil organic carbon and available nitrogen were progressively augmented by incremental levels of N. Nutrient response in terms of partial factor productivity was progressively decreased with incremental levels of N from 60 kg to the highest dose tried. Post soil fertility status revealed that the status was progressively increased with incremental levels of N up to the highest dose tried that increased significantly by elevated levels of N.

Jafari *et al.* (2013) was conducted an experiment and reported that rice-based irrigated lowlands are the major cropping system in north of Iran. This experiment was carried out in split-split plot in basis of randomized complete block design with four replications at Sari, Mazandaran, Iran in 2008. Irrigation system include continues flooding and deficit as main plots and nitrogen rates N0, N46, N92, and N138 kg ha^{-1} as sub plots and silicon rates Si0 and Si500 kg ha-1 as sub-sub plots. Results showed that nitrogen fertilization induced an increase of this variable, and the result is associated to a greater. The number of filled spikelet's per hill also differed for nitrogen rates; higher values were recorded for the rate of N138. 1000 grain weight were increased significantly with increasing irrigation. Grain N content in flooding and deficit irrigation system. Grain yield in flooding irrigation was 31 Kg ha^{-1} higher than that of deficit system, which is not much regarding the much of water spent. Flooding irrigation system had the minimum harvest index and deficit irrigation had maximum harvest index. N138 and N0 had the maximum and the minimum grain yield, biological yield. The highest grain and straw N content were obtained in N138. At triple interaction of irrigation N rate Si rate was observed that the most grain N content was obtained at deficit irrigation in N138 with Si0 and Si500.

Yu *et al*. (2013) stated that, the effects of different nitrogen application levels on nutrient uptake and ammonia volatilization were studied with the rice cultivar Zheyou 12 as a material. The accumulative amounts of nitrogen, phosphorus and potassium in rice plants across all growth stages showed a trend to increase with increasing nitrogen application levels from 0 to 270 kg/hm^2 but decreased at nitrogen application levels exceeding 270 kg/hm^2. Moreover, the accumulative uptake of nitrogen, phosphorus and potassium by the rice plants was increased by application of organic manure in combination with 150 kg/hm^2 nitrogen. The nitrogen uptake was high during the jointing to heading stages. Correlation analysis showed that rice yield was positively correlated with the accumulative uptake of nitrogen, phosphorus and potassium by the rice plants. The highest correlation coefficient observed was between the amount of nitrogen uptake and rice yield. The rate and accumulative amounts of ammonia volatilization increased with increasing nitrogen fertilizer application level. Compared with other stages, the rate and accumulative amount of ammonia volatilization were higher after base fertilizer application. The ammonia volatilization rates in response to the nitrogen application levels of 270 kg/hm^2 and 330 kg/hm^2 were much higher than those in the other treatments. The loss of nitrogen through ammonia volatilization accounted for 23.9% of the total applied nitrogen at the nitrogen application level of 330 kg/hm^2.

Malidareh (2011) conducted an experiment and stated that, silicon is a beneficial element for plant growth. It helps plants to overcome multiple stresses, alleviates metal toxicity and improves nutrient imbalance. Field experiment was conducted as split-split plot arranged in a randomized complete block design with four replications. Irrigation system include continues flooding and deficit as main plots and nitrogen rates N0, N46, N92, and N138 kg/ha as sub plots and silicon rates Si0 & Si500 kg/ha as sub-subplots. Results indicate that grain yield had not significant difference between irrigation systems. Flooding irrigation had higher biological yield than deficit irrigation whereas, no significant difference in grain and straw yield. Nitrogen application increased grain, biological and straw yield. Silicon application increased grain, biological and straw yield but, decreased harvest index. Flooding irrigation had higher number of total tillers / hill than deficit irrigation, but deficit irrigation had higher number of fertile tillers / hill than flooding irrigation. Silicon increased number of filled spikelet and decreased blank spikelet. With high nitrogen application decreased 1000-grain weight. It can be concluded that if the nitrogen application was high and water supplied was available we could have silicon application until increase grain yield.

Hirzel *et al*. (2011) carried out an experiment and found that nutritional management in rice (*Oryza sativa* L.) crops is mainly associated with N fertilization, which is diffcult to adjust in feld conditions due to variations in soil type and climatic conditions. Between 28 000 and 46 000 ha per year is dedicated to rice production in Chile and profts depend on fertilization. A feld experiment determine the effect of N rates and split N fertilization on grain yield and its components was carried out in two locations during two consecutive seasons (2007 to 2009), where fve N rates and fve split N fertilizations were evaluated. The locations were in Parral (36º2' S; 72º08' W, Vertisol) and San Carlos (36º19' S; 71º59' W, Inceptisol), with N rates of 80, 100, 120, 140, and 160 kg ha-1 applied in different development stages, such as sowing, tillering, panicle initiation, and boot. Results indicate an important seasonal effect on grain yield. Yield increased with N rates higher than 120 and 140 kg ha-1 in San Carlos and Parral, respectively. Moreover, higher productivity with split N fertilization was (1) 33% of N at sowing, 33% at tillering, and 34% at panicle initiation or (2) 50% of N at sowing and 50% at panicle initiation. Yield components with the highest effect on productivity were affected by the evaluated split N. On the other hand, higher N rates increased the percentage of both stained and sterile grains per panicle.

Zhang *et al*. (2008) reported that, the differences between upland and paddy rice (*Oryza sativa* L.) as well as the interaction between cultivation methods and nitrogen (N) levels were evaluated. The upland rice cultivar Zhonghan 3 (*japonica*) and the paddy rice cultivar Yangjing 9538 (*japonica*) were field grown under moist cultivation (MC, control) and bare dry-cultivation (DC). Each cultivar had 3 N-treatments under either MC or DC, that is, low N supply (LN, 100 kg ha^{-1}), normal N supply (NN, 200 kg ha^{-1}), and high N supply (HN, 300 kg ha^{-1}). Compared with NN, HN reduced grain yield for both upland and paddy rice cultivars under DC and for the paddy rice cultivar under MC, whereas, it increased the yield of upland rice under MC. With an increase in N level, both upland and paddy rice showed higher productive tillers, more or fewer spikelets per panicle, and lower percentage of ripened grains under MC and DC. However, the seed-setting rate reduced to a greater extent in paddy rice than in upland rice. There was no significant difference in 1000-grain weight for the upland rice among the 3 N levels, whereas, the 1000-grain weight reduced with the increase in N level in the paddy rice. Compared with MC, DC had no significant influence to grain weight of upland rice, however, a significantly negative effect was observed in paddy rice. DC increased the seed-setting rate in both cultivars, with more increase in upland rice than in paddy rice. The upland rice had less number of adventitious roots, lower N absorption ability, lower productive tillering ability, fewer panicles, fewer spikelets per panicle, and lower grain yield than paddy rice. However, upland rice showed more rapid increase in adventitious roots and a slower decline in leaf N content from jointing to heading, and a faster decline in chlorophyll content (SPAD value) after anthesis. In addition, upland rice had a weak negative response to water stress and a strong positive response to the N level. The responses to cultivation methods and N level varied largely between upland and paddy rice.

Bahmaniar and Ranjbar (2007) carried out an experiment in order to consider effects of various levels of nitrogen and potassium application on kernel processing characteristics of rice cultivars, an experiment was developed in 2004 and 2005 using Tarrom (a local Iranian landrace) and Neda (an Iranian improved cultivar). In this experiment four levels of nitrogen fertilizer (0, 50, 100 and 150 kg N ha^{-1} from urea source) and four levels of potassium fertilizer (0, 75, 150 and 225 kg K_2O ha^{-1} from potassium sulfate source) have been applied using a split factorial design with 3 replications. Nitrogen fertilizer have been applied in three stages (1/3 in transplanting stage, 1/3 in tillering stage and finally 1/3 in flowering initiation stage) and potassium fertilizer have been applied in two stages (1/2 in transplanting stage and 1/2 in shooting stage). Results showed that application of nitrogen cause an increase in amount of bran production and have shown significant effects on percentages of bran, head and brewers rice, husking efficiency and transformation degree. However, potassium application has increased percent of bran and husking efficiency and has decrease percentages of brewers rice and has not demonstrated significant effects on percentages of husk, head rice and transformation degree. Furthermore, simultaneous application of nitrogen and potassium in Tarrom genotype has not shown significantly effects on percentages of husk, head and brewers rice and transformation degree. In Neda, cultivar has not also shown significant effects on percentages of bran production, head and brewers rice and husking efficiency, respectively. In Tarrom genotype amount of husk, bran, brewers rice and transformation degree were higher than in Neda cultivar, however, amount of head rice and husking efficiency in Neda cultivar were higher than in Tarrom genotype.

Chaturvedi (2006) conducted a field trial to determine the effect of different nitrogenous (N) fertilizers on growth, yield and quality of hybrid rice variety ‘Proagro 6207’, comprising of 10 different treatments using randomized complete block design with three replications was conducted at Agricultural Research Station, Bilaspur Chhattisgarh, India. The two years data during 2002 and 2003 revealed that all the growth characters, yield parameters and grain nitrogen (N) increased signifi cantly with an application of sulphur-containing nitrogen fertilizer- Super Net. These results were statistically at par with that of treatment T4, where ammonium sulphate nitrate was applied. In this series of experiment, non-sulphur-containing nitrogen fertilizer, urea gave lowest yield and grain nitrogen (N) content and these reductions were signifi can’t in all of the experiments.

Ahmed *et al*. (1998) stated that, proper supply of nitrogen fertilization helped to increase the growth, yield and quality of rice.

Hasegawa and Horie (1997) reported that, a dynamic crop growth model was developed to analyse irrigated paddy rice (*Oryza saliva* L.) productivity as determined by climatic factors and N availability. The model consists of submodels related to soil N processes, rice N-uptake, developmental processes, photosynthesis, dry matter production and spikelet formation. Soil N processes include N mineralization, expressed as a function of temperature and soil moisture before flooding. The balance between soil N supply and crop N demand determines rice N-uptake. The phenological developmental rate was expressed as a non-linear function of daily temperature and daylength. Submodels for canopy photosynthesis and dry matter production were based on an age-dependent relation between single-leaf photosynthesis and leaf N. Spikelet number was determined by an empirical function of dry weight and N concentration of above-ground biomass at the panicle formation stage, which was derived from a number of field experiments conducted in widely different regions in Japan. Data sets covering a range of N and climatic conditions were used for validation. The model, written in BASIC for PCs, satisfactorily simulated daily biomass growth and final spikelet number with inputs of latitude, N fertilizer input and daily climatological data, and might be useful for evaluation of N fertilizer management scenarios over sites and seasons.

2.2 Effect of phosphorus

Massawe and Mrema (2017) conducted an experiement to investigate the effects of phosphorus (P) from Minjingu Phosphate Rock (MPR), Minjingu mazao and Triple Super Phosphate (TSP) fertilizers under irrigated rice (*Oryza sativa* L.) production was conducted in two sites of Lekitatu village, Meru district, Arusha region, Tanzania. The fertility status of the soils and their suitability for rice production at two experimental sites were evaluated based on technical indicators of soil fertility. The major soil fertility limitations included low soil organic matter, low total nitrogen and medium available phosphorus hence the rice soils in Lekitatu village were categorized as of low fertility status and moderately suitable for rice production. A Randomized Complete Block Design (RCBD) with three replications was adopted. Phosphorus was applied at the rates of 0, 20, 40 and 60 kg P ha-1 as MPR, Minjingu mazao and TSP. Nitrogen was applied uniformly at a rate of 60 kg N ha-1 as urea to the MPR, Minjingu mazao and TSP treatments plots taking into account the 10% N contained in the Minjingu mazao fertilizer. The P fertilizers were broadcasted and incorporated into the soils before transplanting the rice seedlings and N was applied at two equal splits, namely at tillering and panicle initiation stages. The ranges in yield components between the control (0 kg P ha^{-1}) and the highest levels of P (60 kg P ha^{-1}) were 23.47 – 64.97, 23.47 – 66.17 and 23.47 – 60.03 cm plant heights, 12–22, 12–19 and 12–22 number of tillers per plant, 7.67–25.97, 7.67–26.83 and 7.67–30.20 tha^{-1} dry matter yields, 3.97 – 15.70, 3.97 – 17.03 and 3.97 – 15.77 tha^{-1} straw dry matter yields and

1.5–8.63, 1.5–9.23 and 1.5–10.43 tha^{-1} grain yields for MPR, TSP and Minjingu mazao, respectively. The P fertilizers applications increased rice yield components as the levels of P increased from 0 to 60 kg P ha^{-1} for all P sources. The yield components increased significantly ($P<0.05$) with increasing rates of P application. The increases were due to increased availability and uptake of plant nutrients particularly P. Based on the generated yields data, it was thus concluded that: Minjingu mazao at the rates of (40 to 60 kg P ha^{-1}), MPR and TSP at a rate of 60 kg P ha^{-1}, respectively could be adopted for increased and sustainable rice production in Lekitatu village.

Ro *et al*. (2016) reported that, nitrogen (N) and phosphorus (P) deficiencies are key constraints in rainfed lowland rice (*Oryza sativa* L.) production systems of Cambodia. Only small amounts of mineral N and P or of organic amendment are annually applied to a single crop of rainfed lowland rice by smallholder farmers. The integration of leguminous crops in the pre-rice cropping niche can contribute to diversify the production, supply of C and N, and contribute to soil fertility improvement for the subsequent crop of rice. However, the performance of leguminous crops is restricted even more than that of rice by low available soil P. An alternative strategy involves the application of mineral P that is destined to the rice crop already to the legume. This P supply is likely to stimulate legume growth and biological N_2 fixation, thus enhancing C and N inputs and recycling N and P upon legume residue incorporation. Rotation experiments were conducted in farmers' fields in 2013–2014 to assess the effects of P management on biomass accumulation and N_2 fixation ($\delta^{15}N$) by mungbean (*Vigna radiata* L.) and possible carry-over effects on rice in two contrasting representative soils (highly infertile and moderately fertile sandy Fluvisol). In the traditional system (no legume), unamended lowland rice (no N, + 10 kg P ha^{-1}) yielded 2.8 and 4.0 t ha^{-1}, which increased to 3.5 and 4.7 t ha^{-1} with the application of 25 kg ha^{-1} of urea-N in the infertile and the moderately fertile soil, respectively. The integration of mungbean as a green manure contributed up to 9 kg of biologically fixed N (17% Nfda), increasing rice yields only moderately to 3.5–4.6 t ha^{-1}. However, applying P to mungbean stimulated legume growth and enhanced the BNF contribution up to 21 kg N ha^{-1} (36% Nfda). Rice yields resulting from legume residue incorporation ("green manure use"–all residues returned and "grain legume use"–only stover returned) increased to 4.2 and 4.9 t ha^{-1} in the infertile and moderately fertile soil, respectively. The "forage legume use" (all above-ground residues removed) provided no yield effect. In general, legume residue incorporation was more beneficial in the infertile than in the moderately fertile soil. We conclude that the inclusion of mungbean into the prevailing low-input rainfed production systems of Cambodia can increase rice yield, provided that small amounts of P are applied to the legume. Differences in the attributes of the two major soil types in the region require a site-specific targeting of the suggested legume and P management strategies, with largest benefits likely to accrue on infertile soils.

Zhang *et al*. (2012) was carried out an experiment and they investigated how upland and paddy japonica rice responded to phosphorous (P) fertilizer under two cultivation methods. The upland rice Zhonghan 3 and the paddy rice Yangfujing 8 were both grown under moist cultivation (MC, control) and bare dry cultivation (DC) with three P levels, low (LP, 45 kg/hm^2), normal (NP, 90 kg/hm^2) and high (HP, 135 kg/hm^2). As P level increased, grain yields of both upland and paddy rice increased under DC. There were no significant differences in grain yields between HP and NP for either rice, although upland rice slightly increased and paddy rice slightly decreased in grain yield. Under DC at LP, Zhonghan 3 showed a higher head milled rice rate and better appearance, cooking and eating qualities than at HP or NP. Yangfujing 8 was similar to Zhonghan 3 except that Yangfujing 8 had better appearance quality at NP. Under MC, Zhonghan 3 had a higher head milled rice rate at LP and better cooking and eating qualities at NP. Yangfujing 8 was similar to Zhonghan 3 except in appearance quality. DC improved head milled rice rate and appearance quality of both upland and paddy rice, and cooking and nutrient qualities of paddy rice. Compared with paddy rice, upland rice had better processing, nutrient and eating qualities. The results suggest that upland and paddy rice respond differently to cultivation method and phosphorus level.

Sharma *et al*. (2011) was carried out a study at the Indian Agricultural Research Institute, New Delhi, for three crop years (2000–2001 to 2003–2004) to find out the effect of rates and sources of phosphorus on production and phosphorus balance in a rice-wheat system. Phosphorus application significantly increased productivity and P uptake of rice-wheat cropping system and resulted in an increase in extractable P (0.5 M $NaHCO_3$) content in soil. Mussoorie rock phosphate with phosphorus solubilizing bacteria inoculation (MRP + PSB) at 35 and 52.5 kg P ha^{-1} was similar to 17.5 and 35 kg P ha^{-1}, respectively, as diammonium phosphate (DAP) in terms of productivity and P uptake of rice-wheat cropping system but significantly superior in terms of PSB population and CO_2 evolution in soil. The P balance was generally more positive for MRP + PSB than for DAP and the highest P balance was observed with the application of 52.5 kg P ha^{-1} as MRP + PSB. At the end of three cycles of rice-wheat cropping system,net change in extractable P content in soil increased with increasing rate of P application and was highest with the application of 52.5 kg P ha^{-1} asMRP + PSB to each crop of every year of the three years of study. The present study, thus, indicates that P requirement of a rice-wheat cropping system can be met with 35–52 kg P ha^{-1} as MRP to each crop with PSB inoculation.

Islam *et al*. (2008) conducted an experiment at the screen house of Tsukuba International Centre (TBIC), Japan to clarify the effect of phosphorus on nutrient absorption characteristics of a japonica (Nipponbare) and an indica (IR-28) rice variety. The experiment was conducted under submerged condition in subsoil of an Andisol, which had a high capacity of phosphate fixation. Levels of phosphorus were 100, 200, 500 and 800 kg P_2O_5 ha^{-1}. The P content in rice plant at different growth stages increased progressively with an increase of P levels for both the varieties. With respect to P content, varietal differences were minimal. But in the case of N and K content, IR-28 showed higher ability than Nipponbare. At maximum tillering stage, both the varieties showed negative co-relation between P and N uptake but at harvest stage, strong positive co-relation between P and N uptake was found for both the varieties. Both the varieties showed positive co-relation between N and K uptake at all the stages.

Choudhury *et al*. (2007) conducted an experiment on various aspects of P fertilization in rice i.e., P nutrition of rice, P response of rice plant, P availability in rice soils and P adsorption in rice soils for better understanding of P fertilization in rice culture. A substantial portion of the applied P along with the soil P is lost from rice fields to water bodies causing environmental pollution problems through eutrophication. These pollution problems can be minimized by using proper source of P as fertilizer, proper timing and methods of P fertilizer application, soil P management, transport management, use of plant growth promoting microorganisms which helps in efficient use of P by crops and use of green manure crops which improves soil fertility as well as helps in efficient use of P by crops.

Khan *et al*. (2007) was conducted a field experiment to study the response of wheat and rice to phosphorus during 20004-05 at D.I.Khan. The basal dose of N at 120 kg and K_2O at 60 kg ha^{-1} was applied with P levels (0, 45 and 90 kg P_2O_5 ha^{-1}) to both wheat and rice crops. Wheat variety Naseer 2000 and rice variety IRRI-6 were used in the study. The experiment was carried out in RCB design with three replications. Phosphorus application significantly increased the grain yield of wheat from 2920 kg ha^{-1} in control to 3560 kg ha^{-1} in the treatments receiving P at 90 kg P_2O_5 ha^{-1} giving an increase of 22 % over control. The number of tillers, spikes, spike length and plant height of wheat were also significantly increased by P application. The rice also showed positively response to P application and hence both yield and yield parameters were significantly greater in the P than in the check treatment. Paddy yield was increased significantly by P application up to 75% over control. Plant height and 1000 grain weight were also significantly increased with P application over control. The application of P significantly increases number of spike plant-1 and spike length over control, however no statistical difference was recorded among the treatment. The cumulative application of 90 kg P_2O_5 ha^{-1} gave the highest increase of 75% while direct application of the same level gave an increase of 54% however 47% increase over control was recorded by the residual application of 90 kg P_2O_5 ha^{-1}. The highest VCR of 3.7:1 was achieved with the cumulative application of 45 kg P_2O_5 ha^{-1}.

