FERTILIZER MANAGEMENT OF HYV RICE IN THE POLDER ECOSYSTEM OF THE COASTAL ZONE OF BANGLADESH

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CERTIFICATE

*This is to certify that thesis entitled, **"FERTILIZER MANAGEMENT OF HYV RICE IN THE POLDER ECOSYSTEM OF THE COASTAL ZONE OF BANGLADESH"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree **of MASTER OF SCIENCE (MS) IN AGRONOMY**, embodies the result of a piece of bona-fide research work carried out by **MD. SHAKHAWAT HOSSAIN, Registration no. 15-06989** under my supervision and guidance. No part of the 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.

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FERTILIZER MANAGEMENT OF HYV RICE IN THE POLDER ECOSYSTEM OF THE COASTAL ZONE OF BANGLADESH

ABSTRACT

A field experiment was conducted of the farmer field in polder 30 at Basurabad village, Batiaghata, Khulna during July to December 2016 in order to develop fertilizer management techniques for HYV rice under tidal ecosystem prevailing in the polders of the coastal zone of Bangladesh. The experiment was comprised three rice varieties viz. BRRI dhan51, BRRI dhan72, and kumragor local *T. aman* rice and six fertilizer doses viz. No N + No P K S Zn(N_1), 50% recommended N + No P K S Zn (N_2), 100% recommended N + No P K S Zn(N_3), 50% recommended N + 50% recommended P K S Zn(N_4), 100% recommended N + 50% recommended P K S Zn (N_5), 100% recommended N + 100% recommended P K S Zn(N_6) and The experiment was laid out in a split-plot design with four replication. The purpose of the experiment was to developed fertilizer management techniques for HYV rice under tidal ecosystem prevailing in the polder of the coastal zone and to find out optimum fertilizer dose of HYV Aman rice for polder ecosystem. Data on different yield contributing characters, growth, and yield were recorded. Interaction between varieties and fertilizer management showed a positive impact on growth, yield and yield attributes of aman rice. Varieties showed the significant variations on plant height, tillers hill^{-1}, panicle length, grains panicle^{-1}, thousand grains weight, grain yield, straw yield, biological yield and harvest index. BRRI dahn51 gave the highest grain yield (5.39 tha^{-1}). Fertilizer management also significantly influenced the growth and yield attributes of aman rice. The highest grain yield (4.98 t/ha) was observed in N_6. Interaction between variety and fertilizer management doses significantly influences plant height, tillers hill^{-1}, panicle length, grains panicle^{-1}, thousand grains weight, grain yield, straw yield, biological yield and harvest index. The highest grain yield (6.30 t ha^{-1}) was recorded from the V_1N_6 treatment combination which was statistically similar with V_1N_5. The highest filled grain panicle^{-1} (137.75) was observed in V_1N_5. Straw yield (8.98 tha^{-1}) was higher in V_3N_4 treatment, biological yield (12.35 tha^{-1}) was observed in V_3N_1 and harvest index (56.13 %) was higher in V_1N_1 treatment. It may be concluded that V_1N_5 and V_1N_6 treatment showed best result in the tidal ecosystem of the polder coastal zone

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LIST OF ACRONYMS

AEZ	=	Agro- Ecological Zone
AIS	=	Agricultural Information System
BARC	=	Bangladesh Agricultural Research Council
BBS	=	Bangladesh Bureau of Statistics
BINA	=	Bangladesh Institute of Nuclear Agriculture
BRRI	=	Bangladesh Rice Research Institute
cm	=	Centimeter
cv.	=	Cultivar
CGR	=	Crop growth rate
CAR	=	Conventional application rate
DAT	=	Days after transplanting
^{0} C	=	Degree Centigrade
df	=	Degree of freedom
DAP	=	Diammonium phosphate
DMA	=	Dry matter accumulation
Ec	=	Emulsifiable Concentrate
et al.	=	and others
etc.	=	Etcetera
FAO	=	Food and Agriculture Organization
FYM	=	Farmyard manure
g	=	Gram
GDP	=	Gross domestic product
HI	=	Harvest Index
HYV	=	High yielding variety
hr	=	hour
IRRI	=	International Rice Research Institute
kg	=	kilogram
LV	=	Local variety
LSD	=	Least significant differences
MV	=	Modern variety
MoP	=	Murate of potash
mm	=	Millimeter

m	=	meter
N	=	Nitrogen
ns	=	Non significant
%	=	Percent
CV %	=	Percentage of Coefficient of Variance
P	=	Phosphorus
K	=	Potassium
SAU	=	Sher-e- Bangla Agricultural University
S	=	Sulphur
SRDI	=	Soil Resource and Development Institute
t ha^{-1}	=	Tons per hectare
TSP	=	Triple super phosphate

CHAPTER I
INTRODUCTION

Rice (*Oryza sativa*) is the most important food crop around the world and the staple food for approximately more than two billion people in the Asia (Hien *et al.*, 2006). Rice is also the main food crop of Bangladesh and it covers about 80% of the total cropped area of the country (AIS, 2013). Rice provides nearly 48% of rural employment, about two-third of total calorie supply and about one-half of the total protein intakes of an average per person in the country. About 75% of the total cropped area and over 80% of the total irrigated area is covered by rice (BBS, 2008). Thus, rice plays a vital role in the livelihood of people of Bangladesh.

Total rice production in Bangladesh was about 10.97 million tons in the year 1971 when the country's population was only about 70.88 millions. At present the country is now producing about 31.98 million tons to feed her 153 million people. Population growth rate in Bangladesh is two million people per year and the population will reach 233.2 million by 2050, if it follows by the current trend. Bangladesh will require more than 55.0 million tons of rice per year to feed its people by the year 2050 (IFPRI, 2013). The nation is still adding about 2.3 million every year to its total of 150 million people (Momin and Husain, 2009). During this time total rice area will also shrink to 10.68 million hectares but rice (clean) yield needs to be increased from the present 2.44 to 3.74 t ha^{-1} (BRKB, 2007).

The polder ecosystem of Bangladesh can be a great scope to feed her increasing population. More than 30% of the cultivable land in Bangladesh is in the coastal area, about 1.0 million ha of which is severely affected by varying degrees of flooding/submergence during the wet season each year. The hydrology of the coastal zone is quite different from other parts of Bangladesh. It is governed by the lunar tidal phenomenon and man-made sluice gates in the polder ecosystem. In the coastal zone, high and low tides occur twice daily. Due to stagnant flooding, most farmers of the coastal zone of Bangladesh grow a single rice crop (aman) during the rainy season using tall, photoperiod-sensitive, local landraces, which can survive stagnant flooding, but have low yield (2.0-2.5 t ha^{-1}).

Rice is grown in Bangladesh in three distinct rice growing seasons namely Aus, Aman and Boro. Among these seasons, Aman rice covers the area of 5.66 million hectares with a production of 13.3 million tons (BBS, 2013). Aman rice can improve productivity, farmers' income, and enhance their livelihood. Productivity of Aman rice is particularly low in most of these coastal areas because of excessive flooding and less adoption of suitable high yielding varieties (HYV) of rice. Farmers rely on traditional rice varieties that are tall, do not respond to inputs and have low yields of 2-2.5 t ha^{-1}. Farmers are reluctant to use HYV because they are short stature, easily submerged and damaged by tidal fluctuations and poor nitrogen management technique. But the excess water could easily be drained out during low tide through managing the sluice gates of the coastal polders. Improving drainage in the monsoon season would help in cultivation of HYV Aman rice and also early establishment of rabi crops in the coastal areas of the country. Besides this in the polder ecosystem of the coastal zone of Bangladesh most of the farmers are cultivated local traditional Aman rice varieties without applying fertilizer as a result the yield of rice per unit area is much lower as compared to other region of the country. It is mainly due to selection of potential varieties and judicious application of fertilizers. Selection of potential variety, planting in appropriate method and application of optimum amount of nutrient elements can play an important role to increase the rice yield, and national income.

Nitrogen is a key nutrient element which plays a vital role in vegetative growth, development of yield components and yield of rice (BRRI, 1990). Efficient fertilizer management gives higher yield of crop and reduces fertilizer cost. In polder ecosystem fertilizer management is an important factor that influences the growth, development, yield and yield components of transplanted Aman rice significantly. Balanced fertilization ensures the plant to grow properly with their aerial and underground parts and help to increase the dry matter of the plant. Application of less or more fertilizer than the optimum are not economic i.e., both of this situation give lower yield. So fertilizer application in right time in right dose and in right form has to be ensured. It increases absorption rate, improves soil health and ultimately increases rice yield. It is known that the response of crops to nitrogen varies due to variety and different water levels. A suitable combination of variety and level of fertilizer is necessary for better yield.

From the above discussion it is clear that fertilizer management of HYV in the polder ecosystem of the coastal zone of Bangladesh is very much important. So there is a wide scope to work on this aspect. Therefore, the proposed research plan is being undertaken with the following objectives.

- To developed fertilizer management techniques for HYV rice under tidal ecosystem prevailing in the polder of the coastal zone of Bangladesh,
- To find out optimum fertilizer dose of HYV Aman rice for polder ecosystem , and
- To assess the interaction effects of rice varieties and fertilizer levels

CHAPTER II

REVIEW OF LITERATURE

A large number of research works on growth and yield of rice and its response to variety and nitrogen have been carried out in different rice growing countries of the world. Research activities on the fertilizer management of HYV rice in the polder ecosystem of the coastal zone are few in Bangladesh. The available relevant reviews of the related works done in the recent past have been presented and discussed in this chapter.

2.1 Effect of Variety

BRRI (2008) conducted a comparative study of some promising lines with BRRI modern rice varieties to different nitrogen levels *viz*. 0, 30, 60, 90, 120 and 150 kg N ha^{-1}. It was reported that tiller production with N @ 120 kg ha^{-1} produced significantly higher tiller than those of lower N levels.

Xia *et al.* (2007) found that Shanyou 63 variety gave the higher yield (12 t ha^{-1}) compared to Xieyou46 variety (10 t ha^{-1}).

Amin *et al.* (2006) conducted a field experiment to find out the influence of variable doses of N fertilizer on growth, tillering and yield of three traditional rice varieties (*viz.* Jharapajam, Lalmota, Bansful Chikon) was compared with that of a modern variety (*viz.* KK-4) and reported that traditional varieties accumulated higher amount of vegetative dry matter than the modern variety.

BRRI (1995) conducted an experiment with rice cv. BR10, BR22, BR23 and Rajasail (ck.) at three locations in the aman season. It was found that BR23 gave the highest yield (5.71 t ha^{-1}) which was similar to BR22 (5.02 t ha^{-1}) and the check Rajasail yielded the lowest (3.63 t ha^{-1})

Islam (1995) in an experiment with four rice cultivars *viz.* BR10, BR11, BR22 and BR23 found that the highest number of non-bearing tillers hill^{-1} was produced by cultivar BR11 and the lowest number was produced by the cultivar BR10.

BRRI (1994) also reported that among the four varieties viz. BR14, Pajam, BR5 and Tulsimala, BR14 produced the highest tillers hill^{-1} and the lowest number of spikelet panicle^{-1} respectively. They also observed that the finer the grain size, the higher was the number of spikelet panicle^{-1}.

BINA (1993) evaluated the performance of four varieties IRATOM 24, BR14, Binadhan13 and Binadhan19. They found that varieties differed significantly on panicle length and sterile spikelet panicle^{-1}. It was also reported that varieties Binadhan13 and Binadhan19each had better morphological characters like more grains panicle^{-1} compared to their better parents which contributed to yield improvement in these hybrid lines of rice.

Chowdhury *et al.* (1993) observed that the cultivar BR23 showed superior performance over cultivar Pajam in respect of number of productive tillers hill^{-1}, length of panicle, 1000-grain weight, grain and straw yields but cultivar Pajam produced significantly taller plants, more number of total spikelet panicle^{-1}, grain panicle^{-1} and sterile spikelet panicle^{-1}. They observed that the finer the grain size the higher the number of spikelet.

BINA (1992) reported in a field experiment that under transplanting conditions the grain yield of BINA13 and BINA19 were 5.39 and 5.57 t ha^{-1} respectively and maturity of the above strains were 160 days and 166 days, respectively.
Dwivedi (1997) in a field experiment found that scented genotypes, Kamini and Sugandha gave higher grain and straw yields than four other cultivars RP615, Harban, Basmati and Kasturi with 60 kg N ha^{-1} under mid upland sandy loam soil conditions of Agwanpur (Bihar).

Associations of various yield components in rice indicate that the plants with large panicles tend to have a high number of fertile grains (Padmavathi *et al.*, 1996). Similarly, a positive correlation was observed between number of panicle/plant and panicle length.

Munoz *et al.* (1996) noted that IR8025A hybrid rice cultivar produced an average yield of 7.1 t ha^{-1} which was 16% higher than the commercial variety Oryzica Yacu-9.

Mishra and Pandey (1998) evaluated standard heterosis for seed yield in the range of 44.7 to 230.9% and 42.4 to 81.4%, respectively. Plant height, panicle per plant, grain per panicle and 1000 grain weight increase the yield in modern varieties.

Om *et al.* (1998) in an experiment with hybrid rice cultivars ORI 161 and PMS 2A x IR 31802 found taller plants, more productive tillers, in ORI 161 than in PMS 2A x IR 31802.

Rajendra *et al.* (1998) carried out an experiment with hybrid rice cv. Pusa 834 and Pusa HR3 and observed that mean grain yields of Pusa 834 and Pusa HR3 were 3.3 t ha^{-1} and 5.6 t ha^{-1}, respectively.

Son *et al.* (1998) reported that dry matter production of four inbred lines of rice (low-tillering large panicle type), YR15965ACP33, YR17104ACP5, YR16510-B-B-B-9, and YR16512-B-B-B-10, and cv. Namcheonbyeo and Daesanbyeo, were evaluated at plant densities of 10 to 300 plants m^{-2} and reported that dry matter production of low-tillering large panicle type rice was lower than that of Namcheonbyeo regardless of plant density.

Xu and Li (1998) observed that the maintainer lines were generally shorter than restorer line. He also observed that the plants, which needed more days for 50% flowering generally, gave more yield.

Ahmed *et al.* (1997) conducted an experiment to compare the grain yield and yield components of seven modern rice varieties (BR4, BR5, BR10, BR11, BR22, BR23, and BR25) and a local improved variety, Nizersail. The fertilizer dose was 60-60-40 kg ha^{-1} of N, P_2O_5 and K_2O, respectively for all the varieties and found that percent filled grain was the highest in Nizersail followed by BR25 and the lowest in BR11 and BR23.

Xu and Wang (2001) evaluated ten restorer and ten maintainer lines. They observed that the restorer lines showed more spikelet fertility than maintainer lines. They studied growth duration, number of effective tillers, number of spikelets per panicle and adaptability.

Chen-Liang *et al*. (2000) showed that the cross between Peiai 64s and the new plant type lines had strong heterosis for filled grains per plant, number of spikes per plant and grain weight per plant, but heterosis for spike fertility was low.

Patel (2000) studied that the varietal performance of Kranti and IR36. He observed that Kranti produced significantly higher grain and straw yield than IR36. The mean yield increased with Kranti over IR36 was 7.1 and 10.0% for grain and straw, respectively.

Bhowmick and Nayak (2000) conducted an experiment with two hybrids (CNHR2 and CNHR3) and two high yielding varieties (IR36 and IR64) of rice and five levels of nitrogenous fertilizers. They observed that CNHR2 produced more number of productive tillers (413.4 m^{-2}) and filled grains $panicle^{-1}$ (111.0) than other varieties, whereas IR36 gave the highest 1000-grain weight (21.07g) and number of panicles m^{-2} than other tested varieties.

A field experiment was conducted by Singh and Shivay (2003) at the Research Farm of the Indian Agricultural Research Institute, New Delhi, India to study the effect of coating prilled urea with eco-friendly neem formulations in improving the efficiency of nitrogen use in hybrid rice. Two rice cultivars, hybrid rice (NDHR-3) and Pusa Basmati-1, formed the main plots, with the levels of nitrogen (0, 60, 120 and 180 kg N ha^{-1}) and various forms of urea at 120 kg N ha^{-1}in the subplots. They found that increasing levels of nitrogen significantly increased the number of effective tillers hill^{-1}.

Bokyeong *et al.* (2003) reported that applied with same nitrogen dose Sindongjinbyeo and Iksan 467 gave higher primary rachis branches than Sindongjinbyeo and Dongjin No. 1 varieties.

Dongarwar *et al.* (2003) comprised an experiment to investigate the response of hybrid rice KJTRH-1 in comparison with 2 traditional cultivars, Jaya and Swarna, to 4 fertilizer rates, i.e. 100:50:50, 75:37.5:37.5, 125:62.5:62.5 and 150:75:75 kg NPK ha^{-1} and reported that KJTRH-1 produced significantly higher yield (49.24 q ha^{-1}) than Jaya (39.64 q ha^{-1}) and Swarna (46.06 q ha^{-1}).

Bisne *et al.* (2006) conducted an experiment with eight promising varieties using four CMS lines and showed that plant height, tiller number hill^{-1} and grain yield differed significantly among the varieties and Pusa Basmati gave the highest plant height tiller number hill^{-1} and grain yield in each line.

Swain *et al.* (2006) evaluated in a field experiment the performance of rice hybrids NRH1, NRH3, NRH4, NRH5, PA6111, PA6201, DRRH1, IR64, CR749-20-2 and Lalat conducted in Orissa, India during 1999-2000. Among the hybrids tested, PA 6201 recorded the highest leaf area index.

Wang *et al.* (2006) studied the effects of plant density and row spacing (equal row spacing and one seedling hill^{-1}, equal row spacing and 3 seedlings hill^{-1}, wide-narrow row spacing and one seedling hill^{-1}, and wide-narrow row spacing and 3 seedlings hill^{-1}) on the yield and yield components of hybrids and conventional cultivars of rice. Compared with conventional cultivars, the hybrids had larger panicles, heavier seeds, resulting in an average yield increase of 7.27%.