Somado *et al*. (2003) stated that, rice demand in West Africa is unmet because of insufficient production. Legume fixed N [biological N fixation (BNF)] may sustainably increase rice productivity in low-input systems. However, P deficiency limits BNF on the acid soils encountered in the region, despite the prevalence of phosphate rock (PR). Pot and field experiments were conducted in Côte d'Ivoire in 1996–1998 to study the impact of combined legume and PR on rice performance. Triple superphosphate and PR were applied at rates of 60 (pot) and at 90 (field) kg P ha^{-1} to rice and the legume *Aeschynomene afraspera* grown for 8 wk and then incorporated before rice transplanting. Legume fixed N was determined by ^{15}N isotope dilution. Under field conditions, addition of PR doubled the biomass of *A. afraspera*Irrespective of P source, P application increased the amount of BNF-N (three- to eightfold) to 36 mg N $plant^{-1}$ in pots and to 84 kg N ha^{-1} in the field. Nitrogen derived from the air was correlated with legume P uptake (r = 0.97***, where *** = significant at the 0.001 level) and nodulation (r = 0.91**, where ** = significant at the 0.01 level). The synergy of PR and BNF on N and P cycling improved P nutrition and total biomass of subsequent lowland rice under pot conditions. Combining legume green manure (GM) with PR enhanced soil extractable Bray-1 P and may thus play an important role in improving the availability of PR. Under field conditions, due to asynchrony in GM nutrient release and demand, the impact of the combined GM–PR treatment on rice yield was minimal.

Singh *et al*. (1988) conducted an experiment where the *Azolla pinnata* (Vietnam) inoculated in rice field 10 days after transplanting (DAT) at a rate of 500 kg ha^{-1} fresh biomass along with phosphorus fertilizer application produced a mat on the water surface at 30 DAT. The three split application of phosphorus as 4.4, 2.2 and 2.2 kg P ha^{-1} applied at 10, 15 and 20 DAT, respectively produced 67% more biomass and 57% more Nitrogen in*Azolla* than those obtained by applying 8.8 kg P ha^{-1} at 10 DAT. Whereas, the two splits of phosphorus as 6.6 and 2.2 kg and 4.4 and 4.4 kg P ha^{-1} applied 10 and 15 DAT, respectively produced 20 and 33% more biomass and 14 and 27% more Nitrogen only. The three-split application of phosphorus also increased the grain and straw yields, panicle number and weight, nitrogen concentration and its uptake in rice significantly over application of the entire amount once only. An increase of 10% grain yield and 13% straw yields was observed when 8.8 kg P ha^{-1} was applied in three splits rather than applied at one time. On the average an increase of 24% grain and 23% straw yields in rice were observed due to *Azolla* intercropping and 22% and 16%, respectively due to phosphorus application. The intercropping of *Azolla* with rice along with phosphorus application also increased the fertility level of soil by increasing the total nitrogen, organic carbon and available phosphorus of soil.

3.3 Effect of variety

Murshida *et al*. (2017) conducted an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during December 2014 to May 2015 to examine the effect of variety and water management system on the growth and yield performance of boro rice. The experiment consisted of three varieties (cv. BRRI dhan28, BRRI dhan29 and Binadhan-14) and four water management systems (viz. Traditional flooding, non-flooded rice straw mulching, non-flooded water hyacinth mulching and non-flooded no mulching). The experiment was laid out in a split plot design with three replications. Different growth characters, yield and yield contributing characters of boro rice were found to the significantly influenced by variety, water management system and their interactions. At 100 DAT, the highest plant height, maximum number of tillers hill^{-1}, dry matter of shoot hill^{-1} and dry matter of root ha^{-1} were obtained from BRRI dhan29 and the lowest values were found in Binadhan-14. At 100 DAT, the highest plant height, maximum number of tillers hill^{-1}, dry matter of shoot hill^{-1} and dry matter of root hill^{-1} were obtained in non-flooded rice straw mulching treatment and the lowest ones were obtained from non-flooded no mulching treatment. Variety had significant effect on all the crop characters under study except 1000-grain weight. The highest grain yield was obtained from BRRI dhan29 and the lowest value was recorded from Binadhan-14. Water management system was also significantly influenced all crop characters. The highest grain yield was recorded from non-flooded rice straw mulching treatment and the lowest grain yield was found from non-flooded no mulching treatment. The interaction of variety and water management system showed that BRRI dhan29 with non-flooded rice straw mulching resulted in the highest grain yield whereas the lowest yield was observed from the interaction of Binadhan-14 with non-flooded no mulching treatment. The result of the experiment suggests that BRRI dhan29 can be grown economically with non-flooded rice straw mulching treatment.

Lemraski *et al*. (2017) carried out an experiment was as a split factorial in randomized complete blocks design with three replications in Sari, Iran during 2013 and 2014. Rice cultivars were chosen as the main factor including Tarom Mahalli and Tarom Hashemi. Nitrogen rates (34 and 69 kg N ha^{-1} and nitroxin) with nano-particle (nano-potassium, nano-silicon and control) selected as the subfactor. The results indicated that the amount of total tiller per hill and fertile tiller per hill for Tarom Hashemi was more than Tarom Mahalli in both years. The highest paddy yield in both years was observed for Tarom Hashemi, the main reason behind it is increasing panicle length and fertile tiller number for this cultivar. For Tarom Hashemi, the highest paddy yield (5000 kg·ha^{-1}) was produced with 34 kg N ha^{-1} and nano potassium application. For Tarom Mahalli, the highest paddy yield 4657 kg·ha^{-1} was obtained with nitroxin and nano potassium consumption. The highest harvest index was achieved with nitroxin and nano-silicon consumption. Therefore, nano particle consumption in both cultivars resulted in improved yield.

Dangi *et al*. (2017) conducted a field experiment entitled “performance of rice varieties at varying levels of nitrogen under direct seeded upland condition” was conducted on silty clay loam soil with low in available nitrogen, medium in phosphorus and high in available potassium at neutral pH Agriculture College Farm, Rewa (M.P.) during Kharif season 2015. The treatments comprising 3 levels of nitrogen (N_1, 40 kg/ha; N_2, 80 kg/ha N_3, 120 kg/ha) in main plots and 07 (seven) varieties (V_1 IET 23824, V_2 IET 24780, V_3 BPT 5204, V_4 Sahbhagi, V_5 Chittimuthyalu, V_6 Kalanamak and V_7 IR-64) assigned in subplot of split-plot design replicated three times. The variety IR – 64 gave higher values of most of the growth and yield component characters and resulted significantly highest grain yield (42.98q/ha) in the Rewa region. Application of 120 kg N/ha produced highest growth characters, yield attributing traits and grain yield (45.13 q/ha). The combination of variety IR-64 and 120 kg N/ha was found the best in respect of most of the growth and yield attributing characters along with grain yield (52.14 q/ha) followed by BPT 5204 sown with 120 kg N/ha (47.62q/ha). The net return as well as benefit cost ratio was also highest from the treatment N3V7 (N level 120kg + IR-64) followed by treatment N3V3 (N level 120kg + BPT-5204).

Chamely *et al*. (2015) conducted an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from November 2010 to May 2011 to study the effect of variety and rate of nitrogen on the performance of Boro rice. The experiment comprised three varieties viz., BRRI dhan28 (V_1), BRRI dhan29 (V_2) and BRRI dhan45 (V_3); and five rates of nitrogen viz., control (N_0), 50 kg (N_1), 100 kg (N_2), 150 kg (N_3) and 200 kg (N_4) N ha^{-1}. The experiment was laid out in a randomized complete block design with four replications. The growth analysis results indicate that the tallest plant (80.88 cm) and the highest number of total tillers hill^{-1} (13.80) were observed in BRRI dhan29 at 70 DATs and the highest total dry matter (66.41 g m^{-2}) was observed in BRRI dhan45. The shortest plant (78.15 cm) and the lowest number of tillers hill^{-1} (12.41) were recorded from BRRI dhan45 and the lowest dry matter (61.24 g) was observed in BRRI dhan29. The tallest plants (84.01 cm), highest number of tillers hill^{-1} (14.06) and the highest dry matter (69.58 g m^{-2}) were obtained from 200 kg N ha^{-1}. The tallest plants (86.48 cm) and maximum dry matter (72.30 g m^{-2}) were recorded from BRRI dhan28 with 200 kg N ha^{-1} and BRRI dhan45 with 200 kg N ha^{-1}, respectively. The highest number of tillers hill^{-1} (15.14) was obtained from BRRI dhan29 with 50 kg N ha^{-1}. The harvest data reveal that variety had significant effect on total tillers hill^{-1}, effective tillers hill^{-1}, non-effective tillers hill^{-1}, panicle length, grain yield, straw yield and harvest index. The highest grain yield (4.84 t ha^{-1}) was recorded from BRRI dhan29. The results of the experiment also indicate that total tillers hill^{-1}, effective tillers hill^{-1}, grains panicle^{-1}, sterile spikelets panicle^{-1}, grain yield, straw yield and harvest index were significantly affected by levels of nitrogen, while plant height, panicle length, 1000-grain weight were not significantly affected by levels of nitrogen. The highest grain yield (5.58 t ha^{-1}) was obtained from 200 kg N ha^{-1}. Interaction effect of variety × 200 kg N ha^{-1} produced the highest grain yield (5.82 t ha^{-1}). From the results of the study it may be concluded that BRRI dhan29 rice may be cultivated with 200 kg N ha^{-1} for obtaining higher yield in AEZ 9 of Bangladesh

Hussain *et al*. (2014) conducted an experiment and found that crop genotypes play a dominant role in crop production systems. They affect crop productivity by their higher yield potentials, resistance against insect pest and diseases under different climatic conditions. To evaluate different varieties of rice for their growth and yield characteristics, an experiment was conducted during 2012. Four varieties including IR- 28, NERICA-4, Koshihikari and Nipponbare were evaluated in a randomized complete block design (RCBD) with three replications. All varieties were transplanted at spacing of 30x15 cm using 3 seedlings / hill. Data on various growth and yield parameters revealed that

Koshihikari was the tallest (117 cm) and Nipponbare the shortest one (102 cm). Japonica varieties produced higher number of tillers/m2, dry weight (t/ha), LAI, number of panicles/m2, ripening ratios and lower nitrogen contents in panicle, stem and leaves. NERICA-4 gave higher values of SPAD, number of spikelets/ panicle (106) and harvest index (0.47). The highest straw weight (11.53 t/ha) and paddy yields (6.79 t/ha) were obtained from IR-28. The lowest values of harvest index (0.37) were also recorded from IR-28. Japonica and IR-28 produced higher paddy yields than NERICA-4 (5.77 t/ha) so they can be cultivated successfully under temperate climatic conditions.

CHAPTER III

MATERIALS AND METHODS

The study was conducted at the research field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh from December 2016 to May 2017 to study the influence of nitrogen and phosphorus levels on yield and seed quality of rice. This chapter will deal with a brief description on experimental site, climate, soil, land preparation, layout, experimental design, intercultural operations, data recording and data analysis.

3.1 Experimental site

The study was conducted at central research field of Sher-e-Bangla Agricultural University, Dhaka, under the Agro-ecological zone of Modhupur Tract, AEZ-28. The location of the site is $23^{0}74^{/}$N latitude and $90^{0}35^{/}$E longitude with an elevation of 8.2 meter from sea level. The location of the experimental field was presented in Appendix I.

3.2 Climate and weather

The geographical location of the experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October. Details of the meteorological data of air temperature, relative humidity and rainfall during the period of the experiment were collected from the Bangladesh Meteorological Department, Agagaon, Dhaka presented in Appendix II.

3.3 Soil

The soil belongs to “The Modhupur Tract”, AEZ – 28. 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 has 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 were presented in Appendix III.

3.4 Plant material

In this research work, two inbreed varieties i.e. BRRI dhan28 and BRRI dhan74 were used as planting materials. The seeds were collected from the Bangladesh Rice Research Institute (BRRI), Gazipur, Bangladesh.

3.5 Experimental details

3.5.1 Treatments

Two factor experiments were conducted to evaluate the influence of nitrogen and phosphorus levels on yield and seed quality of rice. This experiment was conduced for the following factors.

***Factor A*: Fertilizer level**

i. F_0= No fertilizer
ii. F_1= 50% less than recommended dose of chemical fertilizer
iii. F_2= 25% less than recommended dose of chemical fertilizer
iv. F_3= Recommended dose of chemical fertilizer
v. F_4= 25% higher than recommended dose of chemical fertilizer
vi. F_5= 50% higher than recommended dose of chemical fertilizer
vii. F_6= 75% higher than recommended dose of chemical fertilizer

***Factor B*: Two rice varieties**

i. V_1= BRRI dhan28
ii. V_2= BRRI dhan74

Treatment combination

F_0V_1, F_1V_1, F_2 V_1, F_3V_1, F_4V_1, F_5V_1, F_6V_1, F_0V_2, F_1V_2, F_2V_2, F_3V_2, F_4V_2, F_5V_2, F_6V_2.

3.5.2 Experimental design

The experiment was laid out in Split Plot Design with three replications. The layout of the experiment was prepared for distributing the fertilizer doses and varieties. There were 42 plots for this experiment having fertilizer dose in the main plot and variety in the subplot.

The treatments of the experiment were assigned at random into each replication following the experimental design. Seed were sown in the seed bed. When age of seedling was 38 days then up rooted and transplanted maintaining line to line distance 20 cm and hill to hill distance 15 cm. Two seedlings hill^{-1} were used during transplanting.

3.6 Growing of crops

3.6.1 Raising seedlings

3.6.1.1 Seed sprouting

Healthy seeds were selected by specific gravity method and then immersed in water bucket for 24 hours and then it was kept tightly in gunny bags. The seeds started sprouting after 48 hours.

3.6.1.2 Preparation of nursery bed and seed sowing

As per BRRI recommendation seedbed was prepared with 1 m wide adding nutrients as per the requirements of soil. Seed were sown in the seed bed @ 70 g m^{-2} on 20 November, 2016.

3.6.2 Preparation of the main filed

The plot selected for the experiment was opened in 15 December 2016 with a power tiller, and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed, and finally obtained a desirable tilth of soil for transplanting of seedlings.

3.6.3 Fertilizers and manure application

The following doses of manure and fertilizers (BRRI, 2013) were used. Whole amount of cow-dung, TSP, MoP, Gypsum and Zinc sulphate and one third of urea were applied at the time of final plots preparation. Urea and phosphorus applied as per the treatment.

Manure and Fertilizer	**Doses**
Cowdung	5 t ha^{-1}
Urea	220 kg ha^{-1}
TSP	165 kg ha^{-1}
MoP	180 kg ha^{-1}
Gypsum	70 kg ha^{-1}
Zinc sulphate	10 kg ha^{-1}

3.6.4 Uprooting seedlings

The nursery bed was made wet by application of water one day before uprooting the seedlings. The seedlings were uprooted on December 28, 2016 without causing much mechanical injury to the roots.

3.6.5 Transplanting of seedlings in the field

The seedlings were transplanted in the main field on December 28, 2016 and the rice seedlings were transplanted in lines each having a line to line distance of 20 cm and plant to plant distance was 15 cm for all test varieties in the well-prepared plot.

3.6.6 Cultural operations

The details of different cultural operations performed during the course of experimentation are given below:

3.6.6.1 Irrigation and drainage

Irrigations were supplied as per the plant required.

3.6.6.2 Gap filling

Gap filling was done for all of the plots at 10 days after transplanting (DAT) by planting same aged seedlings.

3.6.6.3 Weeding

First weeding was done from each plot at 15 DAT and second weeding was done from each plot at 40 DAT. Mainly hand weeding was done from each plot.

3.6.6.4 Plant protection

Furadan 57 EC was applied before the time of translating and Dimecron 50 EC was applied at 30 DAT.

3.7 Harvesting, threshing and cleaning

The rice plant was harvested depending upon the maturity of grains and harvesting was done manually from each plot. Maturity of crop was determined when 80-90% of the grains become golden yellow in color. Enough care was taken for harvesting, threshing and also cleaning of rice seed.

Fresh weight of grain and straw were recorded plot wise. Finally, the weight was adjusted to a moisture content of 14%. The straw was sun dried and the yields of grain and straw $plot^{-1}$ were recorded and converted to t ha^{-1}.

3.8 Seed Quality test

Seed quality test was under taken in the agronomy laboratory of SAU. Dried and clean seeds was collected from each plot and used for quality tests. For quality test, 25 seeds of each plot set in Petridis using sand media.

3.9 Data recording

A. For field experiment

i. Plant height (cm)
ii. Panicle length (cm)
iii. Number of effective tillers hill^{-1}
iv. Number of filled grains panicle^{-1}
v. Number of unfilled grains panicle^{-1}
vi. Weight of 1000 grains
vii. Grain yield (t ha^{-1})
viii. Straw yield (t ha^{-1})

B. For quality test experiment

ix. Germination percentage
x. Shoot length of seedling (cm)
xi. Root length of seedling (cm)
xii. Dry Shoot weight of seedling (mg)
xiii. Dry Root weight of seedling (mg)

3.9.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of harvest. The height was measured from the ground level to the tip of the plant.

3.9.2 Panicle length

The length of 10 panicles were measured using the measuring scale and averaged and then expressed as centimeter (cm).

3.9.3 Number of effective tillers hill^{-1}

Number of effective tillers were counted from 5 hills and averaged then to get effective tillers hill^{-1}.

3.9.4 Number of filled grains panicle^{-1}

The filled grain was counted from 5 panicles in each plot and averaged then to have number of filled grains panicle^{-1}.

3.9.5 Number of unfilled grains panicle^{-1}

The unfilled grain was counted from 5 panicles in each plot and averaged number of unfilled grains panicle^{-1}.

3.9.6 Weight of 1000 grains

One thousand grains were counted randomly from the total cleaned harvested grains of each individual plot and then weighed with an electric balance in grams and recorded.

3.9.7 Grain yield

The matured plant of central 1m^2 area from each plot were harvested, threshed, dried, weighed and finally converted to yield as t ha^{-1} basis.

3.9.8 Straw yield

The matured plant of central 1m^2 area from each plot were harvested. After threshing it was dried, weighed and finally converted to straw yield as t ha^{-1} basis.

3.9.9 Germination percentage

After harvesting germination test was done in the laboratory of Department of Agronomy, SAU. Twenty five seeds were placed in each petri dis and germinated seedling was counted. Finally, total number was converted as percentage.

3.9.10 Shoot length and root length

From the germinated seedling, shoot length and root length was measured using measuring scale and recorded as centimeter (cm). Average values of 10 shoot and root were used for determining shoot and root length.

3.9.11 Shoot weight and root weight

From the germinated seedling, after taking shoot length and root length the dry weight of shoot and root measured separately. Fifteen days old seedling were used for this estimation. As the weight was very low, the recorded data was measured as miligram (mg).

3.10 Statistical Analysis

The data obtained for different characters were statistically analyzed using statistix 10 software to observe the significant difference among the treatment. The mean values of all the characters were calculated and analysis of variance was performed. The significance of the difference among the treatment means were estimated by the DMRT test at 5% level of probability.

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the influence of nitrogen and phosphorus levels on yield and seed quality of rice. Data on different plant characters, yield attributes and yield were recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix IV to XVI. The results have been presented with the help of graphs and table, and possible interpretations given under the following headings

4.1 Plant height

Effect of fertilizer

Due to application of different levels of fertilizer plant height showed significant variations of rice plant (Figure 1 and Appendix IV). Figure demonstrated that, plant height increased gradually with the increased of fertilizer doses up to F_4 (91.24 cm) after that the height reduce slightly with further increase of fertilizer dose (F_5 and F_6). The tallest plant (91.24 cm) was recorded in F_4 treatment while the shortest plant (73.51 cm) was recorded in F_0 treatment. This might be due to the proper supply of nutrient from F_4 treatment facilitated the proper growth of plant. The present finding was agreed with the findings of Lemraski *et al*. (2017), Malav and Ramani (2017), Wang *et al*. (2017), Liu *et al*. (2016), Massawe and Mrema (2017) and Ro *et al*. (2016).