Murthy *et al.* (2004) conducted an experiment with six varieties of rice genotypes Mangala, Madhu, J-13, Sattari, CR 666-16 and Mukti and observed that Mukti (5268 kg ha^{-1}) out yielded the other genotypes and recorded the maximum number of filled grains and had lower spikelet sterility (25.85%) compared to the others.

Sumit *et al.* (2004) worked with newly released four commercial rice hybrids (DRRH 1, PHB 71, Pro-Agro 6201, KHR 2, ADTHR 1, UPHR 1010 and Pant Sankar Dhan 1) and two high yielding cultivars (HYV) as controls (Pant Dhan 4 and Pant Dhan 12) and reported that KHR 2 gave the best yield (7.0 t ha^{-1}) among them.

2.2 Effect of fertilizer management

Rahman (2003) worked out an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh, during the aman season with three levels of USG viz. one, two and three USG 4 $hills^{-1}$ providing 40, 80 and 120 kg N ha^{-1}. He found that two USG/4 hills produced the higher grain and straw yield (5.22 and 6.09 t ha^{-1}, respectively).

Subhendu *et al.* (2003) conducted a field experiment during *Kharif* season at Hyderabad, India. They found that the application of nitrogen (120 kg Nha^{-1}) as urea in equal split during transplanting, tillering, panicle initiation and 50% flowering resulted straw yield is 5322 kg ha^{-1}.

Geethadevi *et al.* (2000) conducted an experiment with four splits application of nitrogen and found that higher number of tillers, filled grains $panicle^{-1}$ and higher grain weight $hill^{-1}$ for split application of nitrogenous fertilizer at 120 kg N ha^{-1}.

Sharma (1995) reported in an experiment that split application of nitrogenous fertilizer increased the plant height significantly compare to the basal nitrogen application.

Mishra *et al*. (2000) carried out a field experiment in 1994-95 in Bhubaneswar, Orissa, India, and reported that rice cv. Lalate was given 76 kg N ha^{-1} as USG at 0, 7, 14 for 21 days after transplanting (DAT), and these treated control. N increased plant height, panicle length, N up take and consequently the grain and straw yields of lowland rice.

Prasad *et al*. (1999) conducted an experiment on growth of rice plants as influenced by the method of seeding, seed rate and split application of nitrogen and reported that plants were generally tallest with N applied 25% at 15 days after sowing, 50% at active tillering and 25% at panicle initiation stages.

Vijaya and Subbaiah (1997) showed that plant height, number of tillers, number and weight of panicles, N and P uptake, dry matter and grain yield of rice increased with the increasing USG size and were greater with the deep placement method of application both N and P compared with broadcasting.

Reddy *et al.* (1990) reported a significant effect of nitrogen on plant height in rice with 120 kg N ha^{-1} in three split dressings at tillering, panicle initiation and booting stages.

Singh and Singh (1986) reported that plant height increased significantly with the increase in the level of nitrogen from 27 to 87 kg ha^{-1}. Deep placement of USG resulted in the highest plant height than prilled urea (PU). They also reported that number of tillers m^{-2} increased with increasing nitrogen fertilizer.

Akanda *et al*. (1986) at the Bangladesh Agricultural University, Mymensingh observed that applying nitrogen in three splits 20 kg at basal, 40 kg at active tillering and 20 kg at panicle initiation stage had no significant effect on plant height. They also reported that the tallest plants were produced when 80 kg N ha^{-1} was applied in three splits (20 kg at basal, 40 kg at active tillering and 20 kg at maximum tillering).

Shoo *et al.* (1989) reported that nitrogen application upto 120 kg ha^{-1} at transplanting or in two equal split dressing at transplanting and tillering stages increased the total number of tillers hill^{-1}.

Hussain *et al*. (1989) reported that 150 kg N ha^{-1} in split application increased the number of total tillers hill^{-1}. They also observed that nitrogen application date had significant effect on tiller production of aman rice.

Wagh and Thorat (1988) reported that 30+30+10+10 kg N ha^{-1} applied at 8 days after transplanting, maximum tillering, primordial initiation and flowering, respectively produced the highest number of tillers hill^{-1}.

Akanda *et al*. (1986) observed that application of nitrogen in three splits 20 kg at basal, 40 kg at active tillering and 20 kg at panicle initiation stage gave the highest number of total tillers hill^{-1}.

Reddy *et al*. (1985) reported that 120 kg N ha^{-1} applied in three split dressing at transplanting (50%), tillering (25%) and panicle emergence stage (25%) gave higher number of total tillers hill^{-1} than in two equal split dressings at transplanting and tillering or in a single dressing at transplanting.

Islam *et al.* (1996) reported that number of effective tillers hill^{-1} increased with increasing nitrogen level upto 150 kg Nha^{-1} and split application was more effective compare to basal application during transplanting.

Xie *et al.* (2007) reported that increased split application of nitrogen from control to 140 kg ha^{-1} increased dry matter accumulation (DMA) of different growth stages of Jinzao22 and Shanyou63 rice varieties and after that dose the DMA reduced due to the losses of nitrogen by volatilization.

Bayan and Kandasamy (2002) noticed that the application of recommended rates of N in four splits at 10 days after sowing, active tillering, and panicle initiation and at heading stages effective tillers m^{-2}. Islam *et al*. (1996) reported that number of effective tillers $hill^{-1}$ increased with increasing nitrogen level and split application was more effective compare to basal application during transplanting.

Rao *et al*. (1997) showed that nitrogen application at 50 kg ha^{-1} at tillering, 25 kg ha^{-1} at panicle initiation and 25 kg ha^{-1} at booting stage produced the longest panicle.

Patel and Mishra (1994) carried out an experiment with rice cv. IR36 and was given 0, 30, 60 or 90 kg N ha^{-1} as Muossorie rock phosphate-coated urea, neem cake-coated urea, gypsum coated urea, USG or PU. The coated materials as incorporated before transplanting and USG as placed 5-10 deep a week after transplanting and urea as applied in 3 split doses. They showed that N rate had no significant effect on panicle length, percent sterility and harvest index.

Sen and Pandey (1990) reported that the application of USG or PU @ 38.32 kg N ha^{-1} gave higher yield than broadcast PU and there were no significant differences in panicle length.

Reddy *et al*. (1987) observed from an experiment that panicle length increased with 120 kg N ha^{-1} in three split at tillering, panicle initiation and booting stages.

Latchanna and Yogeswara (1977) reported that the longest panicle was obtained when N was applied in three split dressings 1/3 at planting, 1/3 at tillering and 1/3 at panicle initiation.

Kapre *et al.* (1996) reported that USG has favourable effects on rice. They also observed from a study with 8 slow releasing fertilizers that grain yield, straw production, panicle $hill^{-1}$, grains $panicle^{-1}$ and 1000-grain weight increase significantly with USG and sulphur coated urea (SCU).

Faraji and Mirlohi (1998) reported that plant height, number of tillers per unit area and days to heading and maturity increased with the increase of rate of N fertilizer application at 60, 90, 120 or 150 kg N ha^{-1}, were given before transplanting or in 2 or 3 splits while grain yield and panicle number increased with up to 120 kg N ha^{-1} but decreased were decreased with increasing N.

Surendra *et al.* (1995) conducted an experiment during rainy season with nitrogen level @ 0, 40, 80, 120 kg ha^{-1} and sources, of nitrogen, USG and urea dicyandiamide @ 80 kg ha^{-1}. They showed that USG and urea dicyandiamide produced more panicle $hill^{-1}$, filled grains $panicle^{-1}$, panicle weight and grain yield than PU @ 80 kg N ha^{-1}.

Naseem *et al*. (1995) indicated that percent grains remained unchanged in response to different levels but a significantly lower 1000-grain weight was recorded in the control treatment than in the plots received nitrogen fertilizer.

Tantawi *et al.* (1991) stated that split application of nitrogen markedly increased yield and the highest yield obtained from the triple splits. They also observed that split application resulted in greater number of panicles, heavier grains and more grains $panicle^{-1}$.

Angayarkanni and Ravichandran (2001) conducted a field experiment at Tamill Naru from July to October, 1997 and found that split application of nitrogen for rice cv. IR20, treatment applying 16.66% of the recommended N as basal, followed by 33.33% N at 10 DAT, 25% N at 20 DAT and 25% N at 40 DAT recorded the highest grain yield e.g. 6189.4 kg ha^{-1}.

Ehsanullah *et al*. (2001) when work with split application of nitrogenous fertilizer and reported that nitrogen as split application at different growth stages significantly affected grain yield.

Ahmed *et al.* (2000) revealed that USG was more efficient than PU at all respective levels of nitrogen in producing all yield components and in turn, grain and straw yields. Placement of USG @ 160 kg N ha^{-1} produced the highest grain yield (4.32 t ha^{-1}) which was statistically identical to that obtained from 120 kg N ha^{-1} as USG and significantly superior to that obtained from any other level and source of nitrogen.

Surekha *et al.* (1999) found that N application in four equal splits, the last at flowering improved the grain yield as well as nutrient uptake.

Asif *et al*. (1999) noticed that application of 60 : 67 : 67 or 180 : 90 : 90 kg NPK ha^{-1}, with N at transplanting and early tillering or a third each at transplanting, early tillering and panicle initiation resulted in higher grain yield with the higher NPK rates. Split application of N gave higher yields than a single application.

Thakur and Patel (1998) reported that the highest grain yield (3.84 t ha^{-1}) was recorded with the application of 80 kg N ha^{-1} in three split rates with 5 t FYM ha^{-1} and 60 kg N ha^{-1} in three split rates with 5 t FYM gave 3.81 t ha^{-1}.

Das and Singh (1994) reported that grain yield and N use efficiency by rice were greater for deep placed USG than for USG broadcast and incorporated or three split applications of PU.

Chaudhary *et al.* (1994) reported that Basmati rice gave the highest grain yield when fertilized with 124 kg N ha^{-1} in three equal split dressings at transplanting, 20-25 days after transplanting and 40-45 days after transplanting.

Channabasavanan and Setty (1994) found that rice yield was the highest when N was applied in different splits between sowing, tillering, panicle initiation and panicle emergence.

Nair and Gautam (1992) found that grain yield was higher when 60 kg N was applied at initiation, or 50% at transplanting + at tillering + 25% at panicle initiation stages than when all was applied at transplanting or at tillering.

Mongia (1992) reported that grain yield was the highest with 60 kg N ha^{-1} with the application in three split application (50% basal + 25% at flowering + 25% at the flag leaf stage).

Roy and Peterson (1990) reported that application of 40 to 50 percent N at ten days after transplanting, 25-30% at 21 days after transplanting and the rest at the panicle initiation stage were desirable.

Wagh and Thorat (1988) observed that N application date had significant effect on grain yields. Nitrogen application as 30+30+10 kg N ha^{-1} applied at 8 days after transplanting, maximum tillering, primordial initiation and flowering, respectively, produced the highest grain yield.

Park and Lee (1988) reported that brown rice yield of cv. Seomginbyeo increased significantly with up to 100 kg N and was the highest with 20% of N applied 25 days before heading.

Kim *et al*. (1987) stated that the highest rice grain yield was obtained from a basal application of 30 kg N ha^{-1}, three top dressing 32 and 15 days before heading and a final topdressing of 10 kg N ha^{-1} 10 days after heading.

Avasthe *et al.* (1993) reported that the highest grain yield of 5.64 t ha^{-1} was obtained when N was applied in two equal split at transplanting and 7 days before panicle initiation or half of the N at transplanting + ¼ at late tillering + ¼ at panicle initiation.

Rabinson (1992) reported that among 12 different split application treatments, grain yield ranged 4.2-5.9 t ha^{-1} and was the highest with application of three equal splits (Basal application, panicle initiation stages and heading stages).

Mondal and Swamy (2003) found that application N (120 kg ha^{-1}) as urea in equal split during transplanting, tillering, panicle initiation and flowering resulted in the highest number of panicles, number of filled grain panicle^{-1}, 1000-grain weight, straw yield and harvest index.

From the review of literature above it may be said that rates of different levels of fertilizer have decisive influence on the crop performance of rice and very few information are available about the fertilizer management of rice in the coastal polder ecosystem. The above review suggested that a considerable amount of work is still to be carried out in order to evaluate the effect of fertilizer managements of HYV rice in the polder ecosystem of the coastal zone of Bangladesh

CHAPTER III

MATERIALS AND METHODS

3.1 Experimental period

The experiment was conducted in polder 30 at Basurabad village, Batiaghata, district of Khulna during the period from July, 2016 to January, 2017. Details of materials and methods used in this experiment are given below:

3.2 Description of the Experimental Site

3.2.1 Geographical location

The experimental site is geographically situated at 22°43″ N latitude and 89°33″ E longitude at an altitude of 3 meter above sea level. For better understanding about the experimental site has been shown in the Map (AEZ 13) of Bangladesh in Appendix I.

3.2.2 Climate

The experimental site under the sub-tropical climate that is characterized by high temperature, high relative humidity and heavy rainfall with occasional gusty winds in Kharif season (April-September) and scanty rainfall associated with moderately low temperature during Rabi season (October-March). High and low tides occur twice daily.

3.2.3 Soil

The soil of the experimental field belongs to the General soil type, Non-calcareous Grey Floodplain soils (non saline) under Ganges Tidal Floodplain (AEZ 13). The land was located above flood level and sufficient sunshine was available during the experimental period. Soil samples from 0-15 cm depths were collected from the experimental field. The soil analyses were done at the Soil Resource and Development Institute (SRDI), Dhaka. The physicochemical properties of the soil are presented in Appendix III.

3.3 Experimental details

3.3.1 Treatments

There are two sets of treatments in the experiment. The treatments were variety which is considers as Factor A and different fertilizer levels considers as Factor B.

The level of Factor A and B are as follows:

Factor A: Variety (3)

I. BRRI dhan51 (V_1)
II. BRRI dhan72 (V_2)
III. Kumragor (V_3)

Factor B: Fertilizer management

I. No N + No P K S Zn (N_1)
II. 50% recommended N + No P K S Zn (N_2
III. 100% recommended N + No P K S Zn(N_3)
IV. 50% recommended N + 50% recommended P K S Zn (N_4)
V. 100% recommended N + 50% recommended P K S Zn (N_5)
VI. 100% recommended N + 100% recommended P K S Zn (N_6)

No indicate without fertilizer. The recommended dose of N, P, K, S and Zn has been presented in section 3.5.4

3.3.2 Experimental design

The experiment was laid out in a split-plot design with four (4) replications having Variety in the main plots and fertilizer level in the sub-plots. There were 18 treatment combinations. The total numbers of unit plots were 72. The size of unit plot was 6 m by 3.5 m (21 m^2). The distances between each plots and replications were 1 m. The layout of the experimental plots has been shown in Appendix II.

3.4 Planting material

High yielding variety BRRI dhan51 and BRRI dhan72 and Kumragor local traditional variety were used as test crop. BRRI dhan51 and BRRI dhan72 were developed by Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur.

The grains of BRRI dhan51 and BRRI dhan72 are medium-slender. The grain of Kumragor is bold, thick with light golden husks.

3.5 Crop management

3.5.1. Seed Collection

Healthy seeds of BRRI dhan51 and BRRI dhan72 were collected from the Breeding Division, BRRI, Joydebpur, Gazipur. Kumragor was collected from local farmers.

3.5.1.1 Sprouting of seed

Seeds were selected by following specific gravity method. Seeds were immersed into water in a bucket for 24 hours. These were then taken out of water and kept tightly in gunny bags. The seeds started sprouting after 48 hours which were suitable for sowing in 72 hours.

3.5.1.2 Raising of seedlings

Seedlings were raised on a high land in the farmer farm of basurabad village at Khulna. Each variety of seed was sown in separate beds. The nursery beds were prepared by puddling with repeated ploughing followed by laddering. The sprouted seeds were sown as uniformly as possible. Irrigation was gently provided to the bed as and when needed. Proper care was taken to raise seedlings in the nursery bed. The beds were kept weed free throughout the period of seedling raised.

3.5.2 Collection and preparation of initial soil sample

The initial soil samples were collected before land preparation from a 0- 6 inch soil depth. The samples were collected by means of an auger from different location covering the whole experimental plot and mixed thoroughly to make a composite sample. After collection of soil samples, the plant roots, leaves, stubbles etc were picked up and removed. Then the sample was air-dried and sieved through a sieve and stored in a clean plastic container for physical and chemical analysis

3.5.3 Preparation of experimental land

The experimental field was first opened with a tractor drawn disc plough 15 days before transplanting. The land was puddle thoroughly by repeated ploughing and cross ploughing with a power tiller subsequently leveled by laddering. Immediately after final land preparation, the field layout was made (17thAugust, 2016) in field according to experimental specification. It was a bit delayed due to higher water depth 20-25 cm. Individual plots were cleaned and finally leveled with the help of wooden planks so that no water pocket could remain in the puddle field.

3.5.4 Fertilizer application

The experimental area was fertilized with 220, 175, 60, and 10 kg , ha^{-1} N, P, K, S and Zn in the form of urea, triple superphosphate (TSP), Muriate of potash (MoP), gypsum and zinc sulphate as per the treatment respectively. The entire amounts of triple superphosphate (TSP), muriate of potash (MoP), gypsum and zinc sulphate were applied at final land preparation according to the treatments. Urea was applied two splits. The first one-half urea was top dressed at 15 days after transplanting (DAT). The rest of urea was top dressed at panicle initiation stage.

3.5.5 The uprooting of seedlings

Forty days old seedlings were uprooted carefully and were kept in soft mud in shade. Seedlings were then transplanted as per experimental treatment on the well puddled plots.

3.5.6 Transplanting

Seedlings were transplanted on 27 August 2016 in the well-puddled experimental plots. Plant spacing were given 25cm x 15cm for BRRI dhan51, BRRI dhan72 and Kumragor varieties. In each plot, there were 18 rows, each row containing 30 hills of rice seedlings. There were in total 540 hills in each plot. Soil of the plots was kept moist without allowing standing water at the time of transplanting. Two seedlings for BRRI dhan51,BRRI dhan72 and Kumragor varieties were transplanted $hill^{-1}$.

3.5.7 Inter-cultural operations

3.5.7.1 Gap filling

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

3.5.7.2 Weeding

To minimize weed infestation, manual weeding through hand pulling (due to heavy muddy soil) was done three times during entire growing season. The first weeding was done at 15 DAT followed by first top dressing of urea. The second and third weeding were done at 30 DAT and 45 DAT.

3.5.7.3 Irrigation and drainage

There was no additional water supplied in the experimental plots due to tidal flooding is a common phenomenon in coastal zone. The water depth of the experimental plot was measured daily. In October maximum (24.075 cm) water depth was in 20th October and minimum (4.075cm) was in 10th October 2017 in the experimental plots (Appendix viii). The highest water depth occurs due to intruded tidal flooding in the experimental area. In November maximum (26.125 cm) water depth was recorded in 6th November and minimum (0 cm) was in 25-30 November (Appendix viii).The water depth sudden increase at seven November due to tidal flood water inter into the experimental plots

3.5.7.4 Plant protection measures

Plants were infested with rice stem borer (*Scirpophaga incertolus*) to some extent which was successfully controlled by applying Diazinon @ 10 ml 10 litre^{-1} water for 5 decimal lands when infestation was observed. At the grain filling stage plants were infested by false smut to some extent which was removed by cutting the infested grain by manually. To protect the crops from rat attacked ploy sheet was given around the whole experimental area.

3.5.8 Harvesting and processing

The crop of each plot was harvested separately on different dates at full maturity when 80% of the grains become golden yellow in color. The BRRI dhan72, BRRI dhan51 and local Kumragor variety was harvest on December 6, December 12 and December 28, 2016 respectively by cutting the hills above the soil from 4 m^2 harvest area of each plot. The harvested crop of each plot was bundled separately, tagged properly and brought to the clean threshing floor. The crops were threshed by pedal thresher and then grains were cleaned. The grain and straw weights for each plot were recorded after proper sun drying and then converted into ton ha^{-1}. The grain yield was adjusted at 14% moisture level.

3.6 Recording data

Experimental data were determined from 25 days of growth duration and continued until harvest. The following data were determined during the experimentation.

3.6.1 Growth parameter

i. Plant height (cm) at 15 days interval
ii. Number of tillers $hill^{-1}$ at 15 days interval
iii. Dry matter content at flowering and Physiological maturity
iv. Green Seeker reading before and after top dressing of urea

3.6.2 Plant and yield components

i. Number of effective tillers $hill^{-1}$
ii. Number of ineffective tillers $hill^{-1}$
iii. Length of panicle (cm)
iv. Grains $panicle^{-1}$ (no.)
v. Filled grains $panicle^{-1}$ (no.)
vi. Unfilled grains $panicle^{-1}$ (no.)
vii. Weight of 1000-grains (g)
viii. Grain yield (t ha^{-1})
ix. Straw yield (t ha^{-1})
x. Biological yield (t ha^{-1})
xi. Harvest index (%)

3.7 Data recording procedure

A brief outline on data recording procedure followed during the study is given below:

3.7.1 Growth characters

i. Plant height (cm)

Plant height was measured at 25, 40, 55, 70, 85 DAT and at harvest. The height of the plant was determined by measuring the distance from the soil surface to the tip of the leaf height before heading, and to the tip of panicle after heading from the twelve randomly preselected hills.

ii. Tillers hill^{-1} (no)

Number of tillers hill^{-1} were counted at 25, 40, 55, 70, 85 DAT and at harvest from twelve randomly pre-selected hills of two spot in each unit plot and was expressed as number hill^{-1}. Only those tillers having three or more leaves were used for counting.

iii. Dry matter content hill^{-1} (g)

Dry matter content was measured at flowering and physiological maturity of rice randomly from hill^{-1} in each unit plot after oven dry of plant.

iv. Green seeker reading

Green Seeker handheld crop sensor is an affordable, easy-to-use measurement device that can be used to assess the heath or vigor of a crop in order to make better nutrient management decisions on farm applying the right amount of fertilizer, in the right place, at the right time.

3.7.2 Yield and yield components

The sample plants of 4 m^2 were harvested randomly from each plot and tagged them separately. Data on yield components were collected from the sample plants of each plot.

i. Effective tillers hill^{-1} (no.)

The panicles which had at least one grain was considered as effective tillers. The number of effective tillers of 16 hills was recorded and expressed as effective tillers hill^{-1}.

ii. Ineffective tillers hill^{-1} (no.)

The tillers having no panicle were regarded as ineffective tillers. The number of ineffective tillers of 16 hills was recorded and was expressed as ineffective tillers hill^{-1}.

iii. Panicle length (cm)

Measurement of panicle length was taken from basal node of the rachis to apex of each panicle. Each observation was an average of 10 panicles.

iv. Filled grains panicle^{-1}(no.)

Grains were considered to be filled if kernel was present there in. The number of total filled grains present on ten panicles were recorded and finally averaged.

v. Un-filled grains panicle^{-1}(no.)

Unfilled grains means absence of kernel inside and such grains present each of ten panicles were counted and finally averaged.

vi. Total grains panicle^{-1}(no.)

The number of total filled and unfilled grains of a panicle gave the total number of grains panicle^{-1}.

vii. Weight of 1000 grains (g)

One thousand cleaned dried seeds were counted randomly from each sample and weighed by using a digital electric balance at the stage the grain retained 14% moisture and the weight was expressed in gram.

viii. Grain yield (t ha^{-1})

Grain yield was determined from the central area of 4 m^2 from each plot and expressed as t ha^{-1} and adjusted with 14% moisture basis. Grain moisture content was measured by using a digital moisture tester.

ix. Straw yield (t ha^{-1})

Straw yield was determined from the central 4 m^2 area of each plot. After separating the grains, the sub-samples were oven dried to a constant weight and finally converted to t ha^{-1}.

x. Biological yield (t ha^{-1})

Grain yield and straw yield were all together regarded as biological yield. Biological yield was calculated with the following formula and expressed as per hectare basis.

Biological yield (t ha^{-1}) = Grain yield (t ha^{-1}) + Straw yield (t ha^{-1})

xi. Harvest index (%)

It denotes the ratio of economic yield (grain yield) to biological yield and was calculated with following formula.

$$\text{HI (\%)} = \frac{\text{Economic yield (grain weight)}}{\text{Biological yield (Total dry weight)}} \times 100$$

3.8 Statistical Analysis of the Data

All the collected data were analyzed following the analysis of variance (ANOVA) technique and the mean differences were adjudged at 5% level of probability using LSD with a computer operated program named CROPSTAT.

CHAPTER IV

RESULTS AND DISCUSSION

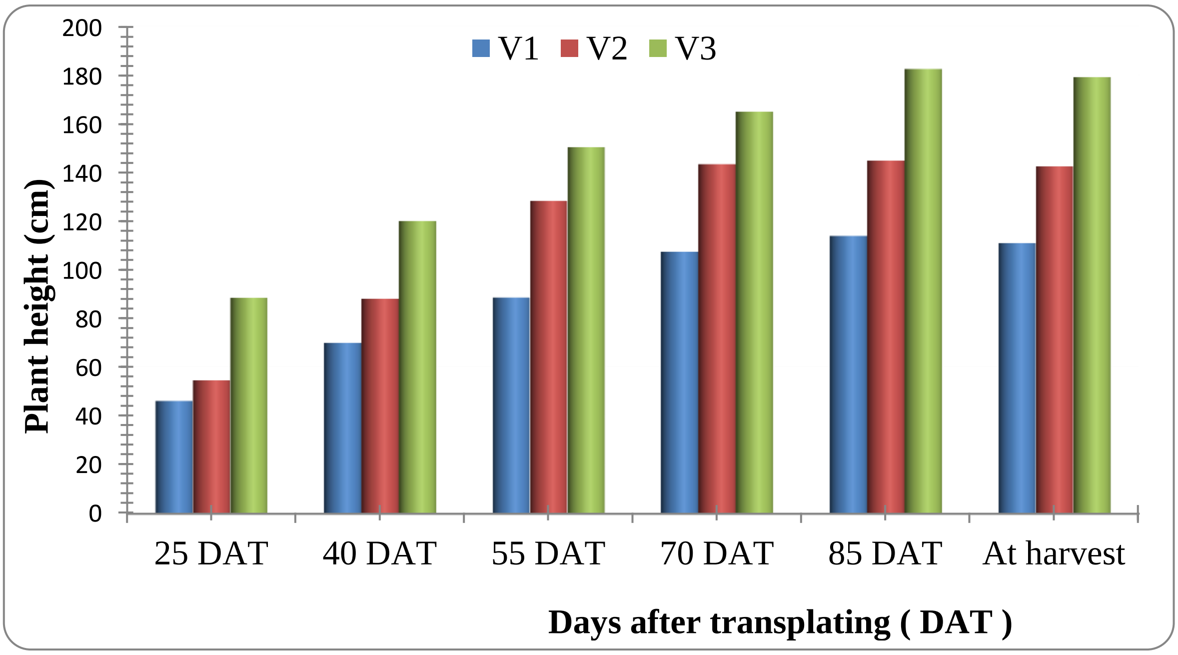
Data obtained from the study of fertilizer management of HYV rice in the polder ecosystem of the coastal zone of Bangladesh have been presented and discussed in this chapter. Treatment effects of variety and fertilizer management on all the studied parameters have been presented in Table 1 to Table 9 and Figure 1 to Figure 17. Summary of analysis of variance (mean squares) for yield contributing characters and yield performance of aman rice as influenced by fertilizer management and variety have been presented in Appendices.

4.1. Growth performance

4.1.1 Plant height

4.1.1.1 Effect of variety

Plant height was significantly influenced by varieties (Figure 1).Plant height showed an increasing trend with the advancement of growth stages irrespective of varieties. At 25, 40, 55, 70 and 85 DAT and at harvest the tallest plant (88.62cm, 120.35 cm, 150.61 cm, 165.35 cm, 182.80 cm and 179.5 cm respectively) was found in V_3 (Kumragor) and the lowest was (46.30 cm, 70.20 cm, 88.88 cm, 107.63 cm, 114.16 cm and 111.16 cm respectively) found in V_1 (BRRI dhan51). This result was in agreement with Bisne *et al.* (2006) who reported that plant height varies significantly among varieties.

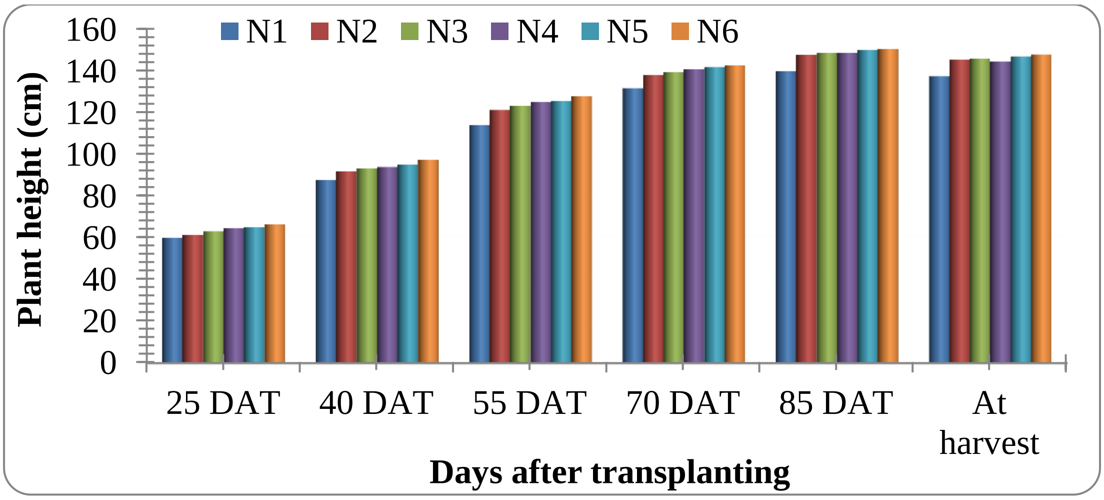


V_1 = BRRI dhan51, V_2 = BRRI dhan72, V_3= Kumragor

Figure 1. Plant height of rice as influenced by variety ($LSD_{0.05}$= 2.226, 3.187, 4.308, 3.094, 2.995 and 2.397 at 25, 40, 55, 70, 85 DAT and at harvest, respectively).

4.1.1.2 Effect of fertilizer management

Plant height was significantly influenced by fertilizer treatments (Figure 2). At 25 DAT, the highest plant height was (66.24 cm) found in N_6 (100% recommended N + 100% recommended P, K, S and Zn) which was statistically similar with N_5 (100% recommended N + 50% recommended P, K, S and Zn). The lowest plant height was (60.02 cm) found in N_1 (Control) and it was statistically similar to N_2 (50% recommended N + No P, K, S and Zn). At 40 DAT, the highest plant height (97.13) was observed in N_6 (100% recommended N + 100% recommended P, K, S and Zn). The lowest plant height was (87.68 cm) found in N_1 (Control). At 55 DAT, the highest plant height (127.80 cm) was recorded in N_6 (100% recommended N + 100% recommended P, K, S and Zn) which was statistically similar with N_5 (100% recommended N + 50% recommended P, K, S and Zn) and N_4 (50% recommended N + 50% recommended P, K, S and Zn). The lowest plant height was (113.96 cm) observed in N_1 (Control). At 70 DAT, the highest plant height (142.43 cm) was recorded in N_6 (100% recommended N + 100% recommended P, K, S and Zn) which was statistically similar with N_5 (100% recommended N + 50% recommended P, K, S and Zn) and N_4 (50% recommended N + 50% recommended P, K, S and Zn). The lowest plant height was (131.56 cm) observed in N_1 (Control). At 85 DAT, the highest plant height (150.27 cm) was recorded in N_6 (100% recommended N + 100% recommended P, K, S and Zn) which was statistically similar with N_5 (100% recommended N + 50% recommended P, K, S and Zn), N_4 (50% recommended N + 50% recommended P, K, S and Zn), N_3 (100% recommended N + No P, K, S and Zn) and N_2 (50% recommended N + No P, K, S and Zn). The lowest plant height was (139.57 cm) observed in N_1 (Control). At harvest, the highest plant height (147.68 cm) was recorded in N_6 (100% recommended N + 100% recommended P, K, S and Zn) which was statistically similar with N_5 (100% recommended N + 50% recommended P, K, S and Zn), N_3 (100% recommended N + No P, K, S and Zn) and N_2 (50% recommended N + No P, K, S and Zn). The lowest plant height was (137.16 cm) observed in N_1 (Control). Data revealed that with the increase of nitrogen fertilizer, plant height increased upto a certain level then decreases. Optimum level of fertilizer is essential for vegetative growth but excess N may cause excessive vegetative growth, prolong the growth duration and delay crop maturity with reduction in grain yield. BRRI (1992) reported that application of nitrogen from 120 to 160 kg ha^{-1} was assumed to be due to excessive vegetative growth followed by lodging after flowering. Rama *et al.* (1989) found that plant height of rice increased significantly with increasing rate of N up to 150 kg ha^{-1}. Andrade and Amorim (1996) also observed that increasing level of N increased plant height.



N_1 = Control, N_2 = 50% recommended N + No P, K, S and Zn, N_3 = 100% recommended N + No P, K, S and Zn, N_4 = 50% recommended N + 50% recommended P, K, S and Zn, N_5 = 100% recommended N + 50% recommended P, K, S and Zn and N_6 = 100% recommended N + 100% recommended P, K, S and Zn.

Figure 2. Plant height of rice as influenced by fertilizer management ($LSD_{0.05}$= 1.683, 2.205, 3.278, 3.217, 3.243 and 3.491 at 25, 40, 55, 70, 85 DAT and at harvest, respectively).

4.1.1.3 Interaction effect of variety and fertilizer management

Interaction between variety and fertilizer had significant influence on plant height of rice (Table 1). At 25 DAT, the highest plant height (91.68 cm) was found in V_3N_6 which was statistically similar with V_3N_5, V_3N_4 and V_3N_3. The lowest plant height (43.15 cm) was observed in V_1N_1 and it was statistically similar to V_1N_2. At 40 DAT, the highest plant height (125.95 cm) was found in V_3N_6. The lowest plant height (66.95 cm) was recorded in V_1N_1 and it was statistically similar to V_1N_2, V_1N_3 and V_1N_4. At 55 DAT, the highest plant height (156.85 cm) was recorded in V_3N_6 which was statistically similar with V_3N_4, V_3N_5 and V_3N_3. The lowest plant height (82.50 cm) was observed in V_1N_1. At 70 DAT, the highest plant height (168.05 cm) was recorded in V_3N_5 which was statistically similar with V_3N_6, V_3N_4, V_3N_3 and V_3N_2. The lowest plant height (103.85 cm) was observed in V_1N_1 which was statistically similar with V_1N_3, V_1N_2 and V_1N_4. At 85 DAT, the highest plant height (184.53 cm) was recorded in V_3N_5 which was statistically similar with V_3N_6, V_3N_3, V_3N_4 and V_3N_2. The lowest plant height (109.13 cm) was recorded in V_1N_1 and it was statistically similar to V_1N_2 and V_1N_5. At harvest, the highest plant height

(183.45 cm) was recorded in V_3N_5 which was statistically similar with V_3N_6, V_3N_3 and V_3N_2. The lowest plant height (104.80 cm) was found in V_1N_1.