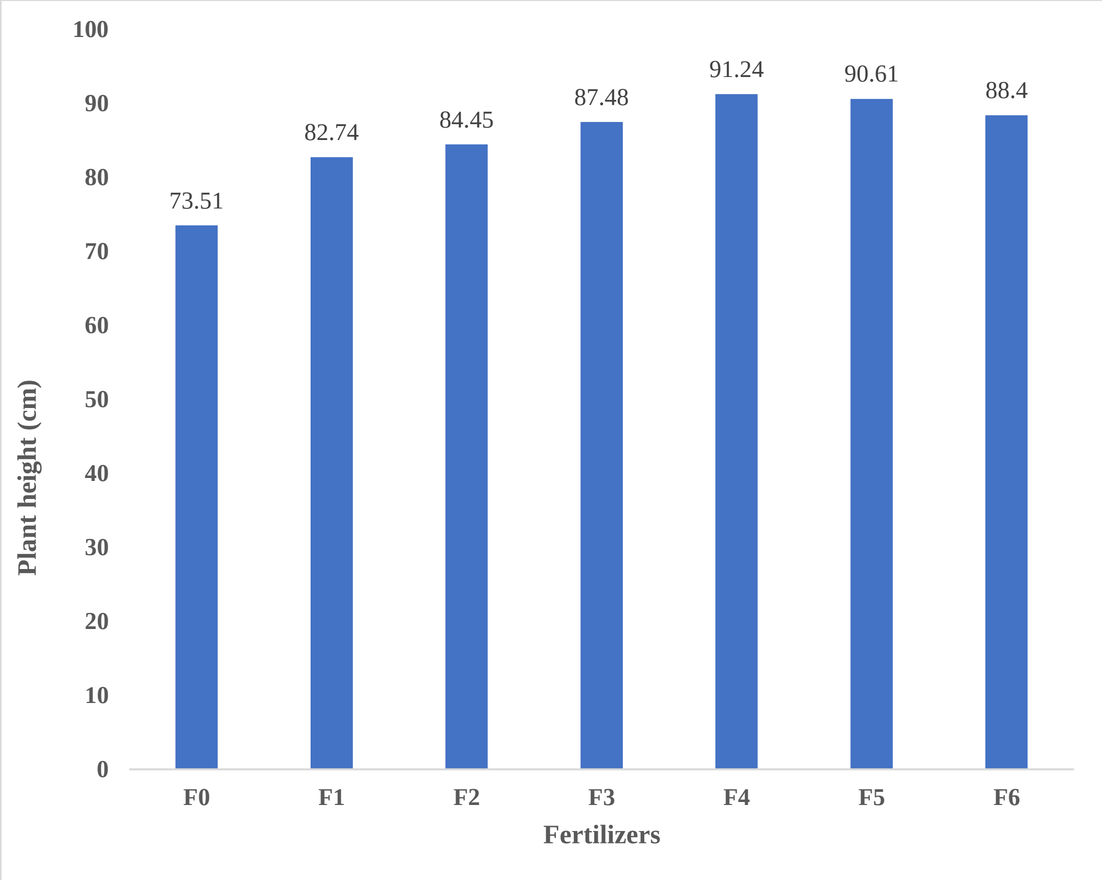

Figure 1. Effect of fertilizer on plant height of rice (SE=1.99)

F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer**,** F_3 = Recommended dose of fertilizer**,** F_4 =25% more than recommended dose of fertilizer**,** F_5 = 50% more than recommended dose of fertilizer, F_6= 75% higher than recommended dose of chemical fertilizer

Effect of variety

Plant height showed statistically significant effect due to different varieties of rice (Figure 2 and Appendix IV). Figure represented that the taller plant (90.58 cm) was recorded in V_1 variety while shorter plant (80.40 cm) was found in V_2 variety. Murshida *et al*. (2017), Lemraski *et al*. (2017) and Dangi *et al*. (2017) reported the similar findings.

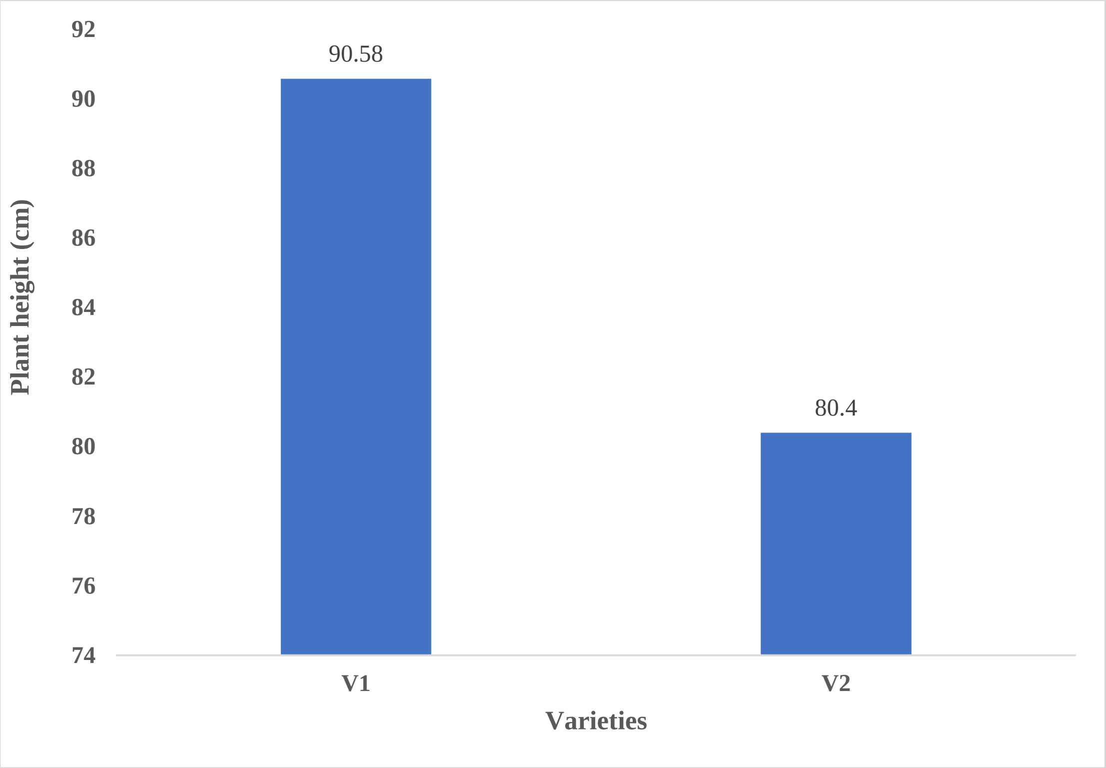

Figure 2. Effect of variety on plant height of rice (SE=1.063)

V_1 = BRRI dhan28, V_2 = BRRI dhan74

Combined effect of fertilizer and variety

Combined effect of fertilizer level and variety produced statistically significant variation in plant height of rice (Table 1 and Appendix IV). Table showed that, the tallest plant (98.20 cm) was found in V_1F_4, which was statistically similar with F_5V_1, F_6V_1 and F_3V_1 (96.75 cm, 96.87 cm and 93.46 cm, respectively). On the other hand, the shortest plant (71.74 cm) was found in F_0V_2 combination compared to the others combination. F_0V_2 was statistically similar with F_0V_1, F_1V_2, F_2V_2, F_3V_2 and F_6V_2 interactions.

Table 1. Combined effect of fertilizer and variety on plant height of rice

Treatments	Plant height (cm)
F_0V_1	75.28 ef
F_1V_1	85.93 cd
F_2V_1	87.58 b-d
F_3V_1	93.46 a-c
F_4V_1	98.20 a
F_5V_1	96.75 ab
F_6V_1	96.87 ab
F_0V_2	71.74 f
F_1V_2	79.56 d-f
F_2V_2	81.33 d-f
F_3V_2	81.50 d-f
F_4V_2	84.28 c-e
F_5V_2	84.46 c-e
F_6V_2	79.94 d-f
CV (%)	**4.03**
SE (±)	**2.814**

F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer, F_3 = Recommended dose of fertilizer, F_4 =25% more than recommended dose of fertilizer, F_5 = 50% more than recommended dose of fertilizer, F_6= 75% higher than recommended dose of chemical fertilizer; V_1 = BRRI dhan28, V_2 = BRRI dhan74

4.3 Panicle length

Effect of fertilizer

The panicle length of rice showed significant difference for different doses of fertilizer application (Figure 3 and Appendix V). The figure revealed that, the values of panicle length increased steadily with the increased fertilizer dose up to F_4 (19.70 cm). The rate of increased in panicle length was more rapid up to F_2 dose after that the increment rate was much slower. The tallest panicle (19.70 cm) was found in F_4 treatment while the shortest panicle (17.59 cm) was recorded in F_0 treatment. The present finding was agreed with the findings of Lemraski *et al*. (2017), Malav and Ramani (2017), Wang *et al*. (2017), Liu *et al*. (2016), Massawe and Mrema (2017) and Ro *et al*. (2016).

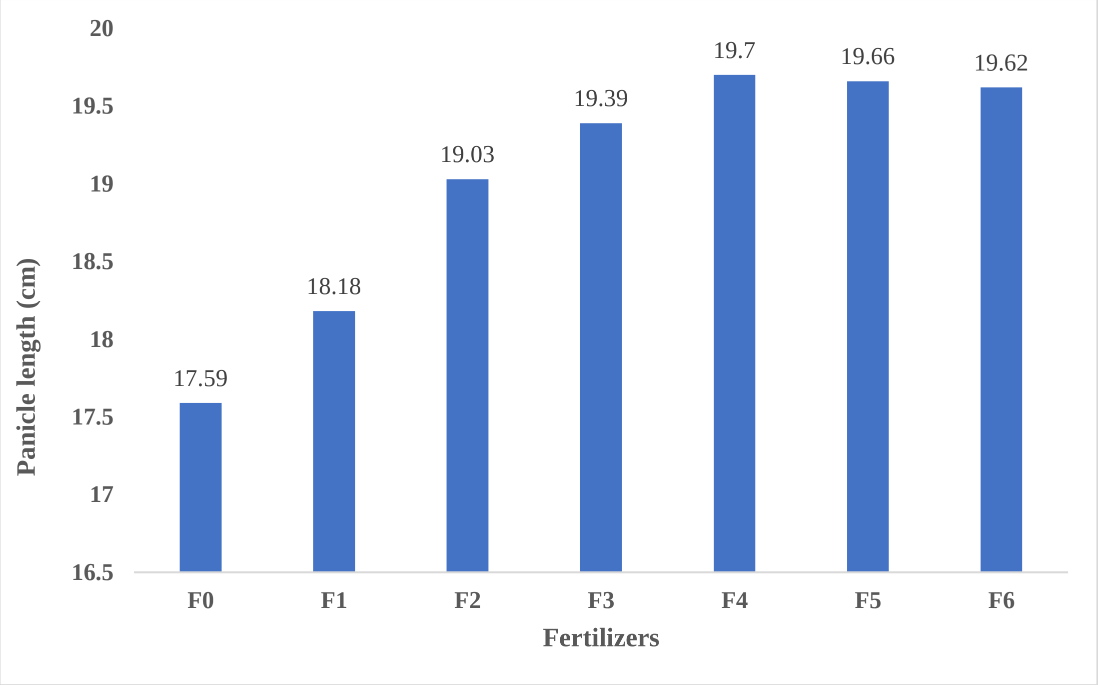

Figure 3. Effect of fertilizer of panicle length of rice (SE= 0.454)

F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer**,** F_3 = Recommended dose of fertilizer**,** F_4 =25% more than recommended dose of fertilizer**,** F_5 = 50% more than recommended dose of fertilizer, F_6= 75% higher than recommended dose of chemical fertilizer

Effect of variety

Impact of variety on rice showed significant effect for panicle length (Figure 3 and Appendix V). The higher value of panicle length (19.41 cm) was found in V_1 variety while lower panicle length (18.64 cm) was recorded in V_2 variety. Murshida *et al*. (2017), Lemraski *et al*. (2017) and Dangi *et al*. (2017) reported the similar findings.

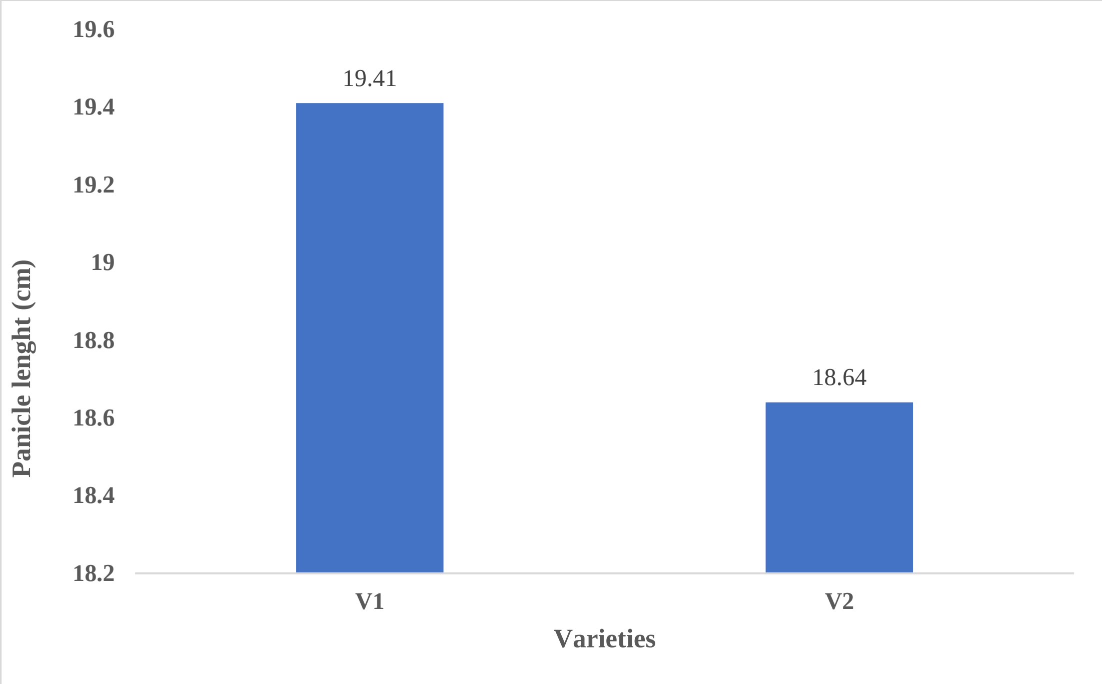

Figure 4. Effect of variety on panicle length of rice (SE=0.232)

V_1 = BRRI dhan28, V_2 = BRRI dhan74

Combined effect of fertilizer and variety

Combined effect of fertilizer and variety showed non-significant impact on panicle length of rice (Table 2 and Appendix V). The combination of F_4V_1 produced the maximum value of panicle length (20.40 cm) which was followed by F_5V_1 (20.36 cm) and F_0V_2 produced minimum value of panicle length (17.45) cm.

Table 2. Combined effect of fertilizer and variety on panicle length of rice

Treatments	Panicle length (cm)
F_0V_1	17.72
F_1V_1	17.91
F_2V_1	19.36
F_3V_1	19.95
F_4V_1	20.40
F_5V_1	20.36
F_6V_1	20.14
F_0V_2	17.45
F_1V_2	18.45
F_2V_2	18.70
F_3V_2	18.84
F_4V_2	19.00
F_5V_2	18.96
F_6V_2	19.10
CV (%)	**3.88**
SE (±)	**NS**

F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer**,** F_3 = Recommended dose of fertilizer**,** F_4 =25% more than recommended dose of fertilizer**,** F_5 = 50% more than recommended dose of fertilizer, F_6= 75% higher than recommended dose of chemical fertilizer; V_1 = BRRI dhan28, V_2 = BRRI dhan74

4.4 Number of effective tillers hill^{-1}

Effect of fertilizer

Due to application of fertilizer, number of effective tillers hill^{-1} exerted significant effect and showed increasing trend with fertilizer doses up to F_5 (Figure 5 and Appendix VI). Numerically, number of effective tillers ranges from 8.50 to 12.13. The highest number of effective tillers hill^{-1} (12.13) was recorded in F_5 treatment and lowest number of effective tillers hill^{-1} (8.50) was recorded in F_0 treatment. This might be due to the proper supply of nutrient from F_5 treatment facilitated proper reproductive growth of plant. The present finding was agreed with the findings of Lemraski *et al*. (2017), Malav and Ramani

(2017), Wang *et al*. (2017), Liu *et al*. (2016), Massawe and Mrema (2017) and Ro *et al*. (2016).

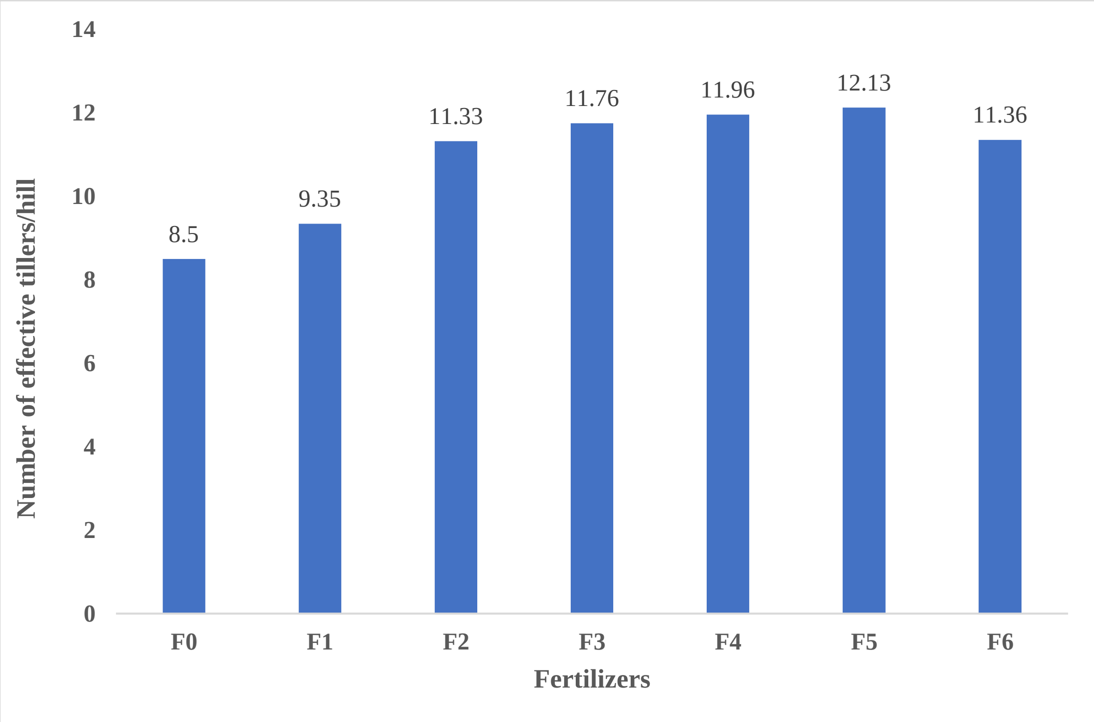

Figure 5. Effect of fertilizer on number of effective tillers hill^{-1} of rice (SE=0.779)

F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer, F_3 = Recommended dose of fertilizer, F_4 =25% more than recommended dose of fertilizer, F_5 = 50% more than recommended dose of fertilizer. F_6= 75% higher than recommended dose of chemical fertilizer

Effect of variety

Number of effective tillers hill^{-1} showed non-significant impact due to different variety of rice (Figure 6 and Appendix VI). Due to influence of variety, the maximum number of effective tillers hill^{-1} (11.11) was recorded in V_2 while the minimum number of effective tillers hill^{-1} (10.72) was in V_1 which was 3.61% higher in V_2 variety. Murshida *et al*. (2017), Lemraski *et al*. (2017) and Dangi *et al*. (2017) reported the similar findings.