Table 1. Interaction effect of variety and fertilizer management on plant height of rice at different growth stages

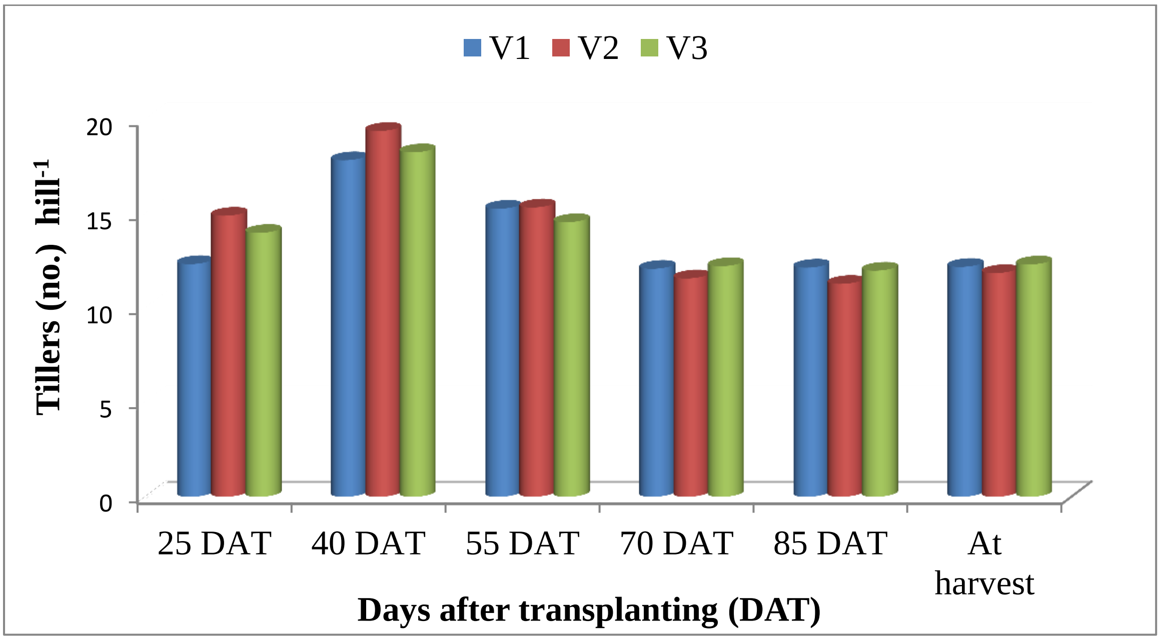
Treatments	Plant height (cm) at					
	25 DAT	**40 DAT**	**55 DAT**	**70 DAT**	**85 DAT**	**At harvest**
V_1N_1	43.15 h	66.95 i	82.50 i	103.85 g	109.13 f	104.80 f
V_1N_2	44.33 gh	69.30 hi	88.25 h	105.60 fg	113.78 ef	110.98 e
V_1N_3	47.08 fg	70.40 hi	89.10 h	105.28 fg	115.70 e	112.33 e
V_1N_4	47.20 fg	70.65 hi	90.20 h	108.95 e-g	115.43 e	113.23 e
V_1N_5	47.30 f	71.10 h	90.53 h	110.30 ef	114.20 ef	111.23 e
V_1N_6	48.78 ef	72.78 h	92.73 h	111.78 e	116.73 e	114.43 e
V_2N_1	50.58 de	81.38 g	118.18 g	130.85 d	131.10 d	131.00 d
V_1N_2	52.63 d	86.58 f	126.55 f	144.93 c	146.15 c	145.45 c
V_2N_3	52.83 d	87.58 ef	128.10 ef	145.98 c	146.13 c	144.98 c
V_2N_4	56.88 c	91.03 de	132.38 de	146.18 c	146.78 c	141.90 c
V_2N_5	58.05 c	91.35 de	132.73 de	146.65 c	150.38 c	145.60 c
V_2N_6	58.28 c	92.65 d	133.83 d	147.75 c	149.58 c	147.35 c
V_3N_1	86.33 b	114.73 c	141.20 c	159.98 b	178.48 b	175.68 b
V_3N_2	86.43 b	118.88 b	148.33 b	163.40 ab	182.78 ab	179.30 ab
V_3N_3	88.90 ab	121.00 b	152.28 ab	166.08 a	183.50 ab	179.95 ab
V_3N_4	89.03 ab	119.63. b	152.58 ab	166.85 a	183.03 ab	177.35 b
V_3N_5	89.35 a	121.93 b	152.45 ab	168.05 a	184.53 a	183.45 a
V_3N_6	91.68 a	125.95 a	156.85 a	167.75 a	184.50 a	181.25 ab
LSD (0.05)	**2.915**	**3.818**	**5.678**	**5.571**	**5.616**	**6.047**
CV (%)	**3.24**	**2.88**	**3.25**	**2.82**	**2.68**	**2.94**

In a column, the means having the same letter (s) do not differ significantly, NS = Not significant, CV = Coefficient of variation, $LSD_{(0.05)}$ =Least significant difference at 5% level, V_1 = BRRI dhan51, V_2 = BRRI dhan72, V_3= Kumragor, N_1 = Control, N_2 = 50% recommended N + No P, K, S and Zn, N_3 = 100% recommended N + No P, K, S and Zn, N_4 = 50% recommended N + 50% recommended P, K, S and Zn, N_5 = 100% recommended N + 50% recommended P, K, S and Zn and N_6 = 100% recommended N + 100% recommended P, K, S and Zn.

4.1.2 Tillers (no.) hill^{-1}

4.1.2.1 Effect of variety

Tiller number per hill was significantly influenced by variety at 25 DAT and 85 DAT and it was not significant at 40, 55 and 70 DAT (due to high tidal flood enters into the plots which hampered the emergence of new tillers) and at harvest (Figure 3). At 25 DAT, the highest tiller number per hill (14.89) was found in V_2 (BRRI dhan72) which was statistically similar with V_3 (Kumragor). The lowest tiller number per hill (12.33) was found in V_1 (BRRI dhan51). At 85 DAT, the highest tiller number per hill (12.14) was recorded in V_1 (BRRI dhan51) which was statistically similar with V_3 (Kumragor). The lowest tiller number per hill (11.28) was found in V_2 (BRRI dhan72). The other findings by Bisne *et al.* (2006), Devaraju *et al.* (1998 b), BRRI (1994), BINA (1993), Chowdhury *et al.* (1993) and Hossain and Alam (1991) were similar with the present finding.

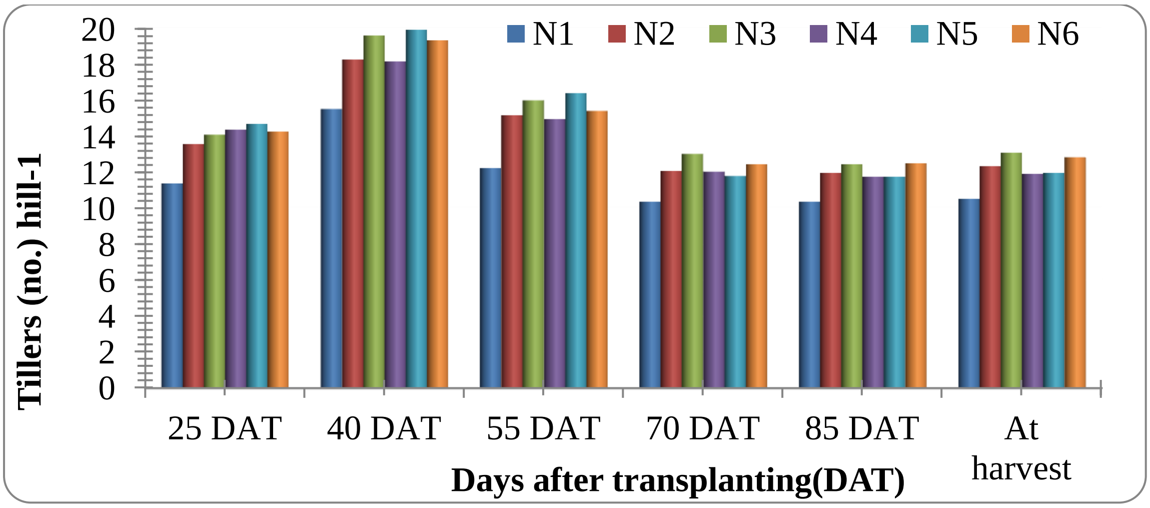


V_1 = BRRI dhan51, V_2 = BRRI dhan72, V_3= Kumragor

Figure 3. Tillers (no.) hill^{-1} of rice as influenced by variety ($LSD_{0.05}$= 1.555 and 0.409 at 25 DAT and 85 DAT, respectively).

4.1.2.2 Effect of fertilizer management

Tiller number per hill was significantly influenced by fertilizer management (Figure 4). At 25, 40 and 55 DAT, The highest tiller number hill (14.70, 19.96 and 16.41) was observed in N_5 (100% recommended N + 50% recommended P, K, S and Zn) and it was statistically similar with N_4 (50% recommended N + 50% recommended P, K, S and Zn), N_6 (100% recommended N + 100% recommended P, K, S and Zn), N_3 (100% recommended N + No P, K, S and Zn) and N_2 (50% recommended N + No P, K, S and Zn). The lowest tiller number per hill (11.38, 15.43 and 12.25) was observed in N_1 (Control). At 70 DAT, the highest tiller number hill (13.02) was observed in N_3 (100% recommended N + No P, K, S and Zn) and it was statistically similar to N_6 (100% recommended N + 100% recommended P, K, S and Zn). The lowest tiller number per hill (10.35) was observed in N_1 (Control). At 85 DAT, the highest tiller number hill (12.50) was observed in N_6 (100% recommended N + 100% recommended P, K, S and Zn) which was statistically similar with N_3 (100% recommended N + No P, K, S and Zn),N_2 (50% recommended N + No P, K, S and Zn), N_5 (100% recommended N + 50% recommended P, K, S and Zn) and N_4 (50% recommended N + 50% recommended P, K, S and Zn). The lowest tiller number per hill (10.37) was found in N_1 (Control). At harvest, the highest tiller number hill (13.08) was observed in N_3 (100% recommended N + No P, K, S and Zn) and it was statistically similar with N_6 (100% recommended N + 100% recommended P, K, S and Zn) and N_2 (50% recommended N + No P, K, S and Zn). The lowest tiller number per hill (10.52) was found in N_1 (Control). BINA (1996) stated that the effect of different levels of nitrogen was significant for number of effective tillers $hill^{-1}$.



N_1 = Control, N_2 = 50% recommended N + No P, K, S and Zn, N_3 = 100% recommended N + No P, K, S and Zn, N_4 = 50% recommended N + 50% recommended P, K, S and Zn, N_5 = 100% recommended N + 50% recommended P, K, S and Zn and N_6 = 100% recommended N + 100% recommended P, K, S and Zn.

Figure 4. Tillers hill^{-1} of rice as influenced by fertilizer management ($LSD_{0.05}$= 2.358, 1.842, 0.918, 0.937, 1.099 and 3.491 at 25, 40, 55, 70, 85 DAT and at harvest, respectively).

4.1.2.3 Interaction effect of variety and fertilizer management

Interaction between variety and fertilizer management had significant influence on tiller number per hill of rice (Table 2). At 25 DAT, the highest tiller number per hill (16.15) was found in V_2N_4 which was statistically similar with V_2N_5, V_2N_2, V_2N_6, V_3N_4, V_3N_3, V_3N_6, V_2N_3, V_1N_5, V_3N_2, V_3N_5 and V_1N_3. The lowest tiller number per hill (10.30) was recorded in V_1N_1 which was statistically similar with V_1N_2, V_3N_1, V_1N_4, V_2N_1, V_1N_6 and V_1N_3. At 40 DAT, the highest tiller number per hill (21.65) was found in V_3N_5 which was statistically similar with V_2N_4, V_2N_5, V_1N_3, V_2N_2, V_2N_3, V_2N_6, V_3N_6, V_1N_6, V_3N_3, V_3N_2 and V_1N_5. The lowest tiller number per hill (14.75) was observed in V_3N_1 which was statistically similar with V_1N_1, V_2N_1, V_3N_4, V_1N_4, V_1N_2 and V_1N_5. At 55 DAT, the highest tiller number per hill (17.45) was observed in V_2N_5 which was statistically similar with V_1N_5, V_1N_3, V_1N_6, V_3N_3, V_2N_2, V_2N_4, V_3N_6, V_2N_3, V_1N_2, V_2N_6, V_3N_4, V_3N_2,V_3N_5 and V_1N_4. The lowest tiller number per hill (11.83) was observed in V_3N_1 which was statistically similar with V_1N_1, V_2N_1, V_1N_4, V_3N_5, V_3N_2, V_3N_4, V_2N_6 and V_1N_2. At 70 DAT, the highest tiller number per hill (13.83) was observed in V_1N_3

Table 2. Interaction effect of variety and fertilizer management on tiller hill^{-1} of rice at different growth stages

Treatments	Tiller number hill^{-1} at					
	25 DAT	**40 DAT**	**55 DAT**	**70 DAT**	**85 DAT**	**At harvest**
V_1N_1	10.30 e	15.85 ef	12.18 cd	10.40 fg	10.50 d-f	10.60 d-f
V_1N_2	10.90 e	17.20 b-f	14.98 a-d	12.18 b-d	12.13 a-c	12.35 a-e
V_1N_3	13.15 a-e	20.05 a-d	16.63 a	13.83 a	13.60 a	13.63 ab
V_1N_4	12.15 c-e	17.05 b-f	14.38 a-d	11.65 c-g	11.78 c-f	11.60 c-f
V_1N_5	14.48 a-d	17.80 a-f	17.15 a	11.93 b-f	12.10 a-d	12.05 a-f
V_1N_6	12.98 b-e	19.00 a-e	16.25 a	12.50 a-d	12.75 a-c	12.83 a-c
V_2N_1	12.23 c-e	15.98 d-f	12.75 b-d	10.08 g	10.28 f	10.53 ef
V_1N_2	15.53 ab	19.85 a-e	15.98 a	11.88 b-f	11.88 b-f	12.00 b-f
V_2N_3	14.53 a-d	19.83 a-e	15.20 a-c	12.03 b-e	11.20 c-f	12.43 a-e
V_2N_4	16.15 a	20.55 ab	15.85 ab	11.93 b-f	11.65 c-f	12.45 a-d
V_2N_5	15.60 ab	20.43 a-c	17.45 a	11.93 b-f	11.45 c-f	11.93 b-f
V_2N_6	15.30 ab	19.68 a-e	14.73 a-d	11.58 d-g	11.25 c-f	11.78 b-f
V_3N_1	11.60 de	14.75 f	11.83 d	10.58 e-g	10.33 ef	10.43 f
V_3N_2	14.25 a-d	17.85 a-e	14.65 a-d	12.18 b-d	11.93 b-e	12.63 a-c
V_3N_3	14.60 a-d	18.93 a-e	16.20 a	13.20 a-c	12.58 a-c	13.20 a-c
V_3N_4	14.78 a-c	16.93 c-f	14.70 a-d	12.58 a-d	11.83 c-f	11.75 b-f
V_3N_5	14.03 a-d	21.65 a	14.63 a-d	11.33 d-g	11.75 c-f	11.90 b-f
V_3N_6	14.60 a-d	19.43 a-e	15.28 a-c	13.25 ab	13.50 ab	13.95 a
LSD (0.05)	**3.002**	**4.083**	**3.191**	**1.589**	**1.622**	**1.904**
CV (%)	**15.35**	**15.51**	**14.89**	**9.33**	**9.65**	**11.04**

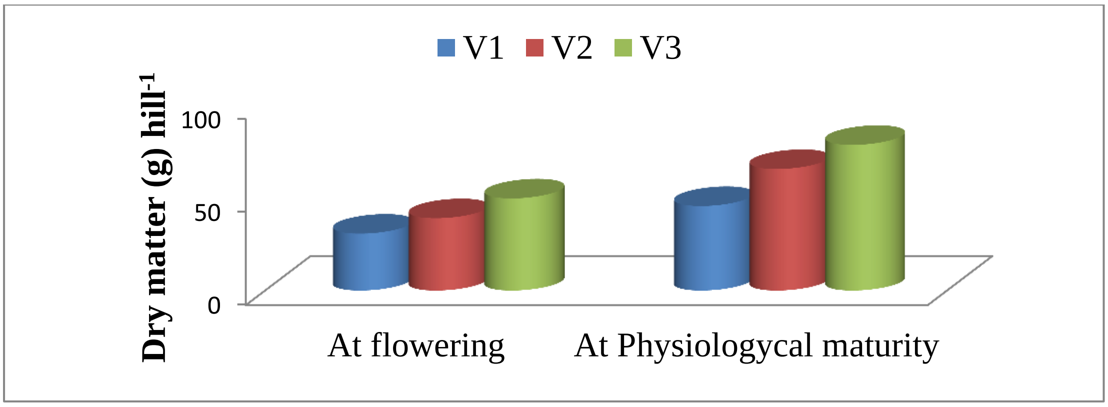
In a column, the means having the same letter (s) do not differ significantly
NS = Not significant, CV = Coefficient of variation, $LSD_{(0.05)}$ =Least significant difference at 5% level,
V_1 = BRRI dhan51, V_2 = BRRI dhan72, V_3= Kumragor
N_1 = Control, N_2 = 50% recommended N + No P, K, S and Zn, N_3 = 100% recommended N + No P, K, S and Zn, N_4 = 50% recommended N + 50% recommended P, K, S and Zn, N_5 = 100% recommended N + 50% recommended P, K, S and Zn and N_6 = 100% recommended N + 100% recommended P, K, S and Zn

which was statistically similar with V_3N_6, V_3N_3, V_3N_4 and V_1N_6. The lowest tiller number per hill (10.08) was observed in V_2N_1 which was statistically similar with V_1N_1, V_3N_1, V_3N_5, V_2N_6 and V_1N_4. At 85 DAT, the highest tiller number per hill (13.60) was observed in V_1N_3 which was statistically similar with V_3N_6, V_1N_6, V_3N_3, V_1N_2 and V_1N_5. The lowest tiller number per hill (10.28) was observed in V_2N_1 which was statistically similar with V_3N_1, V_1N_1, V_2N_3, V_2N_6, V_2N_5, V_2N_4, V_3N_5, V_1N_4, V_3N_4 and V_2N_2. At harvest, the highest tiller number per hill (13.95) was observed in V_3N_6 which was statistically similar with V_1N_3, V_3N_3, V_1N_6, V_3N_2, V_2N_4, V_2N_3, V_1N_2 and V_1N_5. The lowest tiller number per hill (10.43) was observed in V_3N_1 which was statistically similar with V_2N_1, V_1N_1, V_1N_4, V_3N_4, V_1N_6, V_3N_5, V_2N_5, V_2N_2 and V_1N_5

4.1.3 Dry matter content (g) hill^{-1}

4.1.3.1 Effect of variety

Dry matter content was differed significantly due to variety (Figure 5) of rice. The highest (49.50 g) dry matter content at flowering were measured in V_3 (Kumragor) and lowest (30.58 g)was found in V_1 (BRRI dhan51).At physiological maturity of rice the maximum (78.25 g)dry matter was recorded in V_3 (Kumragor) and lowest (45.42 g) was observed in V_1 (BRRI dhan51).