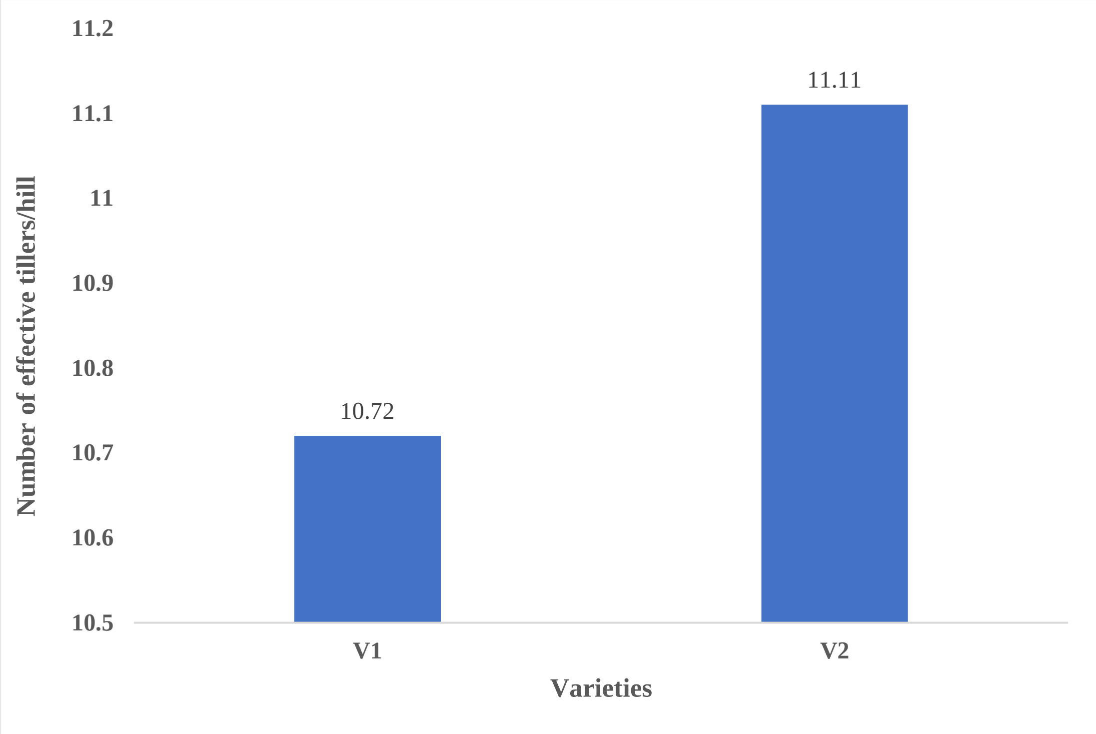

Figure 6. Effect of variety on number of effective tillers hill^{-1} of rice (SE=0.416)

V_1 = BRRI dhan28, V_2 = BRRI dhan74

Combined effect of fertilizer and variety

Combined effect of fertilizer level and variety produced statistically non-significant variations of number of effective tillers hill^{-1} of rice (Table 3 and Appendix VI). The number of effective tillers hill^{-1} ranges from 8.86 to 12.33. Numerically the maximum number of effective tillers hill^{-1} (12.33) was found in F_3V_2 and the minimum number of effective tillers hill^{-1} (8.13) was found in F_0V_2 combination compared to the others combination.

Table 3. Combined effect of fertilizer and variety on number of effective tillers $hill^{-1}$

Treatments	Number of effective tillers $hill^{-1}$
F_0V_1	8.86
F_1V_1	9.17
F_2V_1	10.66
F_3V_1	11.20
F_4V_1	11.73
F_5V_1	12.00
F_6V_1	11.40
F_0V_2	8.13
F_1V_2	9.53
F_2V_2	12.00
F_3V_2	12.33
F_4V_2	12.20
F_5V_2	12.27
F_6V_2	11.33
CV (%)	**12.37**
SE (±)	**NS**

F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer**,** F_3 = Recommended dose of fertilizer**,** F_4 =25% more than recommended dose of fertilizer**,** F_5 = 50% more than recommended dose of fertilizer, F_6= 75% higher than recommended dose of chemical fertilizer; V_1 = BRRI dhan28, V_2 = BRRI dhan74

4.4 Number of filled grains $panlicle^{-1}$

Effect of fertilizer

Number of filled grains $panlicle^{-1}$ exhibited significant difference at different doses of fertilizer application in rice (Figure 7 and Appendix VII). Figure represented that, with the increasing of the fertilizer doses, the number of filled grains $panlicle^{-1}$ showed increasing trend up to the F_4 level of fertilizer dose. After that, the number of filled grains $pnicle^{-1}$ reduced slightly. The maximum number of number of filled grains $panlicle^{-1}$ (89.00) was recorded in F_4 while the minimum number of filled grains $panlicle^{-1}$ (60.28) was recorded in F_0. From the recorded data, finding showed that F_5 and F_6 gave the statistically similar finding.

The maximum number of filled grains panlicle^{-1} in F_4 might be due to adequate nutrient which helped the plant to grow maximum grains panicle^{-1}. The present finding was agreed with the findings of Lemraski *et al*. (2017), Malav and Ramani (2017), Wang *et al*. (2017), Liu *et al*. (2016), Massawe and Mrema (2017) and Ro *et al*. (2016).

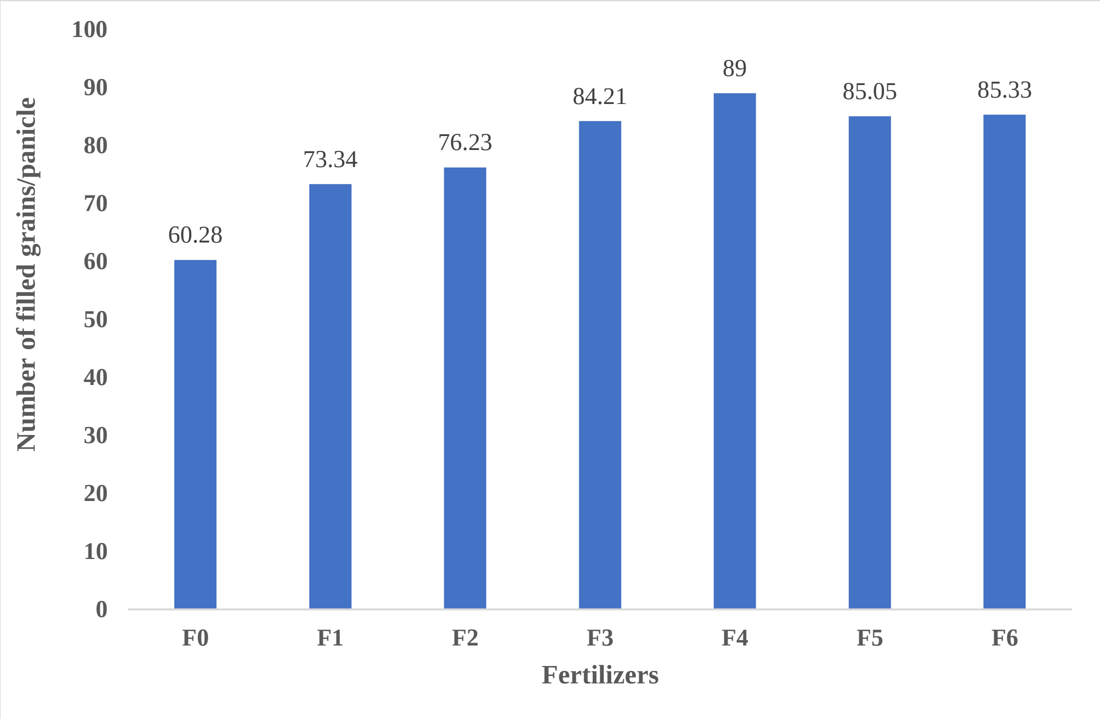

Figure 7. Effect of fertilizer on number of filled grains panicle^{-1} of rice (SE=2.117)

F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer**,** F_3 = Recommended dose of fertilizer**,** F_4 =25% more than recommended dose of fertilizer**,** F_5 = 50% more than recommended dose of fertilizer, F_6= 75% higher than recommended dose of chemical fertilizer

Effect of variety

Impact of variety on rice showed significant effect in terms of number of filled grains panlicle^{-1} (Figure 8 and Appendix VII). The maximum number of filled grains panlicle^{-1} was found in V_1 variety (87.24) while the minimum number of filled grains panlicle^{-1} was recorded in V_2 variety (70.88). It can be inferred from the tabulated data that V_1 variety produced 18.75% higher filled grains than V_2 variety. This might be due to genetic variation among the variety. Murshida *et al*. (2017), Lemraski *et al*. (2017) and Dangi *et al*. (2017) reported the similar findings.

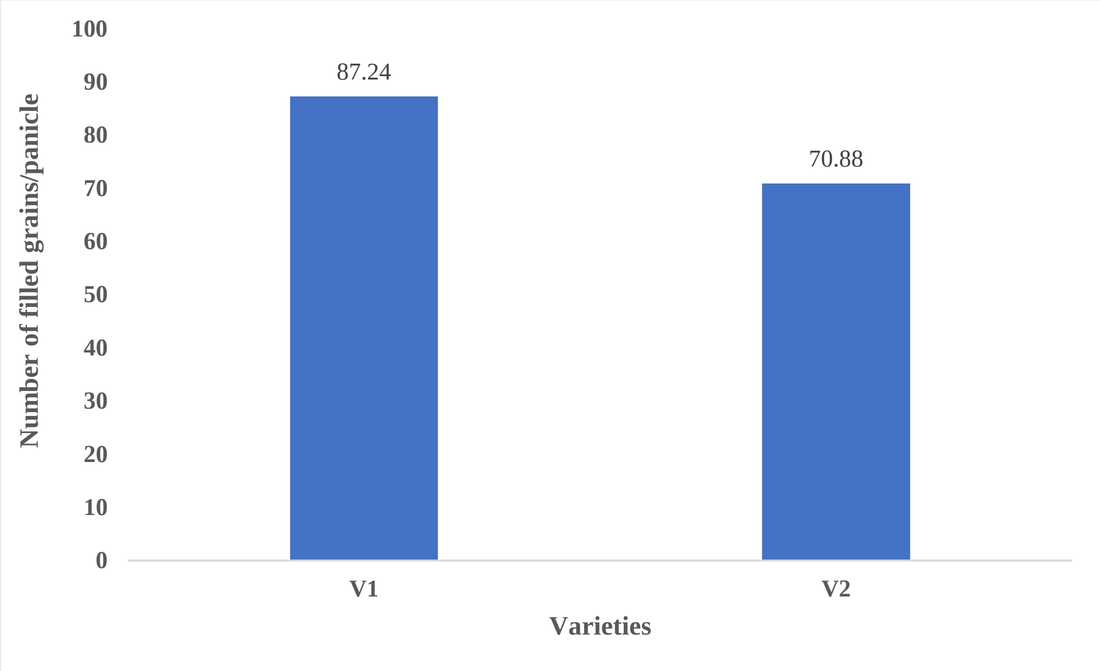

Figure 8. Effect of variety on number of filled grains panicle^{-1} of rice (SE=1.131)

V_1 = BRRI dhan28, V_2 = BRRI dhan74

Combined effect of fertilizer and variety

Combined effect of fertilizer and variety had non-significant effect on number of filled grains panlicle^{-1} of rice (Table 4 and Appendix VII). The number of filled grains panlicle^{-1} ranges from 55.03 to 97.76 while F_4V_1 combination produced the maximum number of filled grains panlicle^{-1} (97.76) and F_0V_0 combination produced the minimum number of filled grains panlicle^{-1} (55.03).

Table 4. Combined effect of fertilizer and variety on number of filled grains panicle^{-1} of rice

Treatments	**Number of filled grain panicle^{-1}**
F_0V_1	65.53
F_1V_1	82.42
F_2V_1	85.94
F_3V_1	90.06
F_4V_1	97.76
F_5V_1	94.00
F_6V_1	95.00
F_0V_2	55.03
F_1V_2	64.26
F_2V_2	66.53
F_3V_2	78.36
F_4V_2	80.23
F_5V_2	76.10
F_6V_2	75.66
CV (%)	**4.64**
SE (±)	**NS**

F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer**,** F_3 = Recommended dose of fertilizer**,** F_4 =25% more than recommended dose of fertilizer**,** F_5 = 50% more than recommended dose of fertilizer, F_6= 75% higher than recommended dose of chemical fertilizer; V_1 = BRRI dhan28, V_2 = BRRI dhan74

4.5 Number of unfilled grains panicle^{-1}

Effect of fertilizer

Number of unfilled grains panlicle^{-1} showed non-significant variations due to application of fertilizer (Figure 9 and Appendix VIII). The figure indicated that there was a decreasing trend of unfilled grains panicle^{-1} with increasing of fertilizer doses. Numerically, the maximum number of unfilled grains panlicle^{-1} was recorded in F_0 fertilizer (16.65) and minimum number of unfilled grains panlicle^{-1} was recorded in F_4 treatment (10.60). This might be due to the proper supply of nutrient from F_4 treatment facilitated to produce maximum number of filled grains panicle^{-1}. The present finding was agreed with the findings of Lemraski *et al*. (2017), Malav and Ramani (2017), Wang *et al*. (2017), Liu *et al*. (2016), Massawe and Mrema (2017) and Ro *et al*. (2016).

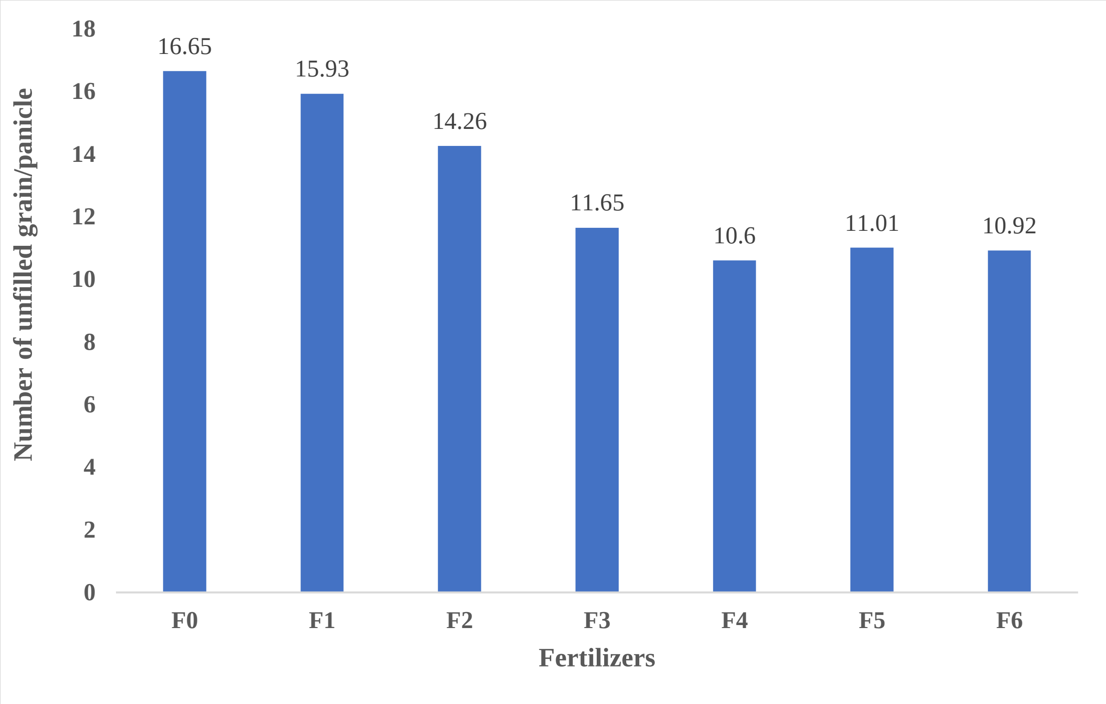

Figure 9. Effect of fertilizer on number of unfilled grains panicle^{-1} of rice (SE= 2.368)

F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer**,** F_3 = Recommended dose of fertilizer**,** F_4 =25% more than recommended dose of fertilizer**,** F_5 = 50% more than recommended dose of fertilizer, F_6= 75% higher than recommended dose of chemical fertilizer

Effect of variety

The number of unfilled grains panlicle^{-1} showed statistically significant impact due to different variety of rice cultivation (Figure 10 and Appendix VIII). Figure indicated that the highest number of unfilled grains panlicle^{-1} was recorded in V_1

variety (14.64) while the lower number of unfilled grains panlicle^{-1} was in V_2 variety (11.36). Murshida *et al*. (2017), Lemraski *et al*. (2017) and Dangi *et al*. (2017) reported the similar findings.

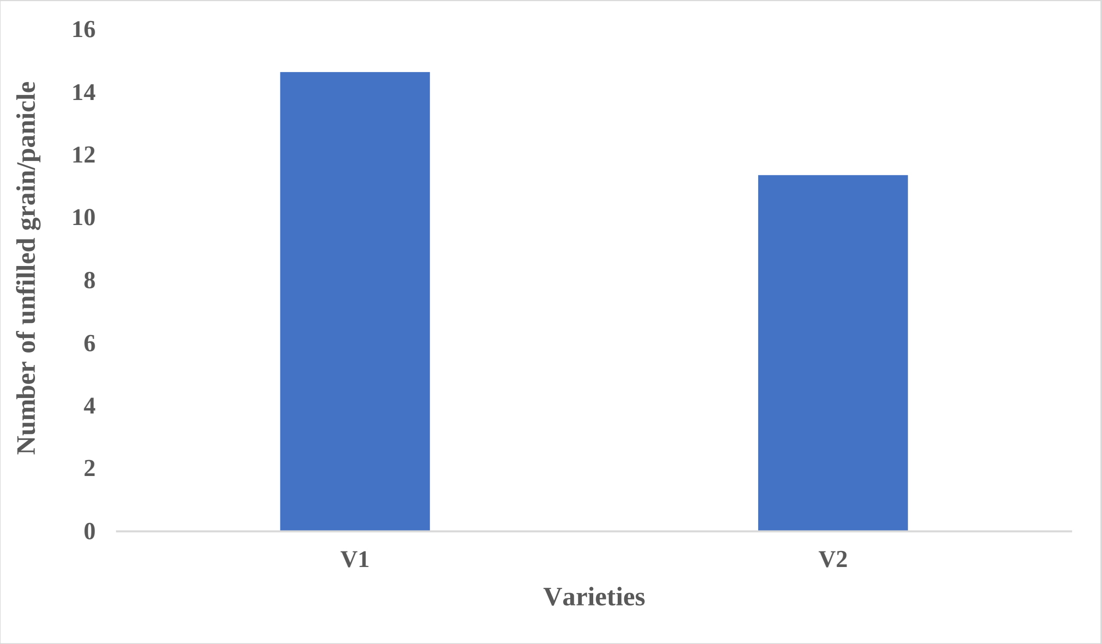

Figure 10. Effect of variety on number of unfilled grains panicle^{-1} of rice (SE=1.266)

V_1 = BRRI dhan28, V_2 = BRRI dhan74

Combined effect of fertilizer and variety

Combined effect of fertilizer and variety produced statistically non-significant effect on number of unfilled grains panlicle^{-1} in rice (Table 5 and Appendix VIII). The number of unfilled grains panlicle^{-1} ranges from 8.53 to 17.90. The maximum number of unfilled grains panlicle^{-1} was found in F_0V_1 (17.90) and minimum number of unfilled grains panlicle^{-1} was found in F_5V_2 combination (8.53) compared to the others combination.

Table 5. Combined effect of fertilizer and variety on number unfilled grains panicle^{-1} of rice

Treatments	Number of unfilled grain
F_0V_1	17.90
F_1V_1	17.16
F_2V_1	16.16
F_3V_1	13.20
F_4V_1	11.50
F_5V_1	13.50
F_6V_1	13.10
F_0V_2	15.40
F_1V_2	14.70
F_2V_2	12.36
F_3V_2	10.10
F_4V_2	9.70
F_5V_2	8.53
F_6V_2	8.75
CV (%)	**31.55**
SE (±)	**NS**

F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer**,** F_3 = Recommended dose of fertilizer**,** F_4 =25% more than recommended dose of fertilizer**,** F_5 = 50% more than recommended dose of fertilizer, F_6= 75% higher than recommended dose of chemical fertilizer; V_1 = BRRI dhan28, V_2 = BRRI dhan74

4.6 Weight of 1000 grains

Effect of fertilizer

The weight of 1000 grains showed non-significant difference at different doses of fertilizer application (Figure 11 and Appendix IX). Figure indicated that due to application of different levels of fertilizer, the maximum value of weight of 1000 grains was recorded in F_4 (29.42 g) while the minimum weight of 1000 grains (27.39 g) was recorded in F_0. It can be inferred from the figure that F_4 treatment produced 7.41% heaver seed than F_0 (control) and that was 4.75% than F_3 treatment. The present finding was agreed with the findings of Lemraski *et al.*

(2017), Malav and Ramani (2017), Wang *et al*. (2017), Liu *et al*. (2016), Massawe and Mrema (2017) and Ro *et al*. (2016).