V_1 = BRRI dhan51, V_2 = BRRI dhan72, V_3= Kumragor

Figure 5. Dry matter content of rice as influence by variety

4.1.3.2 Effect of fertilizer management

Fertilizer had significant influence on dry matter content of rice (Table 3). At flowering the highest dry matter was recorded $hill^{-1}$ (48.75 g) in N_5 (100% recommended N + No P, K, S and Zn) The lowest dry matter content (33.75 g) was observed in N_1 (control) which was statistically similar with N_3 (100% recommended N + No P, K, S and Zn), N_2 (50% recommended N + No P, K, S and Zn) and N_4 (50% recommended N + 50% recommended P, K, S andZn). At physiological maturity of rice the highest (73.67 g) dry matter content was observed in N_4 (50% recommended N + 50% recommended P, K, S and Zn) which as statistically similar with N_3 (100% recommended N + No P, K, S and Zn) and the minimum dry matter was found in N_1 (control).

Table 3: Influence of fertilizer management on dry matter content at flowering and physiological maturity of rice

Treatment	At flowering stage (g)	At physiological maturity stage (g)
N_1	33.75 c	55.08 c
N_2	37.58 bc	58.83 bc
N_3	38.67 bc	66.58 ab
N_4	36.33 c	73.67 a
N_5	48.75 a	61.75 bc
N_6	42.83 b	62.00 bc
LSD(0.05)	5.46	8.91
CV (%)	16.81	17.27

NS = Not significant, CV = Coefficient of variation, $LSD_{(0.05)}$ =Least significant difference at 5% level, V_1 = BRRI dhan51, V_2 = BRRI dhan72, V_3= Kumragor
N_1 = Control, N_2 = 50% recommended N + No P, K, S and Zn, N_3 = 100% recommended N + No P, K, S and Zn, N_4 = 50% recommended N + 50% recommended P, K, S and Zn, N_5 = 100% recommended N + 50% recommended P, K, S and Zn and N_6 = 100% recommended N + 100% recommended P, K, S and Zn.

4.1.3.2 Interaction effect of variety and fertilizer management

Interaction between variety and fertilizer management had significant effect on dry matter content of rice (Table 4). The highest dry matter at flowering (63.00g) was observed in V_3N_5 and the second highest was observed in V_3N_6, which was statistically similar to V_3N_1, V_3N_2, V_3N_3 , V_3N_4, V_2N_5 , and V_2N_6.

At physiological maturity the highest (108.25 g) dry matter was obtained in V_3N_4 treatment and the lowest dry matter content (43.25 g) was found in V_1N_1 which was statistically similar to V_1N_1, V_1N_2, V_1N_3 , V_1N_4, V_1N_5 and V_2N_1.

Table 4. Interaction effect of variety and fertilizer management on dry matter content of rice at different growth stages

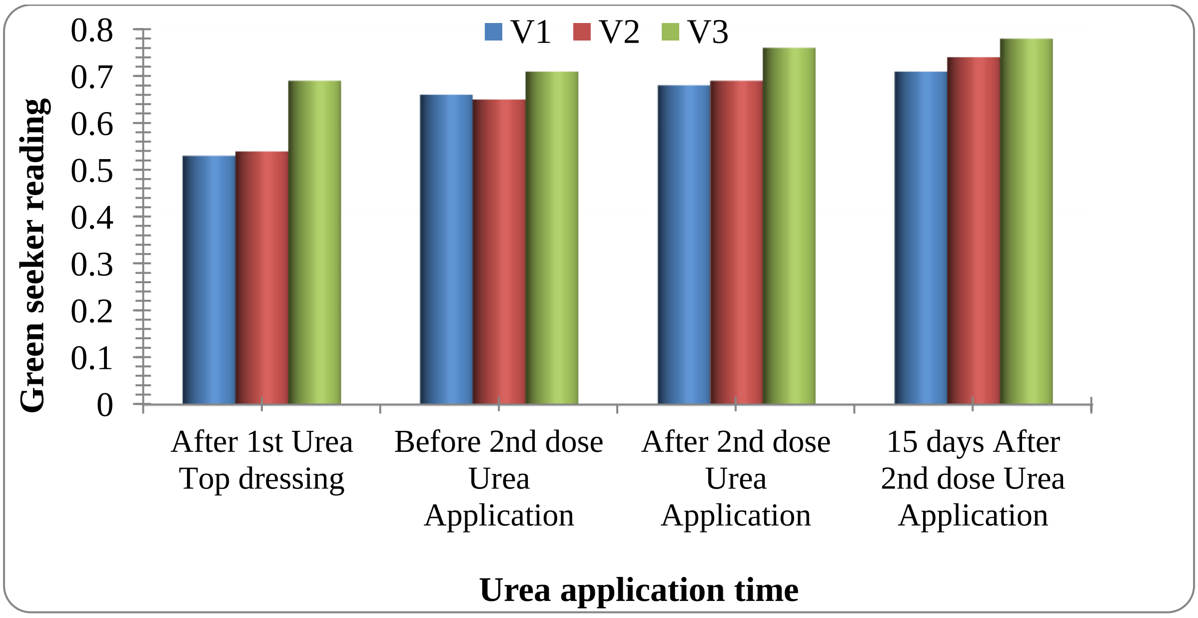
Treatment	At flowering stage (g)	At physiological maturity stage (g)
V_1N_1	28.25 h	43.25 h
V_1N_2	28.00 h	46.00 h
V_1N_3	28.00 h	49.75 fgh
V_1N_4	30.75 gh	48.75 gh
V_1N_5	34.50 efgh	39.75 h
V_1N_6	34.00 efgh	45.00 h
V_2N_1	31.50 fgh	51.00 efgh
V_1N_2	40.50 cdef	66.00 de
V_2N_3	39.00 defg	82.75 b
V_2N_4	29.25 h	64.00 defg
V_2N_5	48.75 bc	63.75 defg
V_2N_6	44.25 bcd	64.25 def
V_3N_1	41.50 bcde	71.00 bcd
V_3N_2	44.25 bcd	64.50 def
V_3N_3	49.00 bc	67.25 cd
V_3N_4	49.00 bc	108.25 a
V_3N_5	63.00 a	81.75 bc
V_3N_6	50.25 b	76.75 bcd
LSD	**9.46**	**15.44**
CV (%)	**16.81**	**17.27**

In a column, the means having the same letter (s) do not differ significantly
NS = Not significant, CV = Coefficient of variation, $LSD_{(0.05)}$ =Least significant difference at 5% level,
V_1 = BRRI dhan51, V_2 = BRRI dhan72, V_3= Kumragor
N_1 = Control, N_2 = 50% recommended N + No P, K, S and Zn, N_3 = 100% recommended N + No P, K, S and Zn, N_4 = 50% recommended N + 50% recommended P, K, S and Zn, N_5 = 100% recommended N + 50% recommended P, K, S and Zn and N_6 = 100% recommended N + 100% recommended P, K, S and Zn.

4.1.4 Green seeker reading

4.1.4.1 Effect of variety

Green seeker reading was significantly influenced by varieties (Figure 6). The highest green seeker reading after 1st Urea Top dressing and after 2nd dose of Urea Application (0.69 and 0.76) was found in V_3 (Kumragor) and the lowest (0.53 and 0.68) was observed in V_1 (BRRI dhan51) which was statistically similar with V_2 (BRRI dhan72). The highest green seeker reading before 2nd dose Urea Application (0.71) was recorded in V_3 (Kumragor) and the lowest (0.65) was observed in V_2 (BRRI dhan72) which was statistically similar with V_1 (BRRI dhan51). Green seeker reading was found (0.78) at 15 days after 2nd dose Urea Application in V_3 (Kumragor) and that of lowest (0.71) was observed in V_1 (BRRI dhan51).

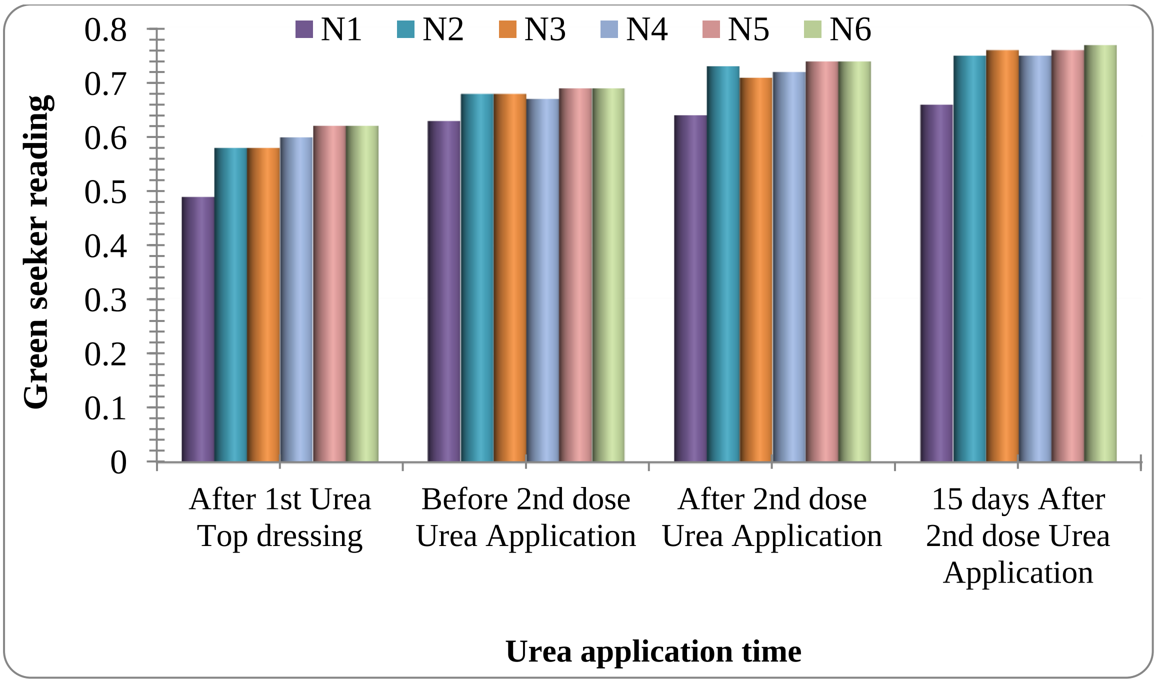


V_1 = BRRI dhan51, V_2 = BRRI dhan72, V_3= Kumragor

Figure 6. Green seeker reading of rice as influenced by variety ($LSD_{0.05}$= 0.04, 0.033, 0.047 and 0.025 at after 1st Urea Top dressing , before 2nd dose Urea Application, after 2nd dose of Urea Application and 15 days after 2nd dose Urea Application, respectively).

4.1.4.2 Effect of fertilizer management

Green seeker reading was affected significantly by fertilizer management (Figure 7). The highest green seeker reading after 1st Urea Top dressing (0.62) was observed in N_5 (100% recommended N + 50% recommended P, K, S and Zn) and N_6 (100% recommended N + 100% recommended P, K, S and Zn) which was statistically similar with N_4 (50% recommended N + 50% recommended P, K, S and Zn). The lowest (0.49) was found in N_1 (Control). The highest green seeker reading before 2nd dose Urea Application (0.69) was observed in N_5 (100% recommended N + 50% recommended P, K, S and Zn) and N_6 (100% recommended N + 100% recommended P, K, S and Zn) which was statistically similar with N_2 (50% recommended N + No P, K, S and Zn), N_3 (100% recommended N + No P, K, S and Zn) and N_4 (50% recommended N + 50% recommended P, K, S and Zn). The lowest (0.63) was found in N_1 (Control). The values of the highest green seeker reading (0.74) after 2nd dose Urea Application was observed in N_5 (100% recommended N + 50% recommended P, K, S and Zn) and N_6 (100% recommended N + 100% recommended P, K, S and Zn) which was statistically similar with N_2 (50% recommended N + No P, K, S and Zn), N_4 (50% recommended N + 50% recommended P, K, S and Zn) and N_3 (100% recommended N + No P, K, S and Zn) and the lowest (0.64) was found in N_1 (Control). The highest green seeker reading 15 days after 2nd dose Urea Application (0.77) was observed in N_6 (100% recommended N + 100% recommended P, K, S and Zn) which was statistically similar with N_3 (100% recommended N + No P, K, S and Zn), N_5 (100% recommended N + 50% recommended P, K, S and Zn), N_2 (50% recommended N + No P, K, S and Zn) and N_4 (50% recommended N + 50% recommended P, K, S and Zn) and the lowest (0.66) was found in N_1 (Control)



N_1 = Control, N_2 = 50% recommended N + No P, K, S and Zn, N_3 = 100% recommended N + No P, K, S and Zn, N_4 = 50% recommended N + 50% recommended P, K, S and Zn, N_5 = 100% recommended N + 50% recommended P, K, S and Zn and N_6 = 100% recommended N + 100% recommended P, K, S and Zn.

Figure 7. Green seeker reading of rice as influenced by fertilizer management ($LSD_{0.05}$= 0.032, 0.02, 0.028 and 0.03 at after 1st Urea Top dressing , before 2nd dose Urea Application, after 2nd dose of Urea Application and 15 days after 2nd dose Urea Application, respectively)

4.1.4.3 Interaction effect of variety and fertilizer management

Interaction between variety and fertilizer exerted significant influence on green seeker reading of rice (Table 5). The result revealed that the (0.7) highest green seeker reading in after 1st Top dressing of urea was found in V_3N_2 which was statistically similar with V_3N_3, V_3N_6, V_3N_4 and V_3N_5 which was happened due to more canopy contain more chlorophyll content and the lowest (0.42) green seeker reading in after 1st Urea Top dressing was found in V_2N_1 which was statistically similar with V_1N_1 which occur due to V_2N and V_1N_1treatment combination showed lower canopy area .The highest green seeker reading in before 2nd dose Urea Application (0.73) was found in V_3N_5 which was statistically similar with V_3N_6, V_2N_5, V_3N_2 and V_3N_3. The lowest green seeker reading in before 2nd dose

Urea Application (0.59) was found in V_2N_1 which was statistically similar with V_1N_1. The highest green seeker reading in after 2nd dose Urea Application (0.78) was found in V_3N_6 which was statistically similar with V_3N_4, V_3N_5, V_3N_2, V_3N_3 and V_2N_5. The lowest green seeker reading in after 2nd dose Urea Application (0.59) was found in V_1N_1 which was statistically similar with V_2N_1. The highest green seeker reading in 15 days after 2nd dose Urea Application (0.80) was found in V_3N_4 which was statistically similar with V_3N_2, V_3N_3, V_3N_5, V_3N_6, V_2N_6, V_3N_1, V_1N_3, V_1N_6, V_2N_4 and V_2N_5. The lowest green seeker reading in 15 days after 2nd dose Urea Application (0.58) was found in V_1N_1.

Table 5. Interaction effect of variety and fertilizer management on green seeker reading of rice

Treatments	Green seeker reading			
	after 1st Urea Top dressing	**before 2nd dose Urea Application**	**after 2nd dose Urea Application**	**15 days After 2nd dose Urea Application**
V_1N_1	0.45 fg	0.62 gh	0.59 f	0.58 e
V_1N_2	0.49 ef	0.66 d-f	0.71 c-e	0.73 bc
V_1N_3	0.56 cd	0.68 c-e	0.69 e	0.75 a-c
V_1N_4	0.54 de	0.65 e-g	0.68 e	0.70 cd
V_1N_5	0.56 cd	0.65 e-g	0.71 c-e	0.74 bc
V_1N_6	0.54 de	0.69 b-d	0.71 c-e	0.75 a-c
V_2N_1	0.42 g	0.59 h	0.61 f	0.66 d
V_1N_2	0.54 de	0.66 d-f	0.72 b-e	0.74 bc
V_2N_3	0.49 ef	0.64 fg	0.70 de	0.74 bc
V_2N_4	0.56 cd	0.66 d-f	0.70 de	0.75 a-c
V_2N_5	0.61 bc	0.71 a-c	0.73 a-e	0.75 a-c
V_2N_6	0.63 b	0.65 e-g	0.72 b-e	0.77 ab
V_3N_1	0.61 bc	0.68 c-e	0.71 c-e	0.76 ab
V_3N_2	0.71 a	0.71 a-c	0.76 a-c	0.78 ab
V_3N_3	0.70 a	0.70 a-c	0.75 a-d	0.78 ab
V_3N_4	0.69 a	0.69 b-d	0.77 ab	0.80 a
V_3N_5	0.69 a	0.73 a	0.77 ab	0.78 ab
V_3N_6	0.70 a	0.72 ab	0.78 a	0.78 ab
LSD (0.05)	**0.055**	**0.034**	**0.048**	**0.052**
CV (%)	**6.63**	**3.55**	**4.73**	**4.89**

NS = Not significant, CV = Coefficient of variation, $LSD_{(0.05)}$ =Least significant difference at 5% level,
V_1 = BRRI dhan51, V_2 = BRRI dhan72, V_3= Kumragor
N_1 = Control, N_2 = 50% recommended N + No P, K, S and Zn, N_3 = 100% recommended N + No P, K, S and Zn, N_4 = 50% recommended N + 50% recommended P, K, S and Zn, N_5 = 100% recommended N + 50% recommended P, K, S and Zn and N_6 = 100% recommended N + 100% recommended P, K, S and Zn.

4.2 Yield components of Aman rice

4.2.1 Effective tillers m^{-2}

4.2.1.1 Effect of variety

Effective tiller number m^{-2} was varied significantly due to varieties of rice (Table 6). The maximum number effective tillers m^{-2}(247.29) was found in V_1 (BRRI dhan51). The minimum no of effective tillersm^{-2} (225.71) was observed in V_3 (Kumragor) and it was statistically similar to V_2 (BRRI dhan72). Varieties produced different number of tillers on the basis of their varietal characters and also genetically influences but different nitrogen management practices also influences different growth parameters as well as tiller production. These findings collaborate with those reported by BINA (1998), Om *et al.* (1998) and Bhowmick and Nayak (2000) who stated that effective tillers hill^{-1} was varied with varieties.

4.2.1.2 Effect of fertilizer management

Fertilizer had significant influence on effective tillersm^{-2}of rice (Table 6). The highest effective tiller was recorded m^{-2}(249.42) in N_3 (100% recommended N + No P, K, S and Zn) which was statistically similar with N_6 (100% recommended N + 100% recommended P, K, S and Zn), N_2 (50% recommended N + No P, K, S and Zn) and N_4 (50% recommended N + 50% recommended P, K, S and Zn). The lowest number of effective tillersm^{-2}(200.33) was observed in N_1 (control). Lafarge (2000) stated that the effect of N fertilizer rates on the number of tillers hill^{-1} was significant.

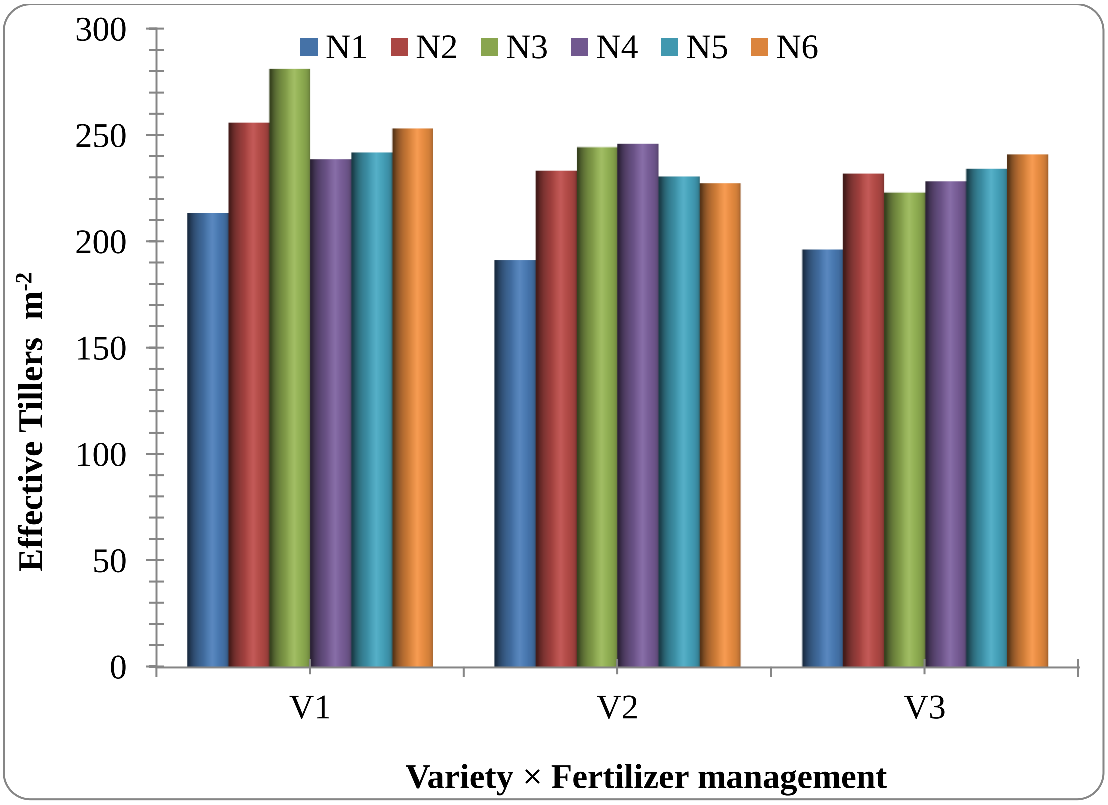
4.2.1.3 Interaction effect of variety and fertilizer management

Interaction between variety and fertilizer had significant effect on effective tillers m^{-2} (Figure 8). The highest effective tillersm^{-2}(281.00) was observed in V_1N_3. The lowest effective tillersm^{-2} (281.00) was recorded in V_2N_1 but it was statistically similar to V_3N_1.

Table 6. Influence of variety and fertilizer management on effective tillers m^{-2} and ineffective tillers m^{-2}

Treatments	Effective tillers(no.) m^{-2}	Ineffective tillers (no.) m^{-2}
Variety		
V_1	247.29a	5.88 b
V_2	228.75b	14.00 a
V_3	225.71b	13.96 a
LSD (0.05)	10.105	2.423
CV (%)	6.12	30.41
Fertilizer		
N_1	200.33 c	11.17
N_2	240.33 ab	13.00
N_3	249.42 a	11.50
N_4	237.58 ab	10.50
N_5	235.42 b	11.00
N_6	240.42 ab	10.50
LSD (0.05)	**12.431**	**2.897 (NS)**
CV (%)	**6.46**	**31.05**

In a column, the means having the same letter (s) do not differ significantly
NS = Not significant, CV = Coefficient of variation, $LSD_{(0.05)}$=Least significant difference at 5% level,
V_1 = BRRI dhan51, V_2 = BRRI dhan72, V_3= Kumragor
N_1= Control, N_2= 50% recommended N + No P, K, S and Zn, N_3= 100% recommended N + No P, K, S and Zn, N_4= 50% recommended N + 50% recommended P, K, S and Zn, N_5= 100% recommended N + 50% recommended P, K, S and Zn and N_6= 100% recommended N + 100% recommended P, K, S and Zn.



V_1 = BRRI dhan51, V_2 = BRRI dhan72, V_3= Kumragor
N_1= Control, N_2= 50% recommended N + No P, K, S and Zn, N_3= 100% recommended N + No P, K, S and Zn, N_4= 50% recommended N + 50% recommended P, K, S and Zn, N_5= 100% recommended N + 50% recommended P, K, S and Zn and N_6= 100% recommended N + 100% recommended P, K, S and Zn.

Figure 8. Effective tillers m^{-2} as influenced by interaction effect of variety and fertilizer management ($LSD_{0.05}$= 21.532).

4.2.2 Ineffective tillers m^{-2}

4.2.2.1 Effect of variety

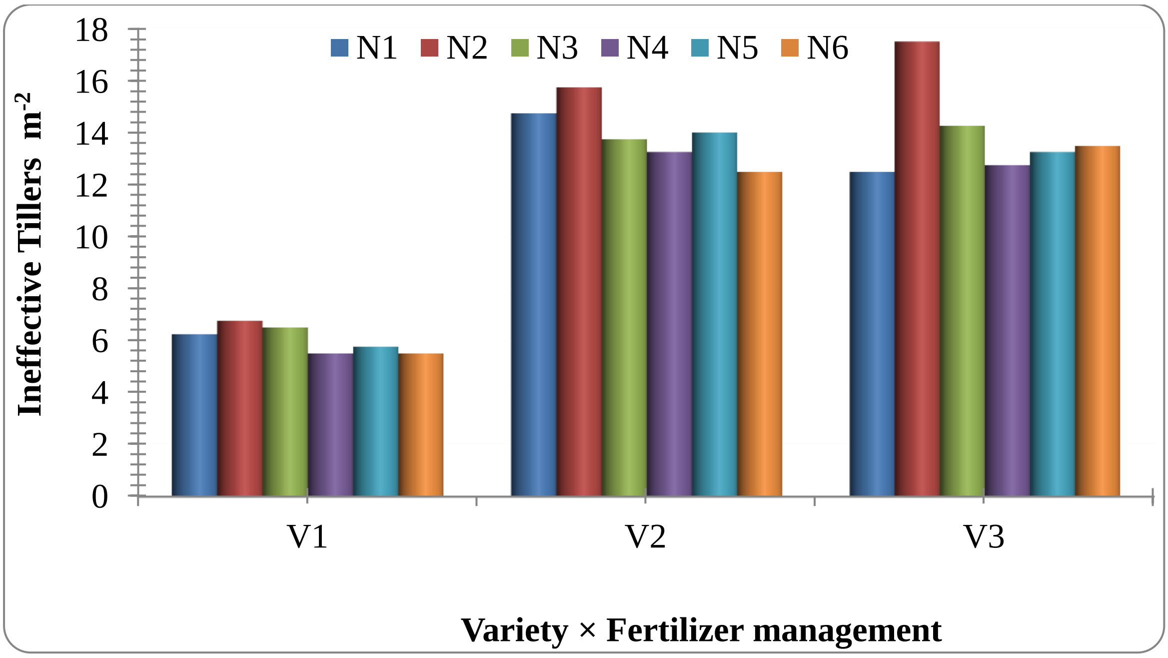
Ineffective tillersm^{-2} was significantly influenced by variety (Table 6). The highest number of ineffective tillers m^{-2}(14.00) was found in V_2 (BRRI dhan72) which was statistically similar to V_3 (Kumragor). The lowest number of ineffective tillers m^{-2}(5.88) was observed in V_1 (BRRI dhan51).

4.2.2.2 Effect of fertilizer management

Ineffective tillers m^{-2} was not significantly influenced by fertilizer management (Table 6). Among all the treatment maximum ineffective tillers m^{-2} was (13.00) observed in N_2 (50% recommended N + No P, K, S and Zn) which was statistically similar to other treatments.

4.2.2.3 Interaction effect of variety and fertilizer management

Interaction between variety and fertilizer management had significant effect on ineffective tillers m^{-2} (Figure 9). The highest ineffective tillers m^{-2}(17.50) was recorded inV_3N_2 but it was statistically similar to V_2N_2, V_2N_1, V_3N_3, V_2N_5, V_2N_3, V_3N_6, V_2N_4, V_3N_5 and V_3N_4. The lowest ineffective tillers m^{-2}(5.50) was observed in V_1N_4 and V_1N_6 which was statistically similar with V_1N_5, V_1N_1, V_1N_3 and V_1N_2.



V_1 = BRRI dhan51, V_2 = BRRI dhan72, V_3= Kumragor
N_1= Control, N_2= 50% recommended N + No P, K, S and Zn, N_3= 100% recommended N + No P, K, S and Zn, N_4= 50% recommended N + 50% recommended P, K, S and Zn, N_5= 100% recommended N + 50% recommended P, K, S and Zn and N_6= 100% recommended N + 100% recommended P, K, S and Zn.

Figure 9. Ineffective tillers m^{-2} as influenced by interaction effect of variety and fertilizer management ($LSD_{0.05}$= 4.987).

4.2.3 Panicle length

4.2.3.1 Effect of variety

The panicle length of rice varied significantly among the three varieties (Table 7). The highest panicle length (26.53 cm) was found in V_2 (BRRI dhan72) and the lowest panicle length (22.41 cm) was observed in V_1 (BRRI dhan51). Devaraju *etal.* (1998), BINA (1993) and Chowdhury *et al.* (1993) achieved similar resultsfrom different experiment with different rice varieties.

4.2.3.2 Effect of fertilizer management

The panicle length of rice was significantly influenced by fertilizer management (Table 7).The longest panicle (24.85 cm) was recorded in N_6 (100% recommended N + 100% recommended P, K, S and Zn) and it was statistically similar with N_2(50% recommended N + No P, K, S and Zn), N_3(100% recommended N + No P, K, S and Zn), N_4(50% recommended N + 50% recommended P, K, S and Zn) and N_5(100% recommended N + 50% recommended P, K, S and Zn). The shortest panicle (23.71 cm) was found in N_1 (control) which was statistically similar with N_5 (100% recommended N + 50% recommended P, K, S and Zn) and N_4 (50% recommended N + 50% recommended P, K, S and Zn). Mondal and Swamy (2003) found that application of N (120 kg ha^{-1}) as urea in equal splits during transplanting, tillering, panicle initiation and flowering resulted in the highest length of panicle. Rao *et al*. (1997) showed that N application at 50 kg ha_{-1} at tillering, 25 kg ha_{-1} at panicle initiation and 25 kg ha_{-1} at booting stage produced the longest panicle.

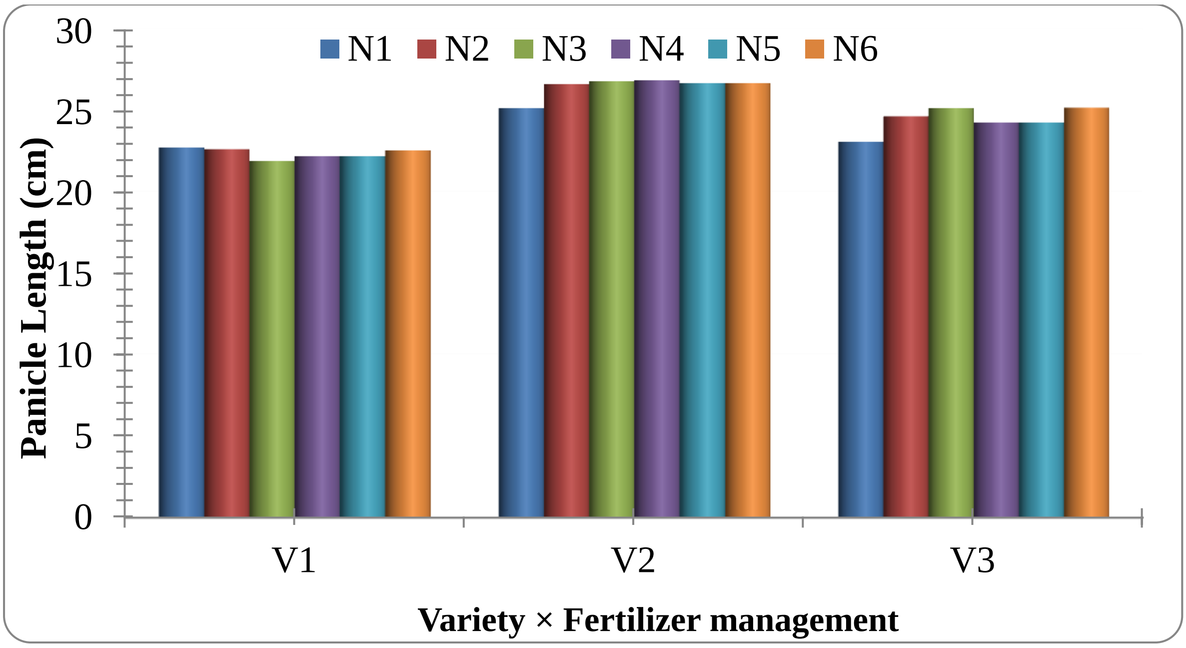
4.2.3.3 Interaction effect of variety and fertilizer management

Interaction between variety and fertilizer management had significant effect on panicle length (Figure10). The highest panicle length (26.90 cm) was recorded in V_2N_4 but it was statistically similar with V_2N_3, V_2N_5, V_2N_6 and V_2N_2. The lowest panicle length (21.95 cm) was found in V_1N_3 which was statistically similar with V_1N_4, V_1N_5, V_1N_6, V_1N_2 and V_1N_1.

Table 7. Influence of variety and fertilizer management on panicle length of rice

Treatments	Panicle length(cm)
Variety	
V_1	22.41 c
V_2	26.53a
V_3	24.48b
LSD (0.05)	0.635
CV (%)	3.67
Fertilizer	
N_1	23.71 b
N_2	24.69 a
N_3	24.67 a
N_4	24.48 ab
N_5	24.43 ab
N_6	24.85 a
LSD (0.05)	0.797
CV (%)	3.96

In a column, the means having the same letter (s) do not differ significantly, NS = Not significant, CV = Coefficient of variation, $LSD_{(0.05)}$=Least significant difference at 5% level,
V_1 = BRRI dhan51, V_2 = BRRI dhan72, V_3= Kumragor
N_1= Control, N_2= 50% recommended N + No P, K, S and Zn, N_3= 100% recommended N + No P, K, S and Zn, N_4= 50% recommended N + 50% recommended P, K, S and Zn, N_5= 100% recommended N + 50% recommended P, K, S and Zn and N_6= 100% recommended N + 100% recommended P, K, S and Zn.



V_1 = BRRI dhan51, V_2 = BRRI dhan72, V_3= Kumragor
N_1= Control, N_2= 50% recommended N + No P, K, S and Zn, N_3= 100% recommended N + No P, K, S and Zn, N_4= 50% recommended N + 50% recommended P, K, S and Zn, N_5= 100% recommended N + 50% recommended P, K, S and Zn and N_6= 100% recommended N + 100% recommended P, K, S and Zn.

Figure 10. Panicle length as influenced by interaction effect of variety and fertilizer management ($LSD_{0.05}$= 1.38)

4.2.4 Filled grains panicle^{-1}

4.2.4.1 Effect of variety

The filled grains panicle^{-1}was differed significantly due variety (Table 8) of rice. The result indicated that the highest filled grain panicle^{-1} (124.71) was counted in V_1 (BRRI dhan51) which was statistically similar to V_2 (BRRI dhan72). The lowest (67.33) was recorded in V_3 (Kumragor). Supporting results were achieved by Bhowmick and Nayak (2000), Chowdhury *etal.* (1993) and Hossain and Alam (1991) that filled grain panicle^{-1}varies among the varieties.