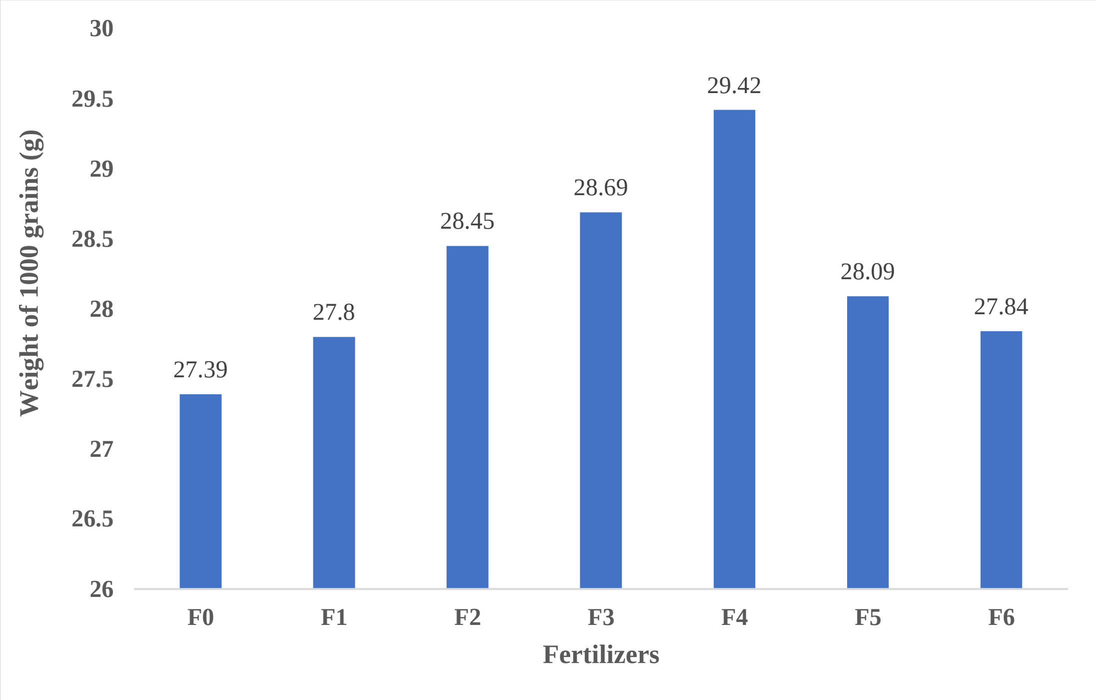

Figure 11. Effect fertilizers on weight of 1000 grains of rice (SE= 0.707)

F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer, F_3 = Recommended dose of fertilizer, F_4 =25% more than recommended dose of fertilizer, F_5 = 50% more than recommended dose of fertilizer

Effect of variety

Variety showed significant variations for weight of 1000 grains in rice (Figure 12 and Appendix IX). The higher value of weight of 1000 grains (32.00 g) was found in V_2 variety and the lower value of weight of 1000 grains (24.48 g) was recorded in V_1 variety. Numerically V_1 variety produced 23.5% lightest seed than V_2. Murshida *et al*. (2017), Lemraski *et al*. (2017) and Dangi *et al*. (2017) reported the similar findings.

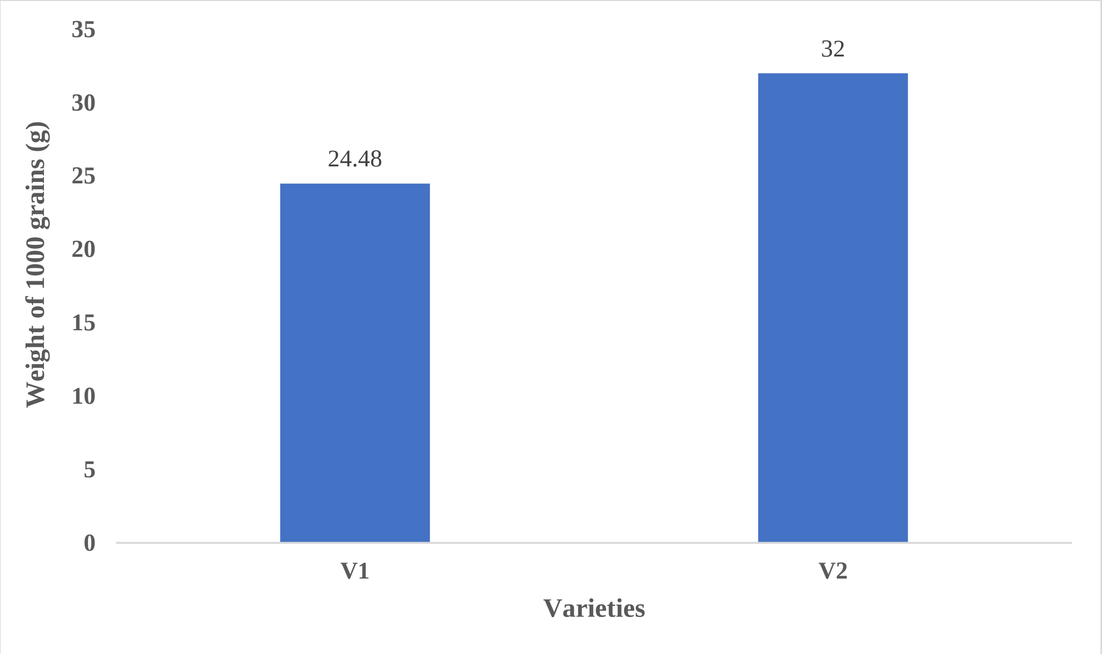

Figure 12. Effect of variety on weight of 1000 grains of rice (SE=0.378)

V_1 = BRRI dhan28, V_2 = BRRI dhan74

Combined effect of fertilizer and variety

Combined effect of fertilizer and variety showed non-significant variations on weight of 1000 grains of rice (Table 6 and Appendix IX). The weight of 1000 grains range from 23.68 g to 32.36 g while F_4V_2 (25% more than recommended dose of fertilizer × BRRI dhan74) combination produced the maximum weight of 1000 grains (32.36 g) and F_0V_1 (Control × BRRI dhan28) combination produced the minimum weight of 1000 grains (23.68 g).

Table 6. Combined effect of fertilizer and variety on weight of 1000 grains of rice

Treatments	Weight of 1000 grains (g)
F_0V_1	23.68
F_1V_1	23.89
F_2V_1	24.67
F_3V_1	25.05
F_4V_1	26.49
F_5V_1	24.07
F_6V_1	23.53
F_0V_2	31.10
F_1V_2	31.72
F_2V_2	32.24
F_3V_2	32.33
F_4V_2	32.36
F_5V_2	32.11
F_6V_2	32.16
CV (%)	**4.34**
SE (±)	**NS**

F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer, F_3 = Recommended dose of fertilizer, F_4 =25% more than recommended dose of fertilizer, F_5 = 50% more than recommended dose of fertilizer, F_6= 75% higher than recommended dose of chemical fertilizer; V_1 = BRRI dhan28, V_2 = BRRI dhan74

4.7 Grain yield

Effect of fertilizer

The grain yield of rice showed significant difference at different doses of fertilizer application (Figure 13 and Appendix X). The figure indicated that, the higher doses of fertilizers (F_4) increased grain yield (6.91 t ha^{-1}) significantly than recommended dose (F_3). On the others hand, lower doses (F_1 and F_2) produced lower grain yield (3.39 and 4.67 t ha^{-1}, respectively) than recommend dose (F_3) in rice. Due to application of different levels of fertilizer, the range of seed yield of rice was found 3.39 to 6.91 t ha^{-1}. The highest grain yield (6.91 t ha^{-1}) was recorded in F_4 (25% more than recommended dose of fertilizer) while grain yield (3.39 t ha^{-1}) was recorded in F_0 (50% less than recommended dose of fertilizer). This might be due to adequate nutrient was in F_4 treatment. The present finding was agreed with the findings of Lemraski *et al*. (2017), Malav and Ramani (2017), Wang *et al*. (2017), Liu *et al*. (2016), Massawe and Mrema (2017) and Ro *et al*. (2016).

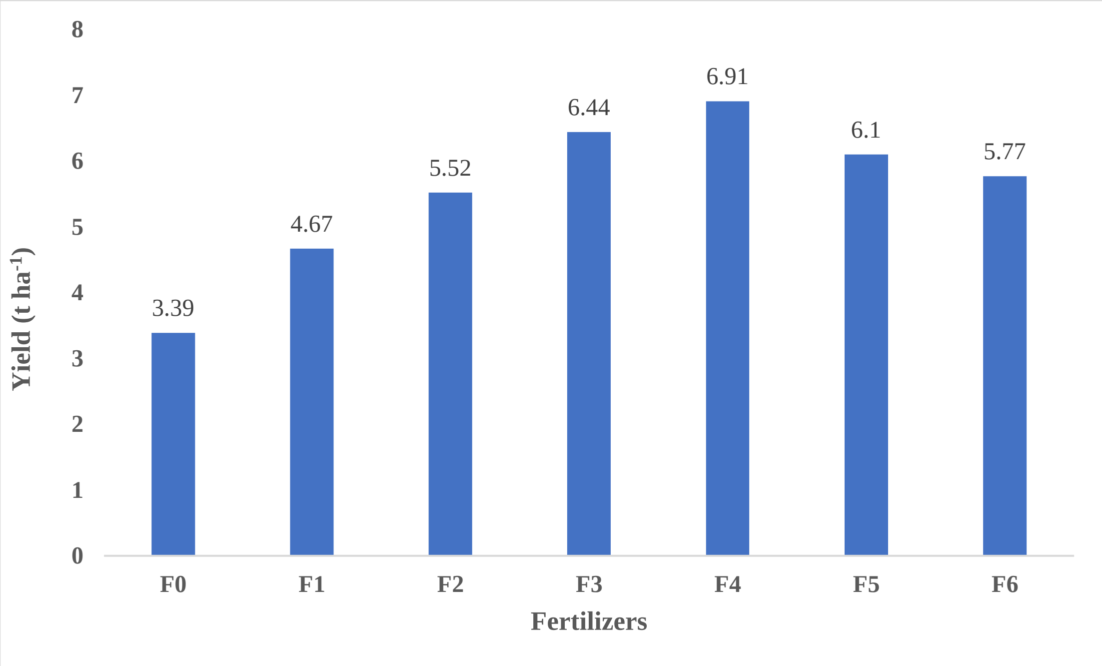

Figure 13. Effect of fertilizers on yield ha^{-1} of rice (SE=0.137)

F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer, F_3 = Recommended dose of fertilizer, F_4 =25% more than recommended dose of fertilizer, F_5 = 50% more than recommended dose of fertilizer, F_6= 75% higher than recommended dose of chemical fertilizer

Effect of variety

Impact of variety on rice showed significant effect for grain yield of rice (Figure 14 and Appendix X). Due to the effect of variety on grain yield of rice, the higher grain yield (5.96 t ha^{-1}) was found in V_1 (BRRI dhan28) while lower grain yield

(5.12 t ha^{-1}) was recorded in V_2 (BRRI dhan74) treatment. Murshida *et al*. (2017), Lemraski *et al*. (2017) and Dangi *et al*. (2017) reported the similar findings.

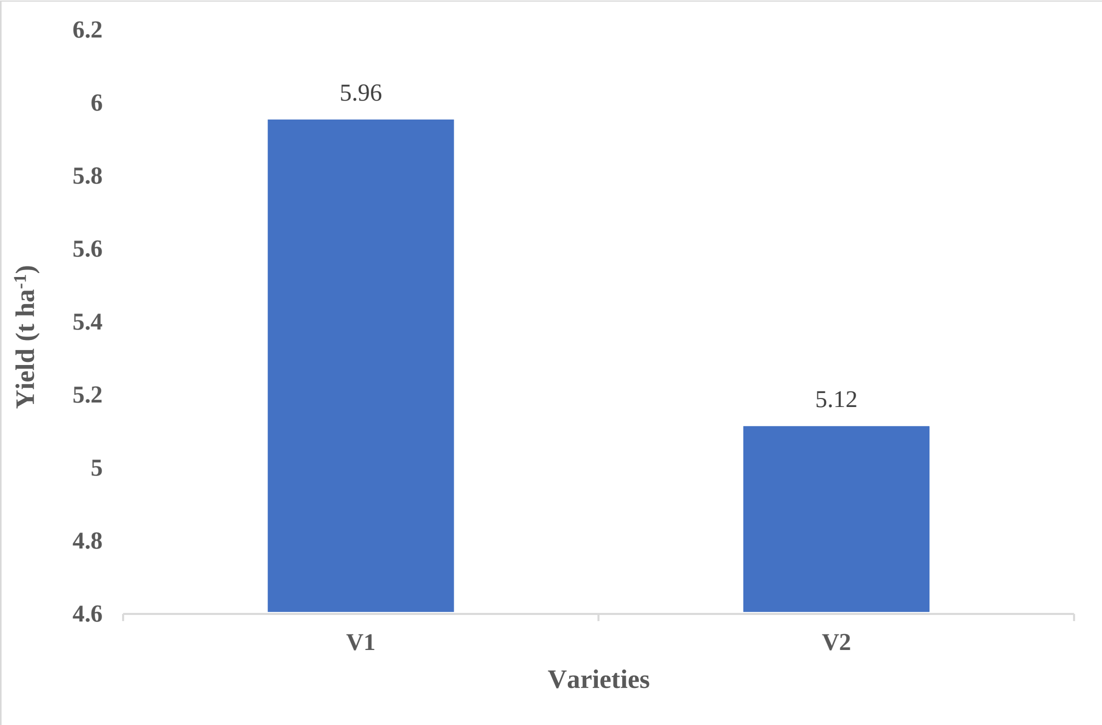

Figure 14. Effect of variety on yield ha^{-1} of rice (SE=0.073)

V_1 = BRRI dhan28, V_2 = BRRI dhan74

Combined effect of fertilizer and variety

Combined effect of fertilizer and variety showed significant impact on seed yield of rice (Table 7 and Appendix X). The seed yield of rice ranges from 3.57 to 7.53 t ha^{-1} while F_4V_1 (25% more than recommended dose of fertilizer × BRRI dhan28) produced the highest seed yield (7.53 t ha^{-1}) and F_0V_2 (Control × BRRI dhan74) produced lowest seed yield (3.21 t ha^{-1}).

Table 7. Combined effect of fertilizer and variety on yield ha^{-1} of rice

Treatments	Yield (t ha^{-1})
F_0V_1	3.57 h
F_1V_1	4.91 fg
F_2V_1	5.80 de
F_3V_1	7.16 ab
F_4V_1	7.53 a
F_5V_1	6.59 bc
F_6V_1	6.18 cd
F_0V_2	3.21 h
F_1V_2	4.43 g
F_2V_2	5.24 ef
F_3V_2	5.73 de
F_4V_2	6.29 cd
F_5V_2	5.62 def
F_6V_2	5.36 ef
CV (%)	**4.26**
SE (±)	**0.194**

F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer**,** F_3 = Recommended dose of fertilizer**,** F_4 =25% more than recommended dose of fertilizer**,** F_5 = 50% more than recommended dose of fertilizer, F_6= 75% higher than recommended dose of chemical fertilizer; V_1 = BRRI dhan28, V_2 = BRRI dhan74

4.8 Straw yield

Effect of fertilizer

Due to application of fertilizer straw yield varied significantly in rice (Figure 15 and Appendix XI). The straw yield increased steadily with the increment of fertilizer dose from the lowest to F_4 dose after that it reduced marginally. The rate of increase was steady from lower to F_4 dose. The straw yield range from 4.31 to 7.36 t ha^{-1} due to different levels of fertilizers. The highest straw yield was recorded in F_4 (25% more than recommended dose of fertilizer) treatment and the lowest straw yield was recorded in F_0 (50% less than recommended dose of fertilizer) treatment. This might be due to the steady supply of nutrient from F_4 treatment facilitated proper growth of plant. The present finding was agreed with the findings of Lemraski *et al*. (2017), Malav and Ramani (2017), Wang *et al*. (2017), Liu *et al*. (2016), Massawe and Mrema (2017) and Ro *et al*. (2016).

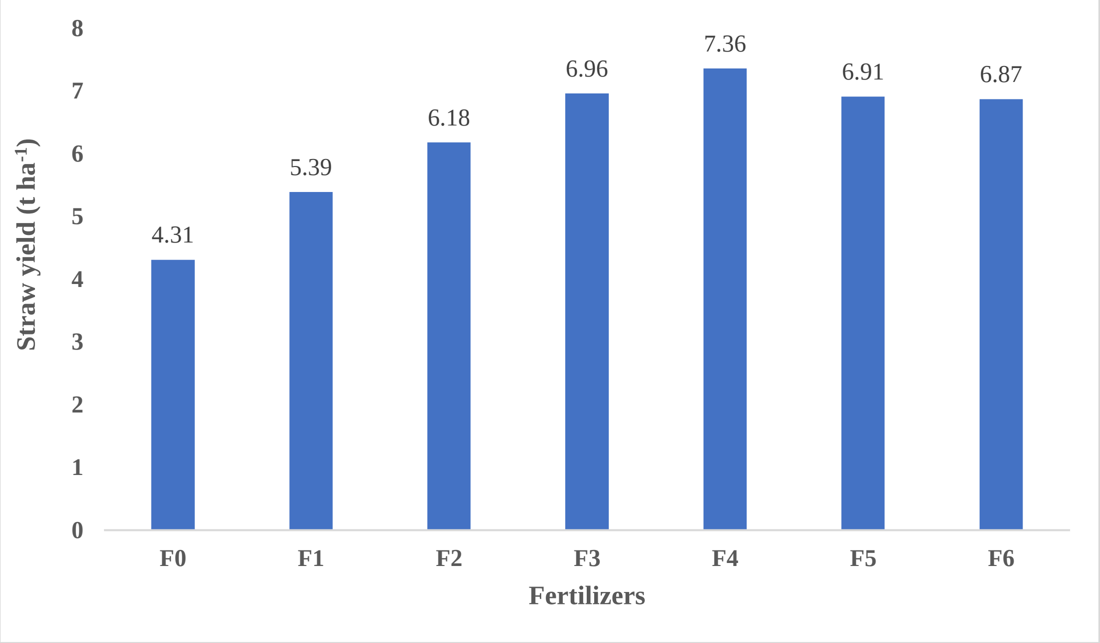

Figure 15. Effect of fertilizers on straw yield ha^{-1} of rice (SE=0.303)

F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer**,** F_3 = Recommended dose of fertilizer**,** F_4 =25% more than recommended dose of fertilizer**,** F_5 = 50% more than recommended dose of fertilizer, F_6= 75% higher than recommended dose of chemical fertilizer

Effect of variety

The straw yield showed statistically non-significant impact due to different variety of rice (Figure 16 and Appendix XI). The higher value of straw yield (6.41 t ha^{-1}) was produced by V_1 variety (BRRI dhan28) while the lower value of straw yield (6.16 t ha^{-1}) was found in V_2 variety (BRRI dhan74). This might be due to genetic variation among the variety. Murshida *et al*. (2017), Lemraski *et al*. (2017) and Dangi *et al*. (2017) reported the similar findings.