Table 8. Influence of variety and fertilizer management on filled grain panicle^{-1}and unfilled grain panicle^{-1}

Treatments	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}
Variety		
V_1	124.71 a	27.63 a
V_2	118.67 a	29.42a
V_3	67.33 b	17.21 b
LSD (0.05)	**7.906**	**2.249**
CV(%)	**10.81**	**12.86**
Fertilizer		
N_1	98.92 c	25.42 ab
N_2	103.08 bc	24.33 b
N_3	100.75 bc	27.92a
N_4	103.58 abc	25.67 ab
N_5	105.67 ab	20.42 c
N_6	109.42 a	24.75 b
LSD (0.05)	**6.017**	**2.904**
CV (%)	**7.07**	**14.27**

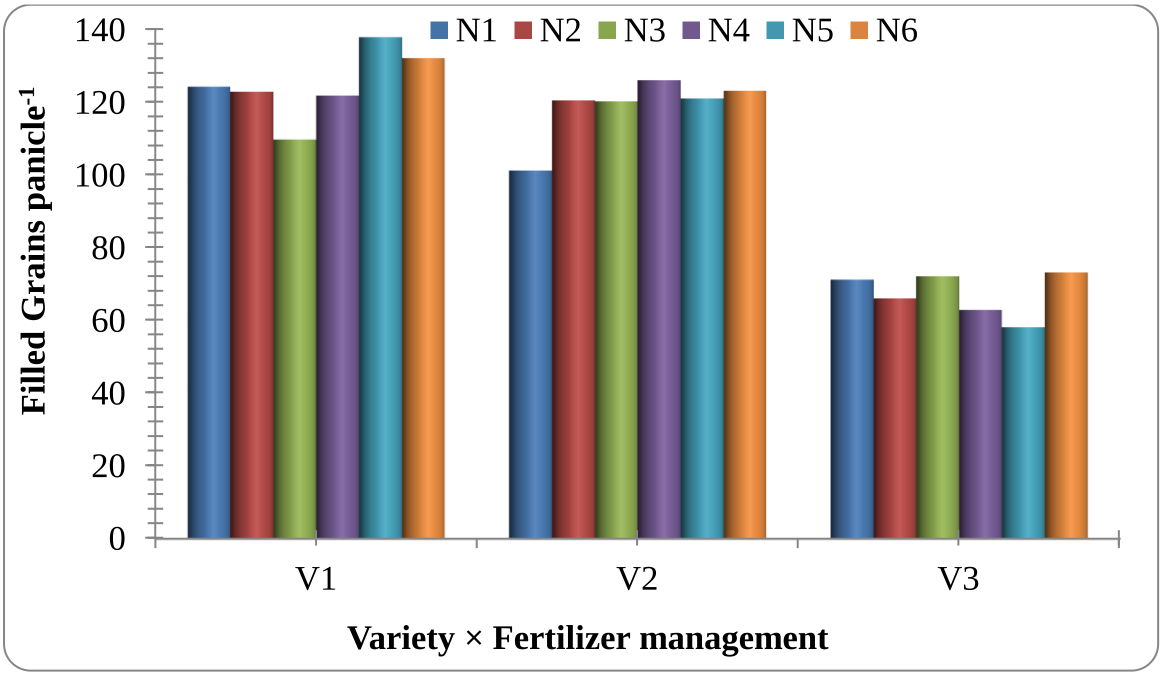
In a column, the means having the same letter (s) do not differ significantly, CV = Coefficient of variation, $LSD_{(0.05)}$=Least significant difference at 5% level,
V_1 = BRRI dhan51, V_2 = BRRI dhan72, V_3= Kumragor
N_1= Control, N_2= 50% recommended N + No P, K, S and Zn, N_3= 100% recommended N + No P, K, S and Zn, N_4= 50% recommended N + 50% recommended P, K, S and Zn, N_5= 100% recommended N + 50% recommended P, K, S and Zn and N_6= 100% recommended N + 100% recommended P, K, S and Zn.

4.2.4.2 Effect of fertilizer management

A significant variation was observed in rice due to fertilizer management (Table 8). The treatment N_6 (100% recommended N + 100% recommended P, K, S and Zn) showed the highest filled grain panicle^{-1} which was statistically similar to N_5 (100% recommended N + 50% recommended P, K, S and Zn) and N_4 (50% recommended N + 50% recommended P, K, S and Zn). The lowest total filled grain panicle^{-1} (98.92) was recorded in N_1 (Control) but it was statistically with N_3 (100% recommended N + No P, K, S and Zn), N_2 (50% recommended N + No P, K, S and Zn) and N_4 (50% recommended N + 50% recommended P, K, S and Zn).. Mondal and Swamy (2003) found that application of N (120 kg ha^{-1}) as urea in equal splits during transplanting, tillering stage, panicle initiation and flowering resulted in the highest number of grains panicle^{-1}

4.2.4.3 Interaction effect of variety and fertilizer management

Interaction between variety and fertilizer management had significant effect on filled grainspanicle^{-1} (Figure 11). The highest filled grainspanicle^{-1} (137.75) was observed in V_1N_5 but it was statistically similar with V_1N_6. The lowest total filled grainspanicle^{-1} (58.25) was observed in V_3N_5 but it was statistically similar with V_3N_4 and V_3N_2.



V_1 = BRRI dhan51, V_2 = BRRI dhan72, V_3= Kumragor
N_1= Control, N_2= 50% recommended N + No P, K, S and Zn, N_3= 100% recommended N + No P, K, S and Zn, N_4= 50% recommended N + 50% recommended P, K, S and Zn, N_5= 100% recommended N + 50% recommended P, K, S and Zn and N_6= 100% recommended N + 100% recommended P, K, S and Zn.

Figure 11. Filled grains panicle^{-1} as influenced by interaction effect of variety and fertilizer management ($LSD_{0.05}$= 10.421).

4.2.5 Unfilled grains panicle^{-1}

4.2.5.1 Effect of variety

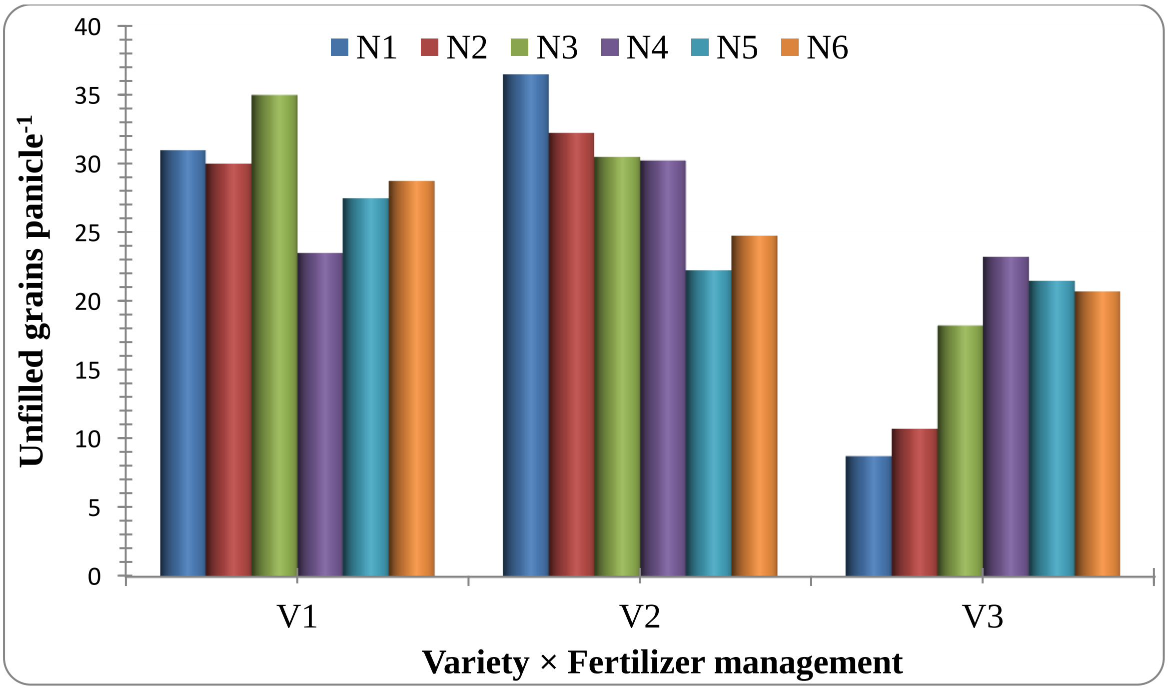
The unfilled grain panicle^{-1}was significantly influenced by variety (Table 8). The highest unfilled grains panicle^{-1} (29.42) was observed in V_2 (BRRI dhan72) which was statistically similar to V_1 (BRRI dhan51). The lowest (7.21) was recorded in V_3 (Kumragor). BINA (1993) observed the similar result that the production of unfilled grains panicle^{-1} differed with variety to variety.

4.2.5.2 Effect of fertilizer management

The unfilled grains panicle^{-1}was significantly influenced by fertilizer management (Table 8). The highest unfilled grains panicle^{-1} (27.92) was recorded in N_3 (100% recommended N + No P, K, S and Zn) which was statistically similar with N_4 (50% recommended N + 50% recommended P, K, S and Zn) and N_1 (Control). The lowest unfilled grain panicle^{-1} (20.42) was found in N_5 (100% recommended N + 50% recommended P, K, S and Zn). The result was supported by BRRI (2006) that without nitrogen produced the highest number of unfilled grains panicle^{-1}.

4.2.5.3 Interaction effect of variety and fertilizer management

Interaction between variety and fertilizer management had significant effect on unfilled grain panicle^{-1} (Figure 12). The highest unfilled grain panicle^{-1} (36.50) was found in V_2N_1 which was statistically similar to V_1N_3 and V_2N_2. The lowest unfilled grain panicle^{-1} (8.75) was recorded in V_3N_1 which was statistically similar with V_3N_2.



V_1 = BRRI dhan51, V_2 = BRRI dhan72, V_3= Kumragor
N_1= Control, N_2= 50% recommended N + No P, K, S and Zn, N_3= 100% recommended N + No P, K, S and Zn, N_4= 50% recommended N + 50% recommended P, K, S and Zn, N_5= 100% recommended N + 50% recommended P, K, S and Zn and N_6= 100% recommended N + 100% recommended P, K, S and Zn.

Figure 12. Unfilled grains panicle^{-1}as influenced by interaction effect of variety and fertilizer management (LSD$_{0.05}$= 5.03).

4.2.6 Spikelet sterility

4.2.6.1 Effect of variety

Spikelet sterility was not significantly influenced by variety (Table 9). However, among all the treatment maximum spikelet sterility (20.21 %) was observed inV_3 (Kumragor) and minimum spikelet sterility (18.17 %) was found in V_1 (BRRI dhan51). But BRRI dhan72 produced the intermediate level of spikelet sterility in rice

Table 9. Influence of variety and fertilizer management on spikelet sterility of rice

Treatments	Spikelet sterility (%)
Variety	
V_1	18.17
V_2	19.79
V_3	20.21
LSD	2.355 (NS)
CV	17.18
Fertilizer	
N_1	19.08 bc
N_2	18.08 c
N_3	21.58 a
N_4	20.75 ab
N_5	18.00 c
N_6	18.83 bc
LSD (0.05)	2.497
CV (%)	15.55

In a column, the means having the same letter (s) do not differ significantlyNS = Not significant, CV = Coefficient of variation, $LSD_{(0.05)}$=Least significant difference at 5% level,
V_1 = BRRI dhan51, V_2 = BRRI dhan72, V_3= Kumragor
N_1= Control, N_2= 50% recommended N + No P, K, S and Zn, N_3= 100% recommended N + No P, K, S and Zn, N_4= 50% recommended N + 50% recommended P, K, S and Zn, N_5= 100% recommended N + 50% recommended P, K, S and Zn and N_6= 100% recommended N + 100% recommended P, K, S and Zn.

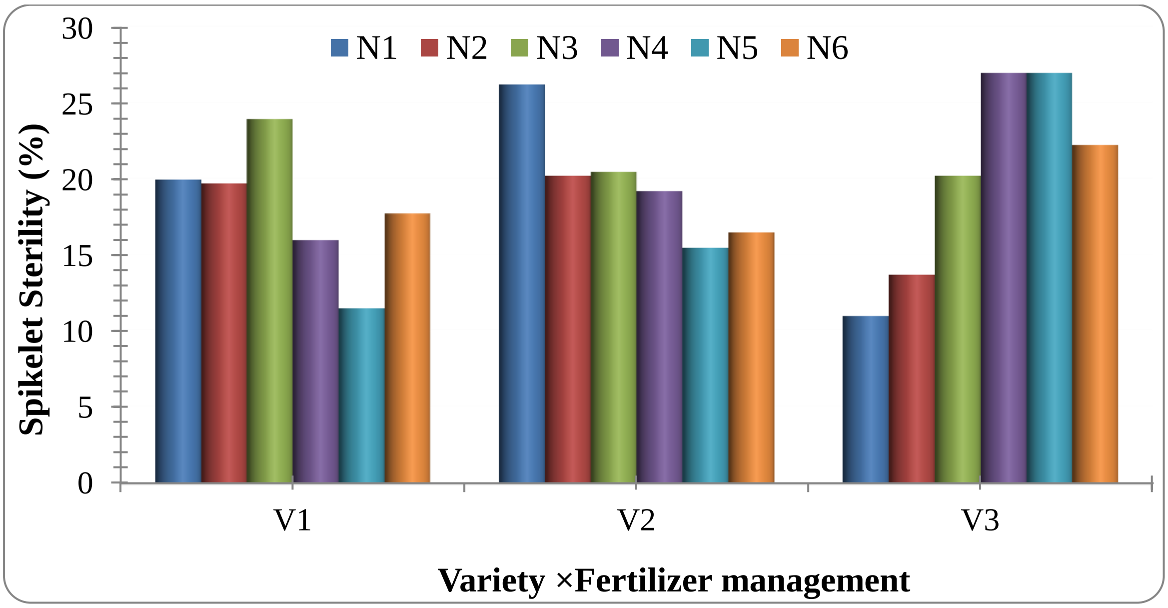
4.2.6.2 Effect of fertilizer management

Spikelet sterility was statistically influenced by fertilizer management (Table 9). The highest spikelet sterility (21.58 %) was recorded in N_3 (50% recommended N + No P, K, S and Zn) which was statistically similar with N_4 (50% recommended N + 50% recommended P, K, S and Zn). The lowest spikelet sterility (18.00 %) was recorded in N_5 (100% recommended N + 50% recommended P, K, S and Zn) and it was statistically similar to N_2 (50% recommended N + No P, K, S and Zn), N_6 (100% recommended N + 100%

recommended P, K, S and Zn) and N_1 (Control). The result indicated that N_5 (100% recommended N + 50% recommended P, K, S and Zn) treatment produced 3.58% higher spikelet sterility than N_3 (100% recommended N + No P, K, S and Zn) treatment plot and that of 2.75 % than N_4 (50% recommended N + 50% recommended P, K, S and Zn) treatment which also indicated that higher dose of N reduced the spikelet sterility of rice.

4.2.6.3 Interaction effect of variety and fertilizer management

Interaction between variety and fertilizer management had significant effect on spikelet sterility (Figure 13). The highest spikelet sterility (27.00 %) was recorded in V_3N_4 and V_3N_5 which was statistically similar to V_2N_1 and V_1N_3. The lowest spikelet sterility (11.00 %) was found V_3N_1 and it was statistically similar to V_1N_5.



V_1 = BRRI dhan51, V_2 = BRRI dhan72, V_3= Kumragor
N_1= Control, N_2= 50% recommended N + No P, K, S and Zn, N_3= 100% recommended N +No P, K, S and Zn, N_4= 50% recommended N + 50% recommended P, K, S and Zn, N_5= 100% recommended N + 50% recommended P, K, S and Zn and N_6= 100% recommended N + 100% recommended P, K, S and Zn.

Figure 13. Spikelet sterility of rice as influenced by interaction effect of variety and fertilizer management ($LSD_{0.05}$= 4.294).

4.2.7 Weight of 1000–grains

4.2.7.1 Effect of variety

Thousand seed weight was significantly influenced by variety (Table 10). The highest thousand seed weight (27.15 g) was observed in V_3 (Kumragor) and the lowest (17.75 g) was recorded in V_1 (BRRI dhan51). Bhowmick and Nayak (2000), Mishra and Pandey (1998) and Chowdhury *et al.* (1993) found almost similar results in respect of 1000 grains weight at different varieties of rice.

Table 10. Influence of variety and fertilizer on thousand seed weight of rice

Treatments	**Thousand seed weight(g)**
Variety	
V_1	17.75 c
V_2	26.40 b
V_3	27.15 a
LSD	0.483
CV	2.876
Fertilizer	
N_1	23.82
N_2	23.93
N_3	23.81
N_4	23.85
N_5	23.42
N_6	23.78
LSD (0.05)	0.609 (NS)
CV (%)	3.118

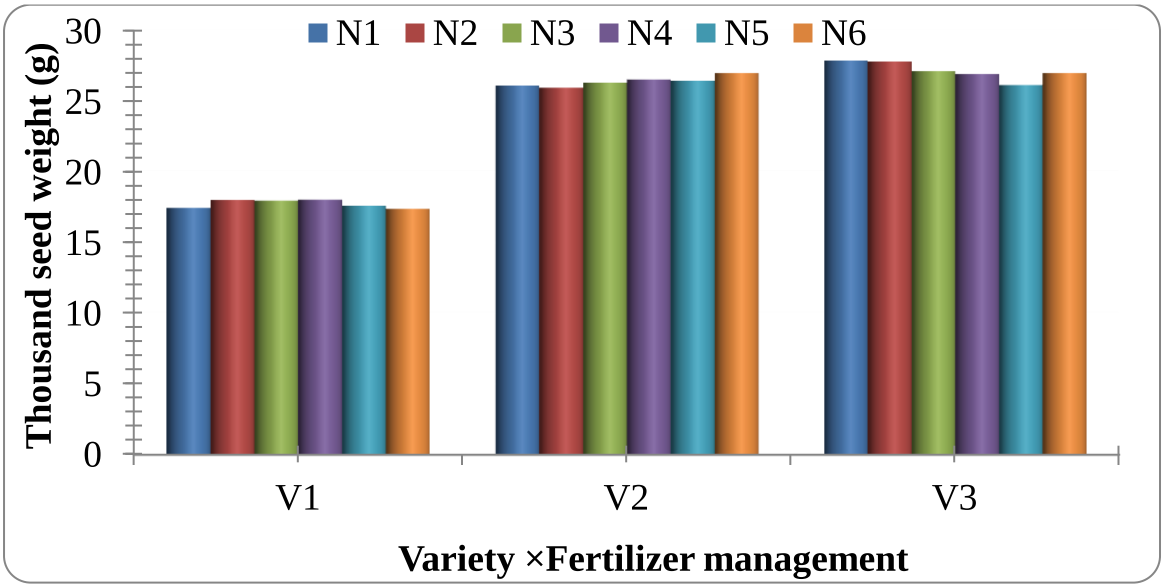
In a column, the means having the same letter (s) do not differ significantlyNS = Not significant, CV = Coefficient of variation, $LSD_{(0.05)}$=Least significant difference at 5% level,
V_1 = BRRI dhan51, V_2 = BRRI dhan72, V_3= Kumragor
N_1= Control, N_2= 50% recommended N + No P, K, S and Zn, N_3= 100% recommended N + No P, K, S and Zn, N_4= 50% recommended N + 50% recommended P, K, S and Zn, N_5= 100% recommended N + 50% recommended P, K, S and Zn and N_6= 100% recommended N + 100% recommended P, K, S and Zn.