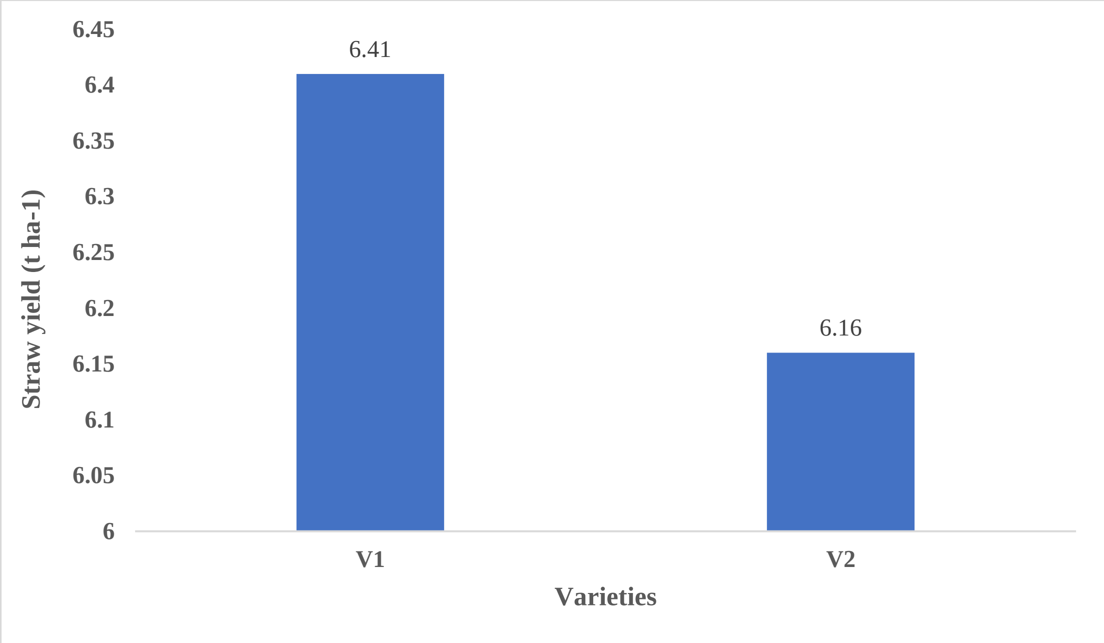

Figure 16. Effect of variety on straw yield of rice (SE=0.162)

V_1 = BRRI dhan28, V_2 = BRRI dhan74

Combined effect of fertilizer and variety

Combined effect of fertilizer and variety produced statistically non-significant variation on straw yield ha^{-1} in rice (Table 8 and Appendix XI). Among the different combinations, the straw yield ranges from 4.19 t ha^{-1} to 7.67 t ha^{-1}. The maximum straw yield (7.67 t ha^{-1}) was found in F_4V_1 combination (25% more than recommended dose of fertilizer × BRRI dhan28) and the minimum (4.19 t ha^{-1}) was found in F_0V_1 combination (Control × BRRI dhan28) compared to the others combination.

Table 8. Combined effect of fertilizer and variety on straw yield ha^{-1} rice

Treatments	Straw yield (t ha^{-1})
F_0V_1	4.19
F_1V_1	5.36
F_2V_1	6.08
F_3V_1	7.00
F_4V_1	7.67
F_5V_1	7.34
F_6V_1	7.21
F_0V_2	4.43
F_1V_2	5.41
F_2V_2	6.29
F_3V_2	6.92
F_4V_2	7.06
F_5V_2	6.47
F_6V_2	6.54
CV (%)	**8.37**
SE (±)	**NS**

F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer**,** F_3 = Recommended dose of fertilizer**,** F_4 =25% more than recommended dose of fertilizer**,** F_5 = 50% more than recommended dose of fertilizer, F_6= 75% higher than recommended dose of chemical fertilizer; V_1 = BRRI dhan28, V_2 = BRRI dhan74

4.9 Germination (%)

Effect of fertilizer

The germination (%) exerted significant effect due to different levels of fertilizers in rice (Figure 17 and Appendix XII). The germination (%) increased sharply with the increases of fertilizers levels up to F^4 level. Although the rate of increase was slower in the lower two doses but highest three doses showed higher increase in germination (%). The highest germination (%) (92.66%) was recorded in F_4 (25% more than recommended dose of fertilizer) treatment and the lowest germination percentage (70.66%) was recorded in F_0 (control) treatment. This might be due to the proper supply of nutrient from F_4 treatment facilitated faster germination in rice plant. The present finding was agreed with the findings of Lemraski *et al*. (2017), Malav and Ramani (2017), Wang *et al*. (2017), Liu *et al*. (2016), Massawe and Mrema (2017) and Ro *et al*. (2016).

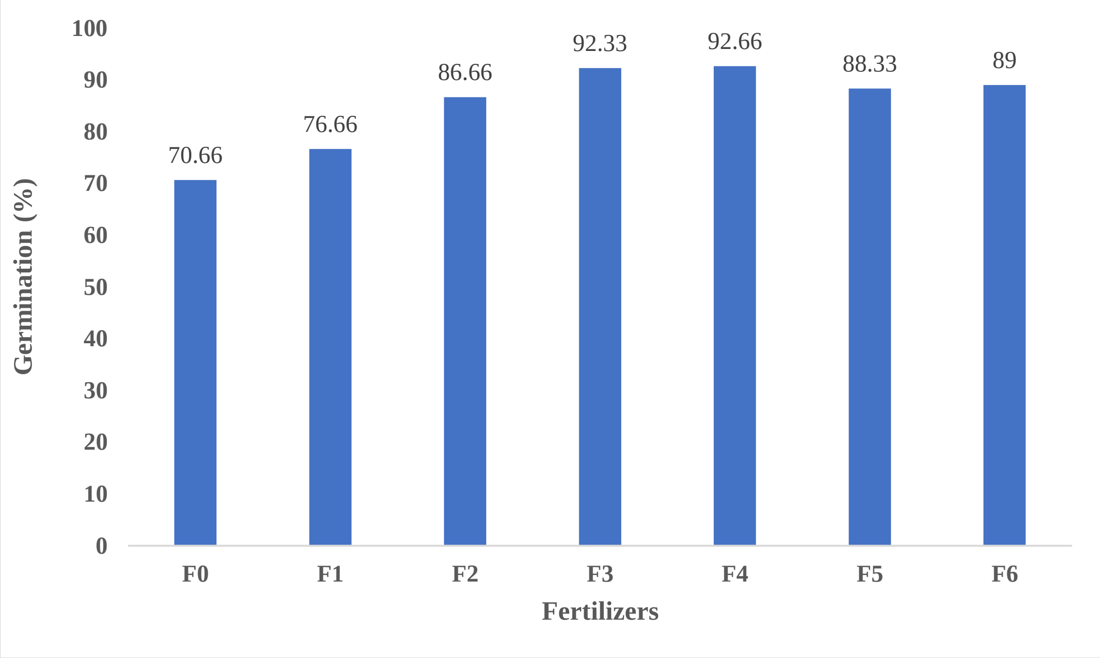

Figure 17. Effect of fertilizers on germination (%) of rice (SE=5.119)

F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer, F_3 = Recommended dose of fertilizer, F_4 =25% more than recommended dose of fertilizer, F_5 = 50% more than recommended dose of fertilizer, F_6= 75% higher than recommended dose of chemical fertilizer

Effect of variety

The germination (%) showed statistically non-significant impact due to different variety of rice cultivation (Figure 18 and Appendix XII). It can be inferred from the figure that the value of germination (%) was higher in V_2 variety (BRRI dhan74) compared to variety V_1 (BRRI dhan28). However, the maximum germination percentage (87.42) was recorded in V_2 variety while the minimum germination percentage (82.95) was in V_1. Murshida *et al*. (2017), Lemraski *et al*. (2017) and Dangi *et al*. (2017) reported the similar findings.

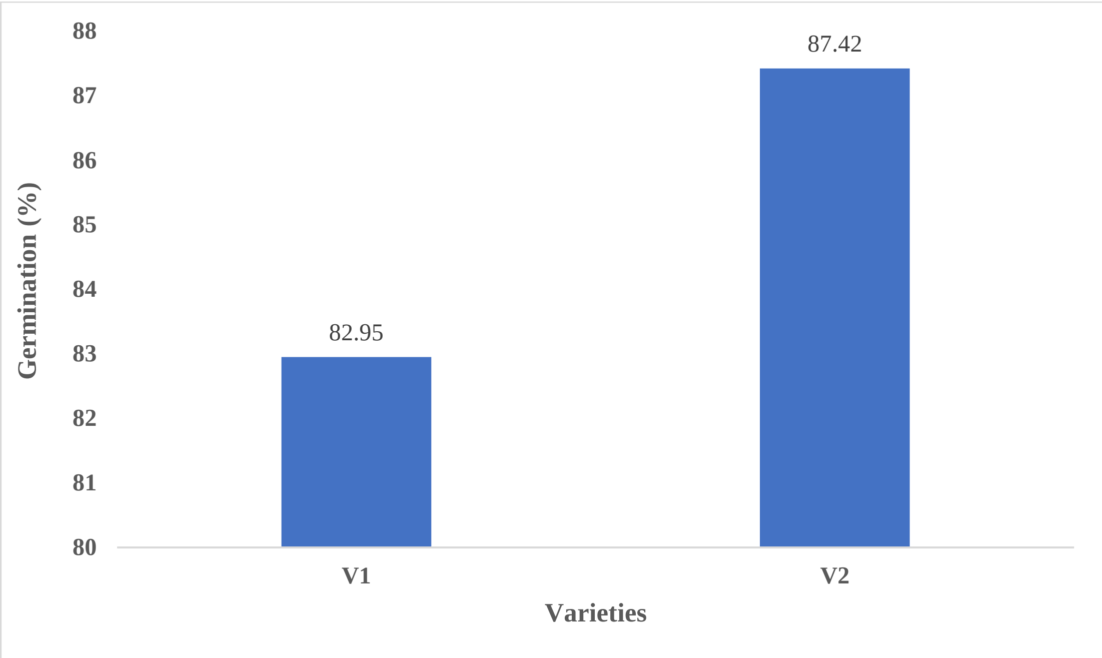

Figure 18. Effect of variety on germination (%) of rice (SE=2.736)

V_1 = BRRI dhan28, V_2 = BRRI dhan74

Combined effect of fertilizer and variety

Combined effect of fertilizer and variety produced statistically non-significant variations in germination (%) of rice (Table 9 and Appendix XII). The germination (%) ranges from 66.66% to 92.66% among the combinations. The maximum germination (%) was found in F_4V_1 (25% more than recommended dose of fertilizer × BRRI dhan28) and the minimum germination (%) was found in F_0V_1 (Control × BRRI dhan28) combination compared to the other combinations.

Table 9. Combined effect of fertilizer and variety on germination (%) of rice

Treatments	Germination (%)
F_0V_1	66.66
F_1V_1	69.33
F_2V_1	84.00
F_3V_1	90.66
F_4V_1	92.66
F_5V_1	90.00
F_6V_1	87.33
F_0V_2	74.66
F_1V_2	84.00
F_2V_2	89.33
F_3V_2	94.00
F_4V_2	92.66
F_5V_2	86.66
F_6V_2	90.66
CV (%)	**10.41**
SE (±)	**NS**

F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer, F_3 = Recommended dose of fertilizer, F_4 =25% more than recommended dose of fertilizer, F_5 = 50% more than recommended dose of fertilizer, F_6= 75% higher than recommended dose of chemical fertilizer; V_1 = BRRI dhan28, V_2 = BRRI dhan74

4.10 Shoot length

Effect of fertilizer

Due to application of fertilizer shoot length showed significant variations of rice (Figure 19 and Appendix XIII). Figure represented that, shoot length showed increasing trend with increasing the fertilizer dose up to F_6. The shoot length ranges from 14.55 cm to 17.80 cm among the fertilizer doses. The highest shoot length (17.80 cm) was recorded in F_6 (75% higher than recommended dose of fertilizer) treatment and the lowest shoot length (14.55 cm) was recorded in F_0 (50% less than recommended dose of fertilizer) treatment. The present finding was agreed with the findings of Lemraski *et al*. (2017), Malav and Ramani (2017), Wang *et al*. (2017), Liu *et al*. (2016), Massawe and Mrema (2017) and Ro *et al*. (2016).

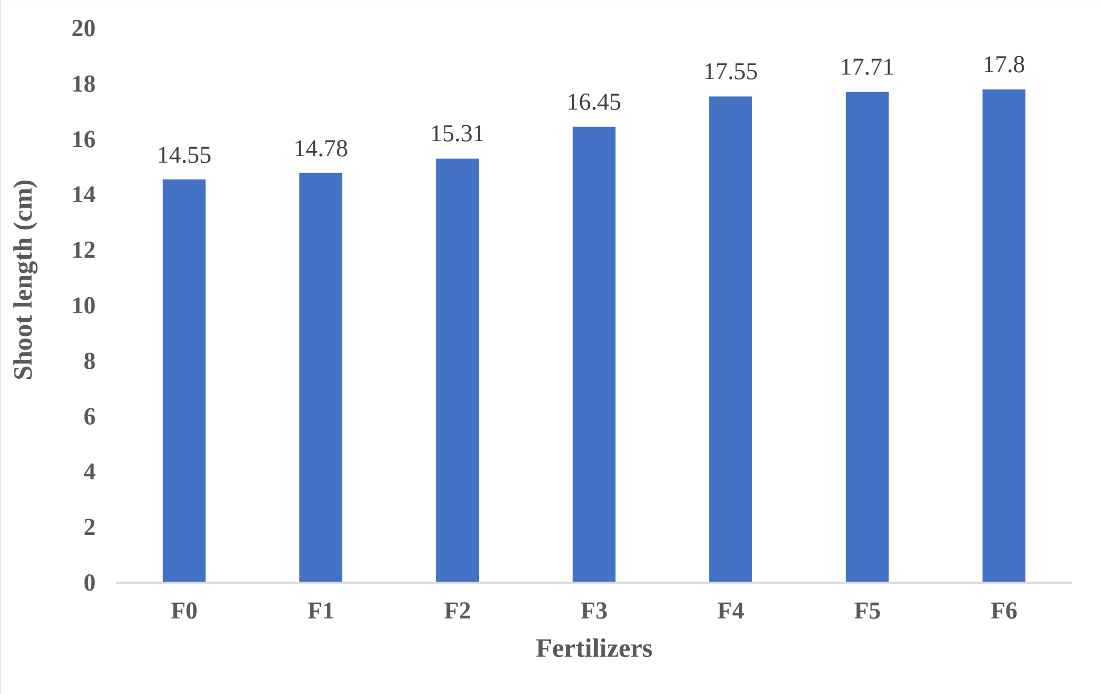

Figure 19. Effect fertilizers on shoot length of rice (SE=0.517)

F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer, F_3 = Recommended dose of fertilizer, F_4 =25% more than recommended dose of fertilizer, F_5 = 50% more than recommended dose of fertilizer, F_6= 75% higher than recommended dose of chemical fertilizer

Effect of variety

The shoot length showed statistically significant impact due to different variety of rice cultivation (Figure 20 and Appendix XIII). The higher shoot length (16.58 cm) was recorded in V_2 variety (BRRI dhan74) while the lower shoot length (16.03 cm) was in V_1 variety (BRRI dhan28). Murshida *et al*. (2017), Lemraski *et al*. (2017) and Dangi *et al*. (2017) reported the similar findings.

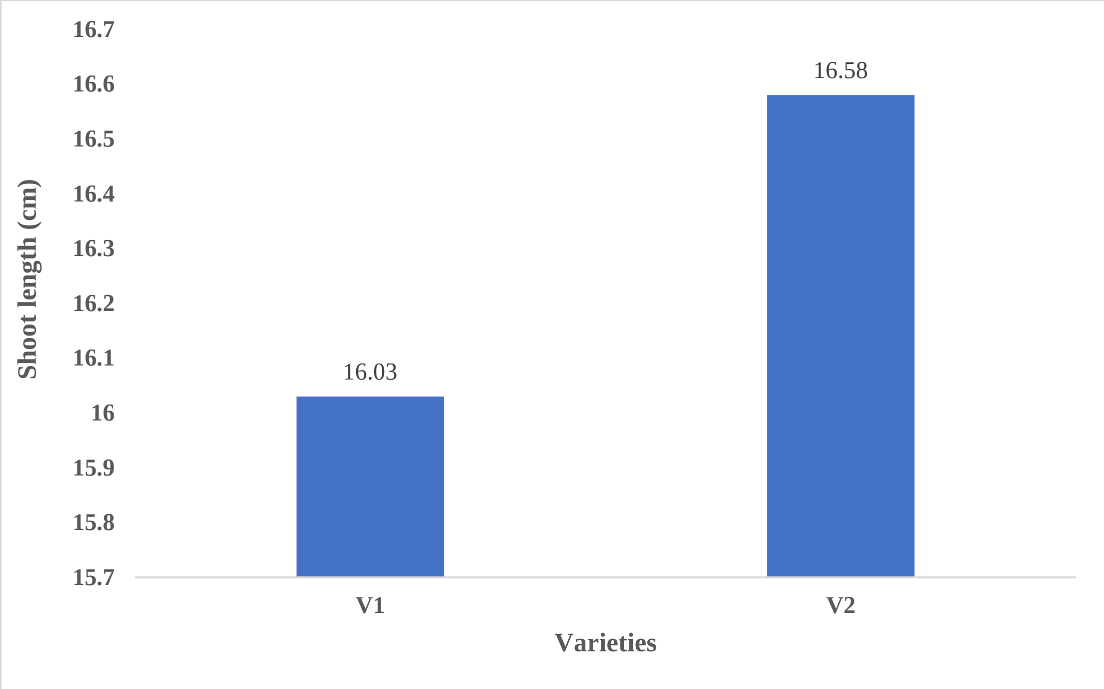

Figure 20. Effect of variety on shoot length of rice (SE=0.276)

V_1 = BRRI dhan28, V_2 = BRRI dhan74

Combined effect of fertilizer and variety

Combined effect of fertilizer and variety produced statistically non-significant shoot length in rice (Table 10 and Appendix XIII). The maximum shoot length (17.89 cm) was found in F_6V_1. The minimum shoot length (14.08 cm) was found in F_0V_1 (Control × BRRI dhan28) combination compared to the other combinations.

Table 10. Combined effect of fertilizer and variety on shoot length of rice

Treatments	Shoot length (cm)
F_0V_1	14.08
F_1V_1	14.38
F_2V_1	14.77
F_3V_1	16.11
F_4V_1	17.38
F_5V_1	17.60
F_6V_1	17.89
F_0V_2	15.02
F_1V_2	15.18
F_2V_2	15.86
F_3V_2	16.79
F_4V_2	17.71
F_5V_2	17.82
F_6V_2	17.71
CV (%)	**5.50**
SE (±)	**NS**

F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer, F_3 = Recommended dose of fertilizer, F_4 =25% more than recommended dose of fertilizer, F_5 = 50% more than recommended dose of fertilizer, F_6= 75% higher than recommended dose of chemical fertilizer; V_1 = BRRI dhan28, V_2 = BRRI dhan74

4.11 Root length

Effect of fertilizer

Due to application of fertilizer root length showed significant variations of rice (Figure 21 and Appendix XIV). Figure represented that, root length showed increasing trend with an increasing the fertilizer dose up to F_5. The highest value of root length (9.03 cm) was recorded in F_5 (50% higher than recommended dose of fertilizer) treatment and the lowest value of root length (7.89 cm) was recorded in F_0 (control) treatment. The present finding was agreed with the findings of Malav and Ramani (2017).

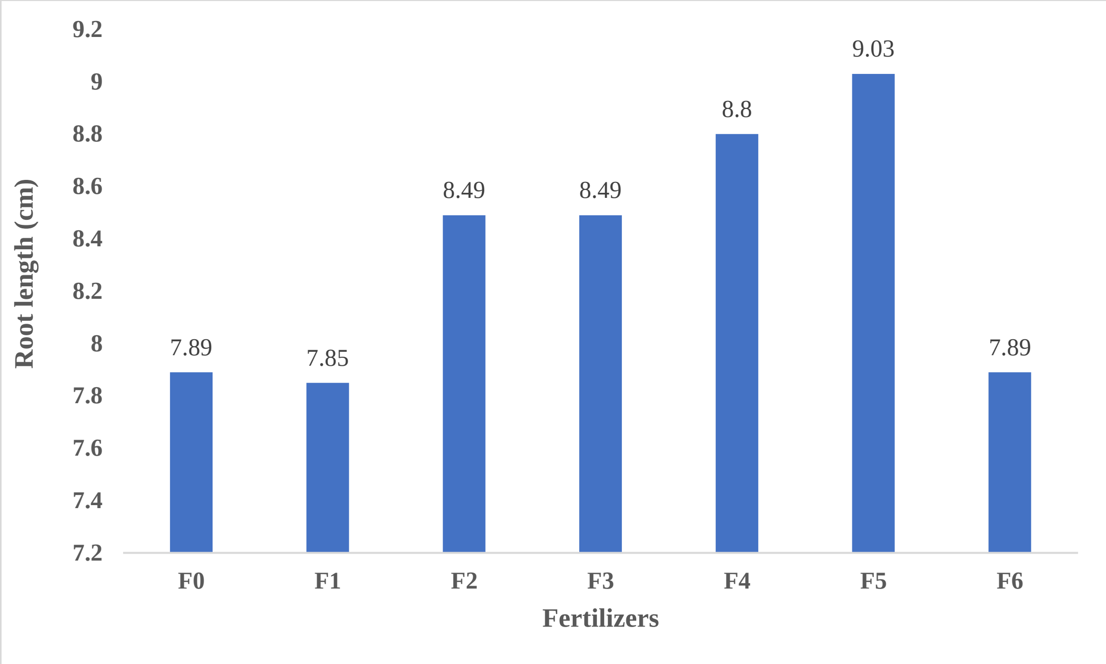

Figure 21. Effect of fertilizers on root length of rice (SE=0.462)

F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer, F_3 = Recommended dose of fertilizer, F_4 =25% more than recommended dose of fertilizer, F_5 = 50% more than recommended dose of fertilizer, F_6= 75% higher than recommended dose of chemical fertilizer

Effect of variety

The root length showed statistically significant impact due to different variety of rice (Figure 22 and Appendix XIV). The higher root length (8.75 cm) was recorded in V_2 variety (BRRI dhan74) while the lower root length (7.95 cm) was in V_1 variety (BRRI dhan28). Murshida *et al*. (2017), Lemraski *et al*. (2017) and Dangi *et al*. (2017) reported the similar findings.

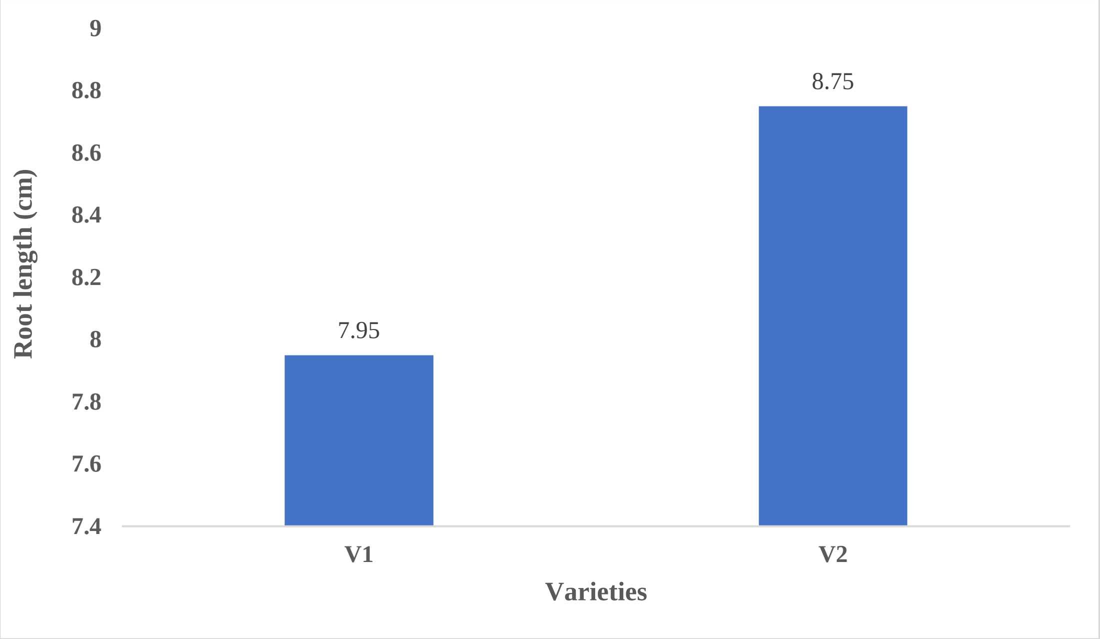

Figure 22. Effect of variety on root length of rice (SE=0.247)

V_1 = BRRI dhan28, V_2 = BRRI dhan74

Combined effect of fertilizer and variety

Combined effect of fertilizer and variety produced statistically non-significant root length in rice (Table 11 and Appendix XIV). The maximum root length (9.52 cm) was found in F_5V_2 while the minimum root length (7.37 cm) was found in F_1V_1 (50% less than recommended dose of fertilizer × BRRI dhan28) combination compared to the others combination.

Table 11. Combined effect of fertilizer and variety on shoot length of rice

Treatments	Root length (cm)
F_0V_1	7.89
F_1V_1	7.37
F_2V_1	7.71
F_3V_1	7.92
F_4V_1	8.33
F_5V_1	8.54
F_6V_1	7.86
F_0V_2	7.88
F_1V_2	8.33
F_2V_2	9.27
F_3V_2	9.06
F_4V_2	9.28
F_5V_2	9.52
F_6V_2	7.92
CV (%)	**9.59**
SE (±)	**NS**

F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer**,** F_3 = Recommended dose of fertilizer**,** F_4 =25% more than recommended dose of fertilizer**,** F_5 = 50% more than recommended dose of fertilizer, F_6= 75% higher than recommended dose of chemical fertilizer; V_1 = BRRI dhan28, V_2 = BRRI dhan74

4.12 Shoot dry weight of seedling

Effect of fertilizer

The shoot dry weight showed non-significant difference at different doses of fertilizer application (Figure 23 and Appendix XV). Figure indicated that due to application of different levels of fertilizer, the highest value of shoot weight was recorded in F_4 (20.86 g) while the lowest shoot weight (15.33 g) was recorded in F_1. The present finding was agreed with the findings of Liu *et al*. (2016) and Ro *et al*. (2016).

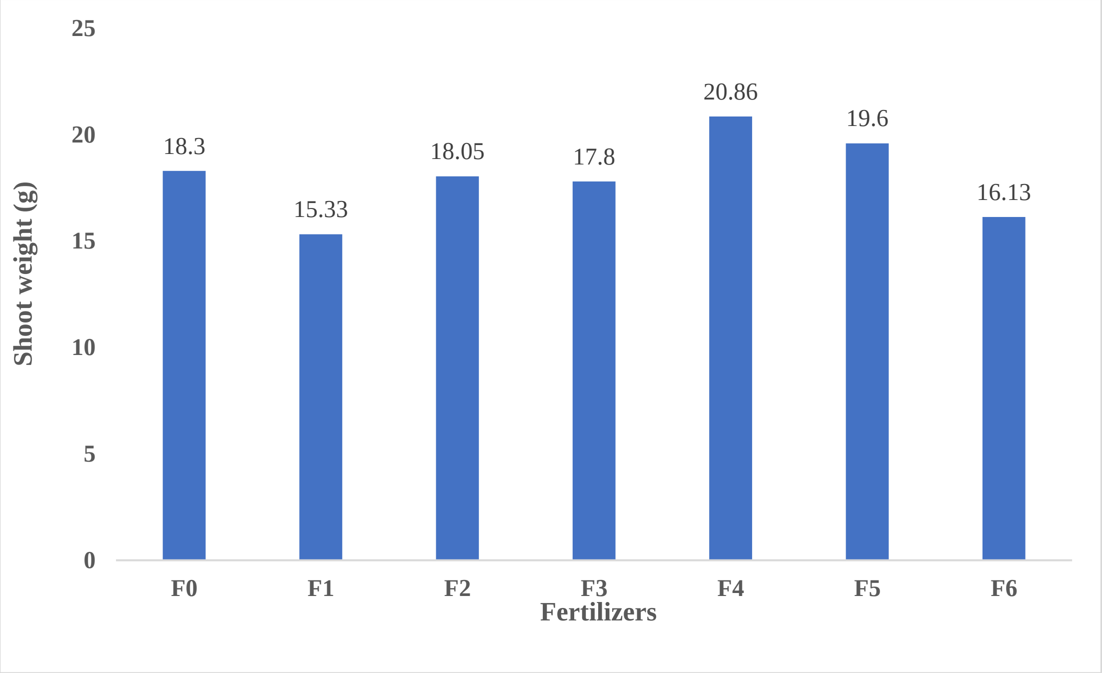

Figure 23. Effect of fertilizers on shoot weight of rice (SE=1.812)

F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer**,** F_3 = Recommended dose of fertilizer**,** F_4 =25% more than recommended dose of fertilizer**,** F_5 = 50% more than recommended dose of fertilizer, F_6= 75% higher than recommended dose of chemical fertilizer

Effect of variety

Varietal difference on rice showed non-significant variations for shoot weight of seedling (Figure 24 and Appendix XV). The maximum value of shoot weight (18.95 g) was found in V_2 variety (BRRI dhan74) and the minimum value of shoot weight (17.06 g) was recorded in V_1 variety (BRRI dhan28). Murshida *et al*. (2017), Lemraski *et al*. (2017) and Dangi *et al*. (2017) reported the similar findings.

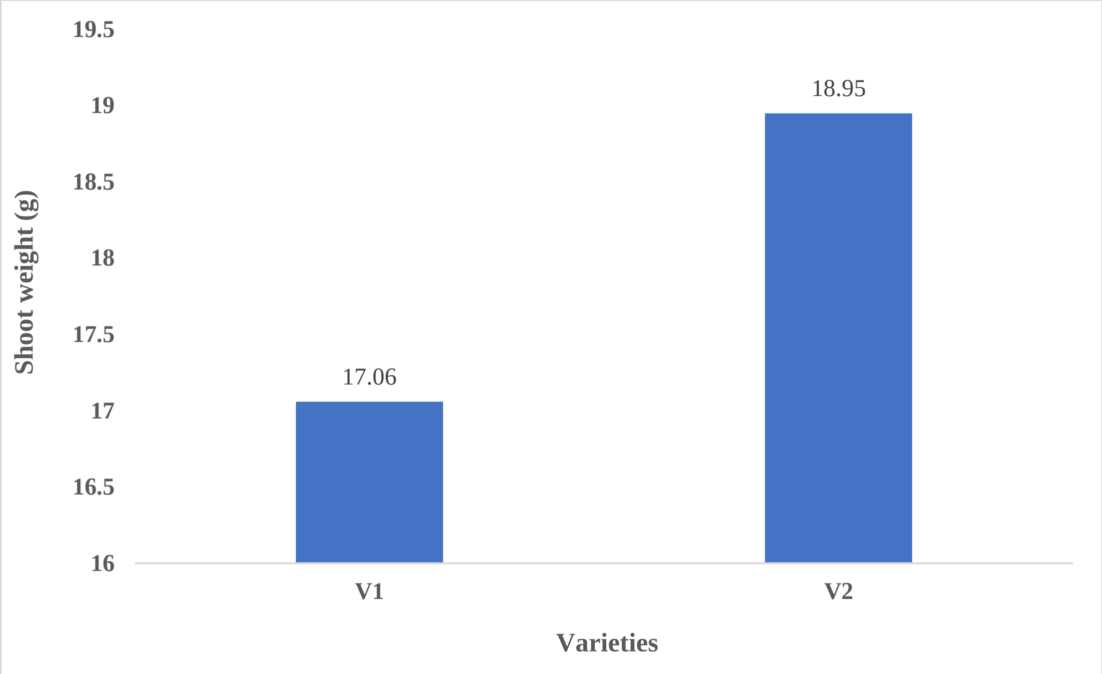

Figure 24. Effect of variety on shoot weight of rice (SE=0.968)

V_1 = BRRI dhan28, V_2 = BRRI dhan74

Combined effect of fertilizer and variety

Combined effect of fertilizer and variety showed non-significant variations on shoot weight of rice (Table 12 and Appendix XV). The shoot weight ranges from 14.93 g to 24.06 g. The combination F_4V_2 (25% more than recommended dose of fertilizer × BRRI dhan74) produced the maximum shoot weight (24.06 g) and F_1V_1 (50% less than recommended dose of fertilizer and × BRRI dhan28) combination produced the lowest shoot weight of seedling (14.93 g).

Table 12. Combined effect of fertilizer and variety on shoot weight of rice

Treatments	Shoot weight (g)
F_0V_1	17.26
F_1V_1	14.93
F_2V_1	18.06
F_3V_1	16.46
F_4V_1	17.66
F_5V_1	18.46
F_6V_1	16.60
F_0V_2	19.33
F_1V_2	15.73
F_2V_2	18.03
F_3V_2	19.13
F_4V_2	24.06
F_5V_2	20.73
F_6V_2	15.66
CV (%)	**17.43**
SE (±)	**NS**

F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer, F_3 = Recommended dose of fertilizer, F_4 =25% more than recommended dose of fertilizer, F_5 = 50% more than recommended dose of fertilizer, F_6= 75% higher than recommended dose of chemical fertilizer; V_1 = BRRI dhan28, V_2 = BRRI dhan74

4.13 Root dry weight of seeding

Effect of fertilizer

The root weight showed non-significant variations for the different doses of fertilizer application (Figure 25 and Appendix XVI). Figure indicated that due to application of different levels of fertilizer, the maximum value of root weight was recorded in F_5 (15.06 g) while the minimum root weight (13.53 g) was recorded in F_0. The present finding was agreed with the findings of Massawe and Mrema (2017) and Ro *et al*. (2016).

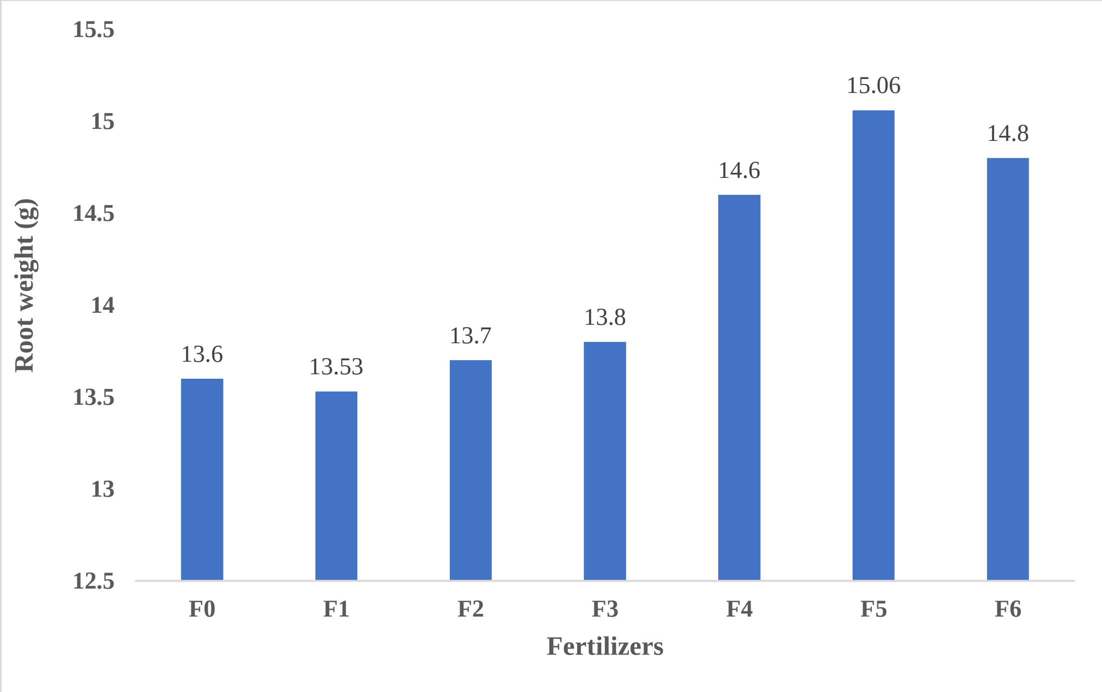

Figure 25. Effect of fertilizers on root weight of rice (SE= 1.218)

F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer, F_3 = Recommended dose of fertilizer, F_4 =25% more than recommended dose of fertilizer, F_5 = 50% more than recommended dose of fertilizer, F_6= 75% higher than recommended dose of chemical fertilizer

Effect of variety

Varietal difference showed significant variations on root dry weight of rice seedling (Figure 26 and Appendix XVI). The higher value of root weight of seedling (16.56 g) was found in V_2 variety (BRRI dhan74) and the lower value of root weight (11.75 g) was recorded in V_1 variety (BRRI dhan28). This might be due to genetic variation among the varieties. Murshida *et al*. (2017), Lemraski *et al*. (2017) and Dangi *et al*. (2017) reported the similar findings.

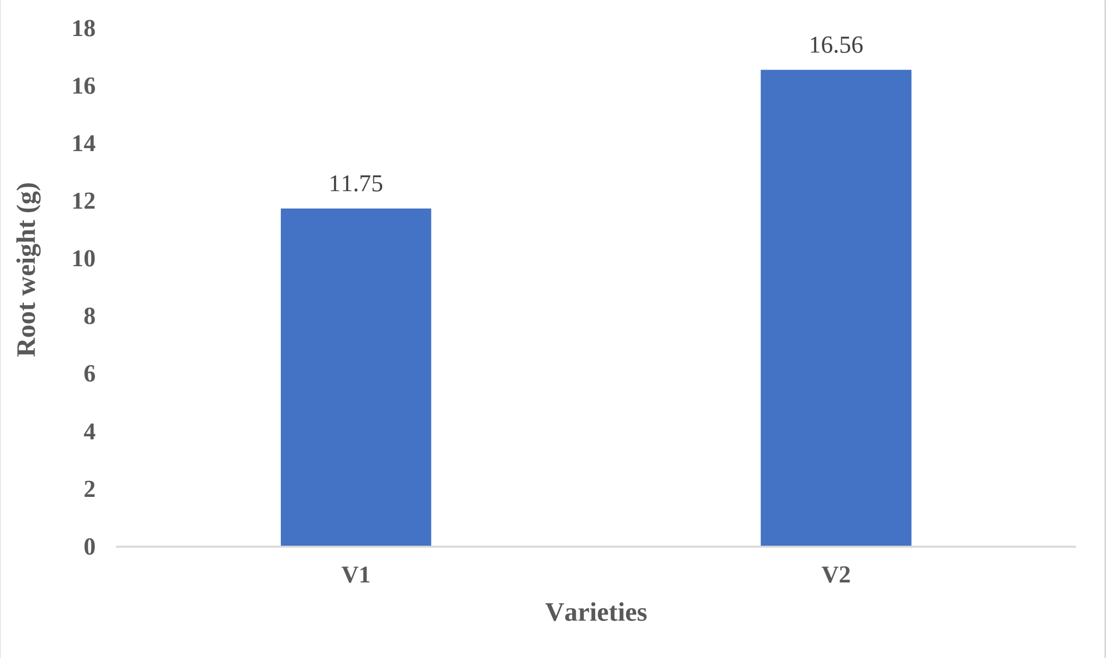

Figure 26. Effect of variety on root weight of rice (SE=0.651)

V_1 = BRRI dhan28, V_2 = BRRI dhan74

Combined effect of fertilizer and variety

Combined effect of fertilizer and variety showed non-significant variations on root weight of rice seedling (Table 13 and Appendix XVI). The combination F_4V_2 (25% more than recommended dose of fertilizer × BRRI dhan74) produced the highest root weight of seedling (17.86 g) and F_2V_1 (25% less than recommended dose of fertilizer and × BRRI dhan28) combination produced the lowest root weight (9.93 g).

Table 13. Combined effect of fertilizer and variety on root weight of rice

Treatments	Root weight (g)
F_0V_1	11.46
F_1V_1	10.33
F_2V_1	9.93
F_3V_1	10.86
F_4V_1	11.33
F_5V_1	13.93
F_6V_1	14.40
F_0V_2	15.73
F_1V_2	16.73
F_2V_2	17.46
F_3V_2	16.73
F_4V_2	17.86
F_5V_2	16.20
F_6V_2	15.20
CV (%)	**14.90**
SE (±)	**NS**

F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer, F_3 = Recommended dose of fertilizer, F_4 =25% more than recommended dose of fertilizer, F_5 = 50% more than recommended dose of fertilizer, F_6= 75% higher than recommended dose of chemical fertilizer; V_1 = BRRI dhan28, V_2 = BRRI dhan74

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Research Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh study the influence of nitrogen and phosphorus levels on yield and seed quality of rice. The experiment comprised as two factors, Factor A: Different fertilizer doses i.e. F_0= No fertilizer, F_1 = 50% less than recommended dose of fertilizer, F_2 = 25% less than recommended dose of fertilizer**,** F_3 = Recommended dose of fertilizer**,** F_4 =25% more than recommended dose of fertilizer**,** F_5 = 50% more than recommended dose of fertilizer; F_6= 75% higher than recommended dose of fertilizer; and two varieties i.e. V_1 = BRRI dhan28, V_2 = BRRI dhan74. The experiment was laid out in Split-plot design with three replications. Data on different growth parameters, yield attributes and yield were recorded and analyzed.

Plant height increased gradually with the increased of fertilizer doses up to F_4 (91.24 cm) after that the height reduce slightly with further increase of fertilizer dose (F_5 and F_6). The tallest plant (91.24 cm) was recorded in F_4 treatment while the shortest plant (73.51 cm) was recorded in F_0 treatment. The tallest plant (90.58 cm) was recorded in V_1 variety while shortest plant (80.40 cm) was found in V_2 variety. The tallest plant (98.20 cm) was found in V_1F_4 and shortest plant (71.74 cm) was found in F_0V_2 combination compared to the others combination.

The values of panicle length increased steadily with the increased fertilizer dose up to F_4 (19.70 cm). The rate of increased in panicle length was more rapid up to F_2 dose after that the increment rate was much slower. The tallest panicle (19.70 cm) was found in F_4 treatment while the shortest panicle (17.59 cm) was recorded in F_0 treatment. The highest value of panicle length (19.41 cm) was found in V_1 variety while lowest panicle length (18.64 cm) was recorded in V_2 variety. The combination F_4V_1 produced the highest value of panicle length (20.40 cm) and F_0V_2 produced lowest value of panicle length (17.45) cm.

Numerically, number of effective tillers ranges from 8.50 to 12.13. The maximum number of effective tillers hill^{-1} (12.13) was recorded in F_5 treatment and minimum number of effective tillers hill^{-1} (8.50) was recorded in F_0 treatment. Due to influence of variety the maximum number of effective tillers hill^{-1} (11.11) was recorded in V_2 while the minimum number of effective tillers hill^{-1} (10.72) was in V_1. For combine effect the number of effective tillers hill^{-1} ranges from 8.86 to 12.33. The maximum number of effective tillers hill^{-1} (12.33) was found in F_3V_2 and the minimum number of effective tillers hill^{-1} (8.86) was found in F_0S_2 combination compared to the others combination.

With the increasing of the fertilizer doses, the number of filled grains panlicle^{-1} showed increasing trend up to the highest level of fertilizer dose (F_4). The maximum number of number of filled grains panlicle^{-1} (89.00) was recorded in F_4 while the minimum number of filled grains panlicle^{-1} (60.28) was recorded in F_0. From the recorded data, finding showed that F_5 and F_6 gave the statistically similar finding. The maximum number of filled grains panlicle^{-1} in F_5 might be due to adequate nutrient was in F_5 treatment. The maximum number of filled grains panlicle^{-1} was found in V_1 variety (87.24) while the minimum number of filled grains panlicle^{-1} was recorded in V_2 variety (710.88). The number of filled grains panlicle^{-1} ranges from 55.03 to 97.76 while F_4V_1 combination produced the maximum number of filled grains panlicle^{-1} (97.76) and F_0V_0 combination produced the minimum number of filled grains panlicle^{-1} (55.03).

Numerically, the maximum number of unfilled grains panicle^{-1} was recorded in F_0 fertilizer (16.65) and minimum number of unfilled grains panicle^{-1} was recorded in F_4 treatment (11.69). This might be due to the proper supply of nutrient from F_4 treatment facilitated to produce maximum number of filled grains panicle^{-1}. The maximum number of unfilled grains panicle^{-1} was recorded in V_1 variety (14.64) while the minimum number of unfilled grains panicle^{-1} was in V_2 variety (11.36). For combine effect number of unfilled grains panicle^{-1} ranges from 8.53 to 17.90. The maximum number of unfilled grains panicle^{-1} was found in F_0V_1 (13.32) and minimum number of unfilled grains panicle^{-1} was found in F_5V_2 combination (8.53) compared to the others combination.

Due to application of different levels of fertilizer, the highest value of weight of 1000 grains was recorded in F_4 (29.42 g) while the lowest weight of 1000 grains (27.39 g) was recorded in F_1. The highest value of weight of 1000 grains (32.00 g) was found in V_2 variety and the lowest value of weight of 1000 grains (24.48 g) was recorded in V_1 variety. The weight of 1000 grains range from 23.68 g to 32.36 g while F_4V_2 (25% more than recommended dose of fertilizer × BRRI dhan74) combination produced the highest weight of 1000 grains (32.36 g) and F_0V_1 (Control × BRRI dhan28) combination produced the lowest weight of 1000 grains (23.68 g).

The higher doses of fertilizers (F_4) increased grain yield significantly than recommended dose (F_3). On the others hand, lower doses (F_1 and F_2) produced lower grain yield than recommend dose (F_3) in rice. Due to application of different levels of fertilizer, the range of seed yield of rice was found 3.39 to 6.91 t ha^{-1}. The highest grain yield (6.91 t ha^{-1}) was recorded in F_4 (25% more than recommended dose of fertilizer) while grain yield (3.39 t ha^{-1}) was recorded in F_0 (50% less than recommended dose of fertilizer). Due to the effect of variety on grain yield of rice, the highest grain yield (5.96 t ha^{-1}) was found in V_1 (BRRI dhan28) while lowest grain yield (5.12 t ha^{-1}) was recorded in V_2 (BRRI dhan74) treatment. The seed yield of rice ranges from 3.57 to 7.53 t ha^{-1} while F_4V_1 (25% more than recommended dose of fertilizer × BRRI dhan28) produced the highest seed yield (7.53 t ha^{-1}) and F_0V_2 (Control × BRRI dhan74) produced lowest seed yield (3.21 t ha^{-1}).

The straw yield ha^{-1} increased steadily with the increment of fertilizer dose from the lowest to highest doses, but rate of increase was slower in the lower two doses after that the rate of increase was steady. The straw yield ha^{-1} range from 4.31 to 7.36 t ha^{-1} due to different levels of fertilizers. The highest straw yield ha^{-1} was recorded in F_4 (25% more than recommended dose of fertilizer) treatment and the lowest straw yield ha^{-1} was recorded in F_0 (50% less than recommended dose of fertilizer) treatment. The highest value of straw yield ha^{-1} (6.41 t ha^{-1}) was produced by V_1 variety (BRRI dhan28) while the lowest value of straw yield ha^{-1} (6.16 t ha^{-1}) was found in V_2 variety (BRRI dhan74). Among the different combinations the straw yield ha^{-1} ranges from 4.19 t ha^{-1} to 7.67 t ha^{-1}. The highest straw yield ha^{-1} (7.67 t ha^{-1}) was found in F_4V_1 combination (25% more than recommended dose of fertilizer × BRRI dhan28) and the lowest 7.67 t ha^{-1} (4.19 t ha^{-1}) was found in F_0V_1 combination (Control × BRRI dhan74) compared to the others combination.

The highest germination (%) (92.66%) was recorded in F_4 (25% more than recommended dose of fertilizer) treatment and the lowest germination percentage (70.66%) was recorded in F_1 (50% less than recommended dose of fertilizer) treatment. The value of germination (%) increased sharply in V_2 variety (BRRI dhan74) compared to variety V_1 (BRRI dhan28). However, the highest germination percentage (87.42%) was recorded in V_2 variety while the lowest germination percentage (82.95%) was in V_1. The germination (%) ranges from 66.66% to 92.66% among the combinations. The highest germination (%) was found in F_4V_1 (25% more than recommended dose of fertilizer × BRRI dhan28) and the lowest germination (%) was found in F_0V_1 (Control × BRRI dhan28) combination compared to the others combination.

The shoot length showed increasing trend with an increasing the fertilizer dose up to F_6. The shoot length ranges from 14.55 cm to 17.80 cm among the fertilizer doses. The highest shoot length (17.80 cm) was recorded in F_6 (75% higher than recommended dose of fertilizer) treatment and the lowest shoot length (14.44 cm) was recorded in F_0 (50% less than recommended dose of fertilizer) treatment. The highest shoot length (16.58 cm) was recorded in V_2 variety (BRRI dhan74) while the lowest shoot length (16.03 cm) was in V_1 variety (BRRI dhan28). The highest shoot length (17.89 cm) was found in F_6V_1. The lowest shoot length (14.08 cm) was found in F_0V_1 (Control × BRRI dhan28) combination compared to the others combination.

The root length showed increasing trend with an increasing the fertilizer dose up to F_5. The highest value of root length (9.03 cm) was recorded in F_5 (50% higher than recommended dose of fertilizer) treatment and the lowest value of root length (7.89 cm) was recorded in F_0 (control) treatment. The highest root length (8.75 cm) was recorded in V_2 variety (BRRI dhan74) while the lowest root length (7.95 cm) was in V_1 variety (BRRI dhan28). The highest root length (9.52 cm) was found in F_5V_2 while the lowest root length (7.37 cm) was found in F_1V_1 (50% less than recommended dose of fertilizer × BRRI dhan28) combination compared to the others combination.

Due to application of different levels of fertilizer, the highest value of shoot weight was recorded in F_4 (20.86 g) while the lowest shoot weight (15.33 g) was recorded in F_1. The highest value of shoot weight (18.95 g) was found in V_2 variety (BRRI dhan74) and the lowest value of shoot weight (17.06 g) was recorded in V_1 variety (BRRI dhan28). The shoot weight ranges from 14.93 g to 24.09 g. The combination F_4V_2 (25% more than recommended dose of fertilizer × BRRI dhan74) produced the highest shoot weight (24.06 g) and F_1V_1 (50% less than recommended dose of fertilizer and × BRRI dhan28) combination produced the lowest shoot weight of seedling (14.93 g).

Due to the application of different levels of fertilizer, the highest value of root weight was recorded in F_5 (15.06 g) while the lowest root weight (13.60 g) was recorded in F_0. The highest value of root weight of seedling (16.56 g) was found in V_2 variety (BRRI dhan74) and the lowest value of root weight (11.75 g) was recorded in V_1 variety (BRRI dhan28). The combination F_4V_2 (25% more than recommended dose of fertilizer × BRRI dhan74) produced the highest root weight of seedling (17.86 g) and F_2V_1 (25% less than recommended dose of fertilizer and × BRRI dhan28) combination produced the lowest root weight (9.93 g).

From the above result it can be concluded that, in terms of vegetative growth and reproductive unit, 25% more than recommended dose of fertilizer × BRRI dhan74 gave the best result.

By considering the results of the present experiment, further studies in the following areas are suggested below

I. Studies of similar nature could be carried out in different agro-ecological zones (AEZ) in different seasons of Bangladesh for the evaluation of zonal adaptability.
II. In this study, few levels of fertilizer and only two varieties were used, it is recommended to increase the fertilizer levels and variety to get accurate result.

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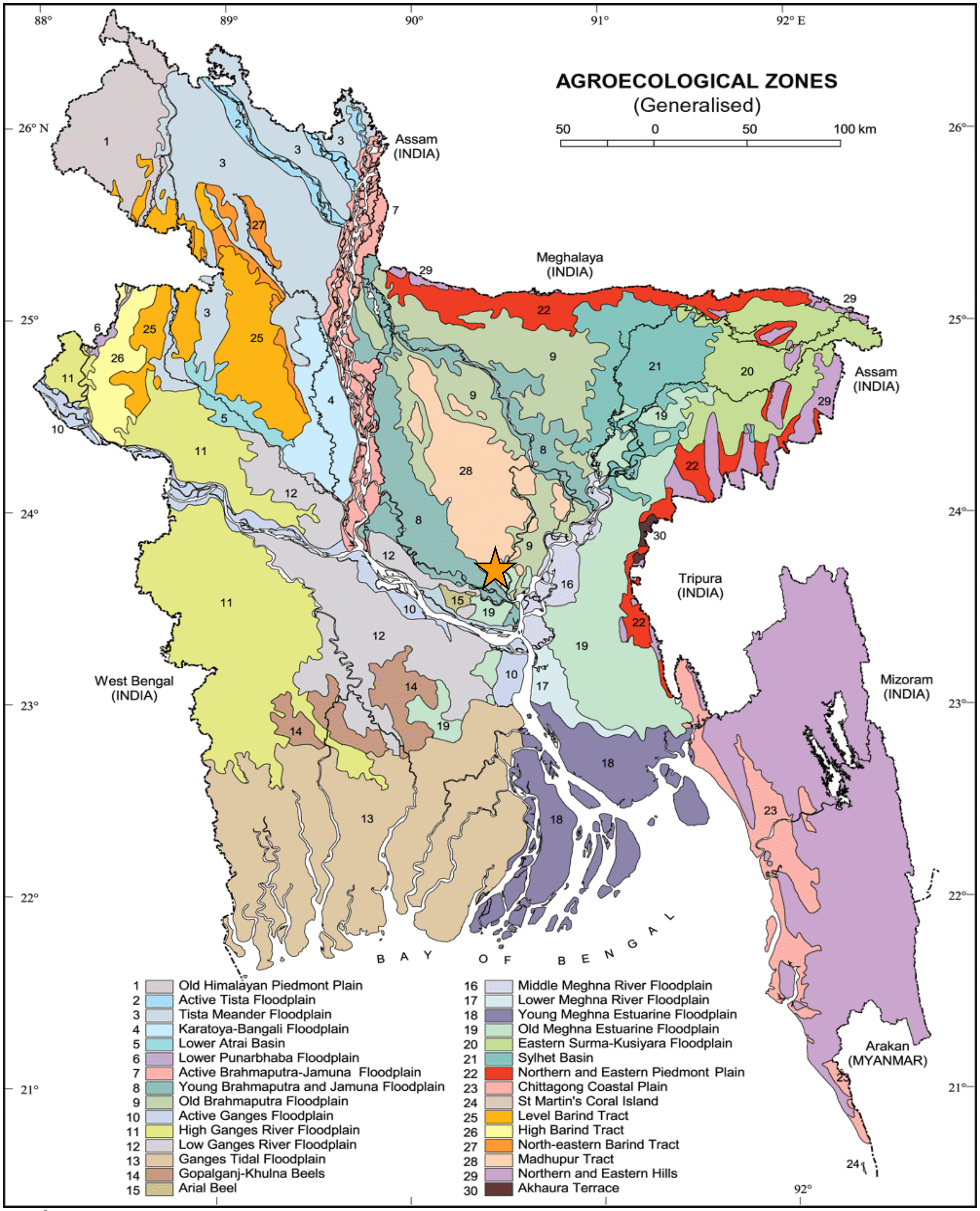
APPENDICES

Appendix I. Map showing the experimental sites under study



★ **The experimental site under study**

Appendix II. Monthly recorded the average air temperature, rainfall, relative humidity and sunshine of the experimental site during the period from December 2016 to May 2017.

Month	Air temperature (^0C)		Relative humidity (%)	Total rainfall(mm)	Sunshine (hr)
	Maximum	Minimum			
December, 2016	26.4	14.1	69	12.8	5.5
January, 2017	25.4	12.7	68	7.7	5.6
February, 2017	28.1	15.5	68	28.9	5.5
March, 2017	32.5	20.4	64	65.8	5.2
April, 2017	38.9	23.6	70	76.4	5.7
May, 2017	40.5	24.5	75	80.6	5.8

Source: Sher-e-Bangla Agricultural University Weather Station and Bangladesh Meteorological Department.

Appendix III. Physical and chemical soil properties of experimental plot

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: Soil Resources Development Institute (SRDI)

Appendix IV. Factorial ANOVA for plant height

Source of variances	DF	SS	MS	F	P
Replication	2	89.99	45.00		
Variety	1	1088.34	1088.34	194.11	0.0051
Error Replication*Variety	2	11.21	5.61		
Fertilize	6	1342.42	223.74	18.03	0.0000
Variety*Fertilize	6	211.95	35.33	2.85	0.0308
Error Replication*Variety*Fertilize	24	297.82	12.41		

Appendix V. Factorial ANOVA for panicle length

Source	DF	SS	MS	F	P
Replication	2	4.9286	2.46428		
Variety	1	5.8932	5.89319	68.12	0.0144
Error Replication*Variety	2	0.1730	0.08652		
Fertilize	6	24.1136	4.01893	6.87	0.0003
Variety*Fertilize	6	4.3177	0.71962	1.23	0.3272
Error Replication*Variety*Fertilize	23	13.4517	0.58485		

Appendix VI. Factorial ANOVA for number of effective tillers hill^{-1}

Source	DF	SS	MS	F	P
Replication	2	4.415	2.2074		
Variety	1	1.640	1.6402	5.15	0.1514
Error Replication*Variety	2	0.637	0.3186		
Fertilize	6	71.850	11.9749	6.14	0.0005
Variety*Fertilize	6	4.400	0.7334	0.38	0.8869
Error Replication*Variety*Fertilize	24	46.794	1.9497		

Appendix VII. Factorial ANOVA for filled grain panicle^{-1}

Source	DF	SS	MS	F	P
Replication	2	14.93	7.46		
Variety	1	2810.98	2810.98	187.53	0.0053
Error Replication*Variety	2	29.98	14.99		
Fertilize	6	3562.84	593.81	44.57	0.0000
Variety*Fertilize	6	121.75	20.29	1.52	0.2132
Error Replication*Variety*Fertilize	24	319.73	13.32		

Appendix VIII. Factorial ANOVA for unfilled grains panicle^{-1}

Source	DF	SS	MS	F	P
Replication	2	67.823	33.911		
Variety	1	113.193	113.193	4.89	0.1576
Error Replication*Variety	2	46.304	23.152		
Fertilize	6	236.117	39.353	2.41	0.0574
Variety*Fertilize	6	11.629	1.938	0.12	0.9931
Error Replication*Variety*Fertilize	24	391.394	16.308		

Appendix IX. Factorial ANOVA for weight of 1000 grains

Source	DF	SS	MS	F	P
Replication	2	33.982	16.991		
Variety	1	594.080	594.080	937.75	0.0011
Error Replication*Variety	2	1.267	0.634		
Fertilize	6	16.445	2.741	1.74	0.1543
Variety*Fertilize	6	6.573	1.095	0.70	0.6550
Error Replication*Variety*Fertilize	24	37.757	1.573		

Appendix X. Factorial ANOVA for grain yield ha^{-1}

Source	DF	SS	MS	F	P
Replication	2	0.1811	0.09055		
Variety	1	7.4172	7.41720	348.30	0.0029
Error Replication*Variety	2	0.0426	0.02130		
Fertilize	6	50.5730	8.42883	141.84	0.0000
Variety*Fertilize	6	1.4484	0.24140	4.06	0.0060
Error Replication*Variety*Fertilize	24	1.4262	0.05943		

Appendix XI. Factorial ANOVA for straw yield ha^{-1}

Source	DF	SS	MS	F	P
Replication	2	1.5341	0.76705		
Variety	1	0.6463	0.64629	1.16	0.3949
Error Replication*Variety	2	1.1186	0.55932		
Fertilize	6	42.4983	7.08305	27.97	0.0000
Variety*Fertilize	6	1.9289	0.32149	1.27	0.3081
Error Replication*Variety*Fertilize	24	6.0779	0.25325		

Appendix XII. Factorial ANOVA for germination percentage

Source	DF	SS	MS	F	P
Replication	2	102.05	51.024		
Variety	1	210.38	210.381	4.78	0.1604
Error Replication*Variety	2	88.05	44.024		
Fertilize	6	2502.48	417.079	5.12	0.0016
Variety*Fertilize	6	300.95	50.159	0.62	0.7160
Error Replication*Variety*Fertilize	24	1956.57	81.524		

Appendix XIII. Factorial ANOVA for shoot length

Source	DF	SS	MS	F	P
Replication	2	1.895	0.9474		
Variety	1	3.209	3.2093	12.42	0.0719
Error Replication*Variety	2	0.517	0.2584		
Fertilize	6	72.892	12.1487	14.30	0.0000
Variety*Fertilize	6	1.818	0.3031	0.36	0.8988
Error Replication*Variety*Fertilize	24	20.387	0.8495		

Appendix XIV. Factorial ANOVA for root length

Source	DF	SS	MS	F	P
Replication	2	1.7758	0.88789		
Variety	1	6.8002	6.80024	14.36	0.0631
Error Replication*Variety	2	0.9473	0.47363		
Fertilize	6	8.2820	1.38033	2.11	0.0899
Variety*Fertilize	6	2.9565	0.49275	0.75	0.6139
Error Replication*Variety*Fertilize	24	15.7234	0.65514		

Appendix XV. Factorial ANOVA for shoot weight

Source	DF	SS	MS	F	P
Replication	2	58.135	29.0674		
Variety	1	37.526	37.5260	1.16	0.3949
Error Replication*Variety	2	64.975	32.4874		
Fertilize	6	129.029	21.5048	2.70	0.0380
Variety*Fertilize	6	50.962	8.4937	1.07	0.4098
Error Replication*Variety*Fertilize	24	191.257	7.9690		

Appendix XVI. Factorial ANOVA for root weight

Source	**DF**	**SS**	**MS**	**F**	**P**
Replication	2	119.937	59.969		
Variety	1	242.881	242.881	23.24	0.0404
Error Replication*Variety	2	20.905	10.452		
Fertilize	6	14.836	2.473	0.63	0.7079
Variety*Fertilize	6	55.312	9.219	2.33	0.0645
Error Replication*Variety*Fertilize	24	94.811	3.950		