4.2.7.2 Effect of fertilizer management

Thousand seed weight was not significantly influenced by fertilizer management(Table 10). Numerically the maximum thousand seed weight (23.93 g) was observed in N_2 (50% recommended N + No P, K, S and Zn) and the minimum (23.42 g) was recorded in N_5 (100% recommended N + 50% recommended P, K, S and Zn). Subhendu *et al.* (2003) conducted a field experiment during *kharif* season at Hyderabad, India and they found that the application of N (120 kg N ha^{-1}) as urea in equal splits resulted in the highest 1000 grain weight (22.57 g).

4.2.7.3 Interaction effect of variety and fertilizer management

Interaction between variety and nitrogen management had significant effect on thousand seed weight (Figure 14). The highest thousand seed weight (27.88 %) was recorded in V_3N_1 which was statistically similar to V_3N_2, V_3N_3, V_2N_6, V_3N_6 andV_3N_4. The lowest thousand seed weight (17.38 %) was recorded in V_1N_6 which was statistically similar toV_1N_1, V_1N_5, V_1N_3,V_1N_2 andV_1N_4.



V_1 = BRRI dhan51, V_2 = BRRI dhan72, V_3= Kumragor
N_1= Control, N_2= 50% recommended N + No P, K, S and Zn, N_3= 100% recommended N + No P, K, S and Zn, N_4= 50% recommended N + 50% recommended P, K, S and Zn, N_5= 100% recommended N + 50% recommended P, K, S and Zn and N_6= 100% recommended N + 100% recommended P, K, S and Zn.

Figure 14. Thousand seed weight as influenced by interaction effect of variety and fertilizer management ($LSD_{0.05}$= 1.055)

4.2.8 Grain yield

4.2.8.1 Effect of variety

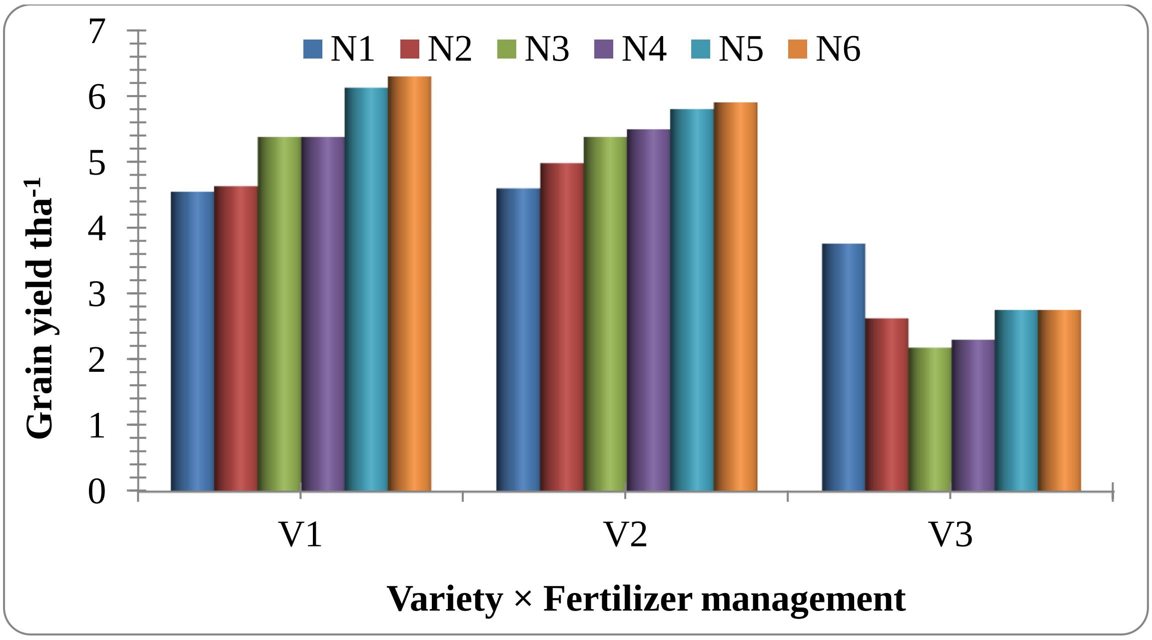
Variety had significant influence on grain yield of rice (Table 11). The result showed that higher yielding varieties V_1 (BRRI dhan51) and V_2 (BRRI dhan72) more yielded over local variety V_3 (Kumragor) by producing 2.56 and 2.53 tha^{-1} higher yieldrespectively. However the highest grain yield (5.39 tha^{-1}) was observed in V_1 (BRRI dhan51) which was statistically similar to V_2 (BRRI dhan72). The lowest grain yield (2.83 tha^{-1} was observed inV_3 (Kumragor). The present finding was conformity with Bisne *et al.* (2006), Patel (2000), Devaraju *et al.* (1998), Dwivedi (1997) and Chowdhury *et al.* (1993) that HYV varieties showed higher yield than local varieties.

4.2.8.2 Effect of fertilizer management

Grain yield was significantly influenced by fertilizer management(Table 11). The highest grain yield (4.98 tha^{-1}) was observed in N_6 (100% recommended N + 100% recommended P, K, S and Zn) which was statistically similar to N_5 (100% recommended N + 50% recommended P, K, S and Zn). The lowest grain yield (4.08 tha^{-1}) was found in N_2 (50% recommended N + No P, K, S and Zn). It can be inferred from the result that increased N rate N_6 (100% recommended N + 100% recommended P, K, S and Zn) and N_5 (100% recommended N + 50% recommended P, K, S and Zn) prove their superiority by producing 10.42%and 8.43 %respectively higher yield than N_1 (Control) and 22.06 % and 19.85 % respectively than N_2 (50% recommended N + No P, K, S and Zn). Idris and Matin, (1990) reported that application of fertilizer increased the yield of rice which supports the results of the present experiment.

4.2.8.3 Interaction effect of variety and fertilizer management

Interaction between variety and fertilizer management had significant effect on grains yield (Figure 15). The highest grain yield (6.30 t/ha) was found in V_1N_6 which was statistically similar with V_1N_5. The lowest grain yield (2.18 tha^{-1}) was recorded in V_3N_3 and it was statistically similar with V_3N_4.



V_1 = BRRI dhan51, V_2 = BRRI dhan72, V_3= Kumragor

N_1= Control, N_2= 50% recommended N + No P, K, S and Zn, N_3= 100% recommended N + No P, K, S and Zn, N_4= 50% recommended N + 50% recommended P, K, S and Zn, N_5= 100% recommended N + 50% recommended P, K, S and Zn and N_6= 100% recommended N + 100% recommended P, K, S and Zn.

Figure 15. Grain yield (tha^{-1}) as influenced by interaction effect of variety and fertilizer management (LSD$_{0.05}$= 0.351).

4.2.9 Straw yield

4.2.9.1 Effect of variety

Variety had significant influence on straw yield of rice (Table 11). The highest straw yield (8.48 tha^{-1}) was found in the local variety V_3 (Kumragor). The lowest straw yield (5.15 tha^{-1}) was recorded in the higher yielding variety V_1 (BRRI dhan51) which was statistically similar with V_2 (BRRI dhan72). These results are in agreement with the findings of by Patel (2000), Dwivedi (1997) and Chowdhury *et al.* (1993) that straw yield differed among the varieties.

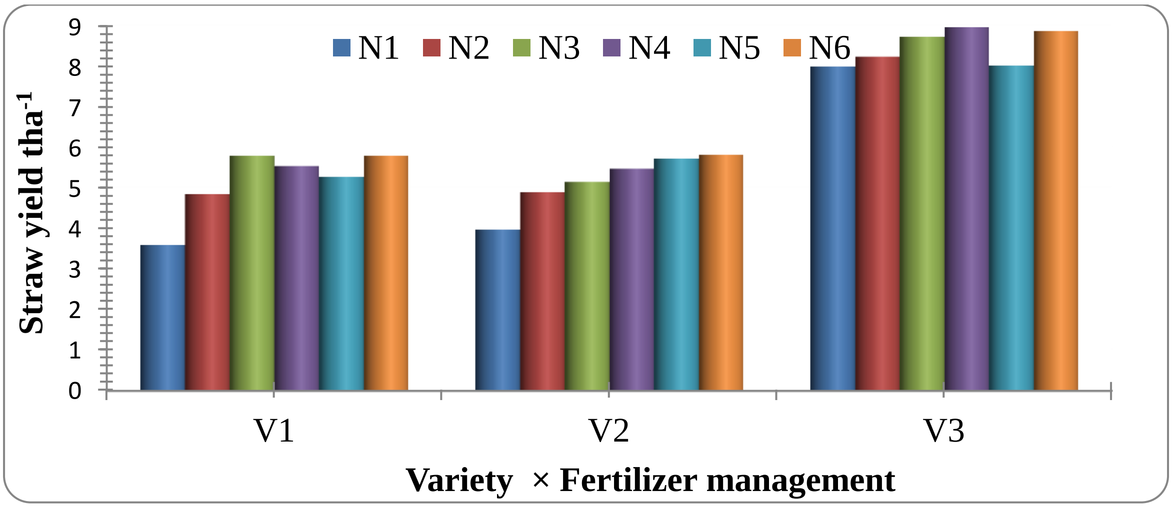
4.2.9.2 Effect of fertilizer management

Straw yield was significantly influenced by fertilizer management (Table 11). The highest straw yield (6.83 tha^{-1}) was observed in N_6 (100% recommended N + 100% recommended P, K, S and Zn) which was statistically similar with N_4 (50% recommended N + 50% recommended P, K, S and Zn), N_3 (100%

recommended N + No P, K, S and Zn) andN_5 (100% recommended N + 50% recommended P, K, S and Zn). The lowest straw yield (5.19 t/ha) was found in N_1 (Control). Elbadry *et al.* (2004), Meena *et al.* (2003) and El-Rewainy (2002) observed similar view on straw yield due to nitrogen application.

4.2.9.3 Interaction effect of variety and fertilizer management

Interaction between variety and fertilizer management had significant effect on straw yield (Figure 16). The highest straw yield (8.98 tha^{-1}) was observed in V_3N_4 which was statistically similar to V_3N_6, V_3N_3 andV_3N_2. The lowest straw yield (3.60 tha^{-1}) was found in V_1N_1 which was statistically similar to V_2N_1.



V_1 = BRRI dhan51, V_2 = BRRI dhan72, V_3= Kumragor
N_1= Control, N_2= 50% recommended N + No P, K, S and Zn, N_3= 100% recommended N + No P, K, S and Zn, N_4= 50% recommended N + 50% recommended P, K, S and Zn, N_5= 100% recommended N + 50% recommended P, K, S and Zn and N_6= 100% recommended N + 100% recommended P, K, S and Zn.

Figure 16. Straw yield (tha^{-1}) as influenced by interaction effect of variety and fertilizer management ($LSD_{0.05}$= 0.859).

4.2.10 Biological yield

4.2.10.1 Effect of variety

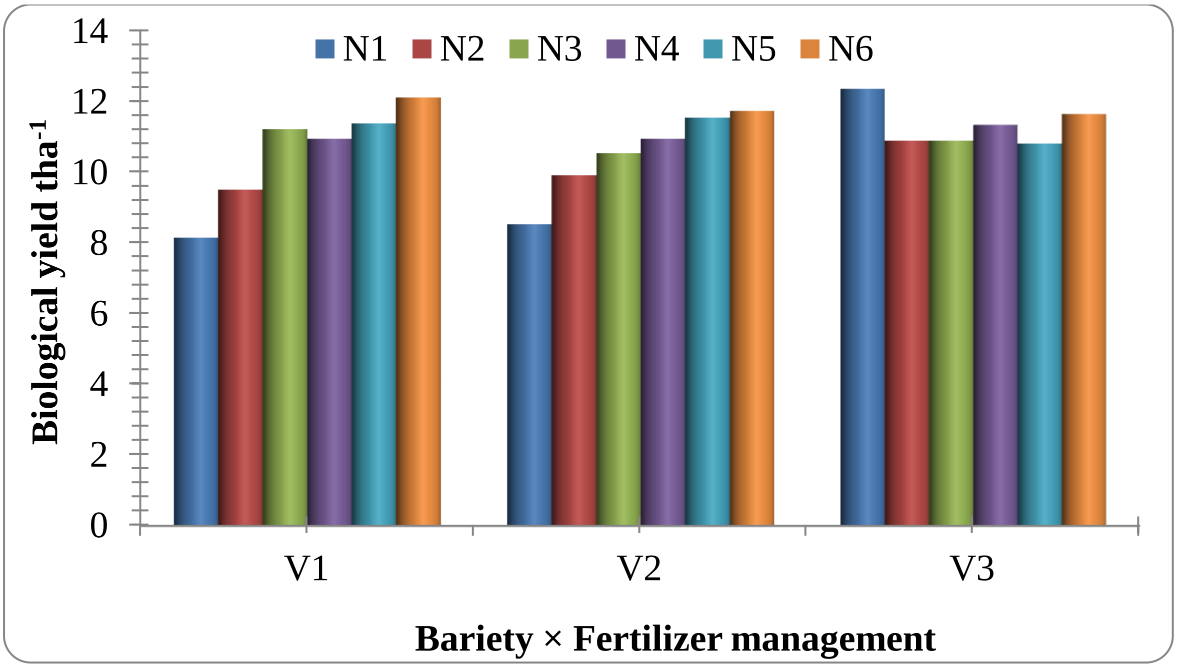
There observed a significant influence on biological yield of rice due to varieties (Table 11). The highest biological yield (11.31tha^{-1}) was observed in V_3 (Kumragor). The lowest biological yield (10.52 tha^{-1}) was found in V_2 (BRRI dhan72) which was statistically similar with V_1 (BRRI dhan51).

4.2.10.2 Effect of fertilizer management

Fertilizer management exerted significant influence on biological yield of rice (Table 11).The highest biological yield (11.82 tha^{-1}) was recorded in N_6 (100% recommended N + 100% recommended P, K, S and Zn) which was statistically similar with N_5 (100% recommended N + 50% recommended P, K, S and Zn). The lowest biological yield (9.68 tha^{-1}) was observed in N_1 (Control) and it was statistically similar to N_2 (50% recommended N + No P, K, S and Zn). The result agreed with the findings of Ahmed *etal.* (2005) observed the significant effect of nitrogen on biological yield (t ha^{-1}) of rice.

4.2.10.3 Interaction effect of variety and fertilizer management

Interaction between variety and fertilizer had significant effect on biological yield (Figure 17). The highest biological yield (12.35 tha^{-1}) was observed in V_3N_1treatment combination which was statistically similar to V_1N_6, V_2N_6, and V_2N_5. The lowest biological yield (8.15tha^{-1}) was found in V_1N_1 which was statistically similar to V_2N_1. In case of V_3N_1 treatment combination higher biological yield obtained but V_1N_1 andV_2N_1 treatment combination give lower biological yield due to local Kumragor variety (V_3) perform better without nitrogen but high yielding variety showed poor performance without nitrogen.



V_1 = BRRI dhan51, V_2 = BRRI dhan72, V_3= Kumragor
N_1= Control, N_2= 50% recommended N + No P, K, S and Zn, N_3= 100% recommended N + No P, K, S and Zn, N_4= 50% recommended N + 50% recommended P, K, S and Zn, N_5= 100% recommended N + 50% recommended P, K, S and Zn and N_6= 100% recommended N + 100% recommended P, K, S and Zn.

Figure 17. Biological yield (tha^{-1}) as influenced by interaction effect of variety and fertilizer management ($LSD_{0.05}$= 0.939).

4.2.11 Harvest index

4.2.11.1 Effect of variety

Variety showed significant influence on harvest index of rice (Table 11). The highest harvest index (51.35 %) was observed in V_1 (BRRI dhan51) which was statistically similar with V_2 (BRRI dhan72). The lowest harvest index (24.97 %) was found in V_3 (Kumragor). Alam (2002) also found the similar findings in respect of harvest index.

4.2.11.2 Effect of fertilizer management

Harvest index was significantly influenced by fertilizer management of rice (Table 11). The highest harvest index (48.43 %) was found in N_1 (Control). The lowest harvest index (39.63 %) was recorded in N_3 (100% recommended N + No P, K, S and Zn) and it was statistically similar with N_4 (50%

recommended N + 50% recommended P, K, S and Zn) and N_2 (50% recommended N + No P, K, S and Zn)

Table 11. Influence of variety and fertilizer management on grain yield, straw yield, biological yield and harvest index of rice

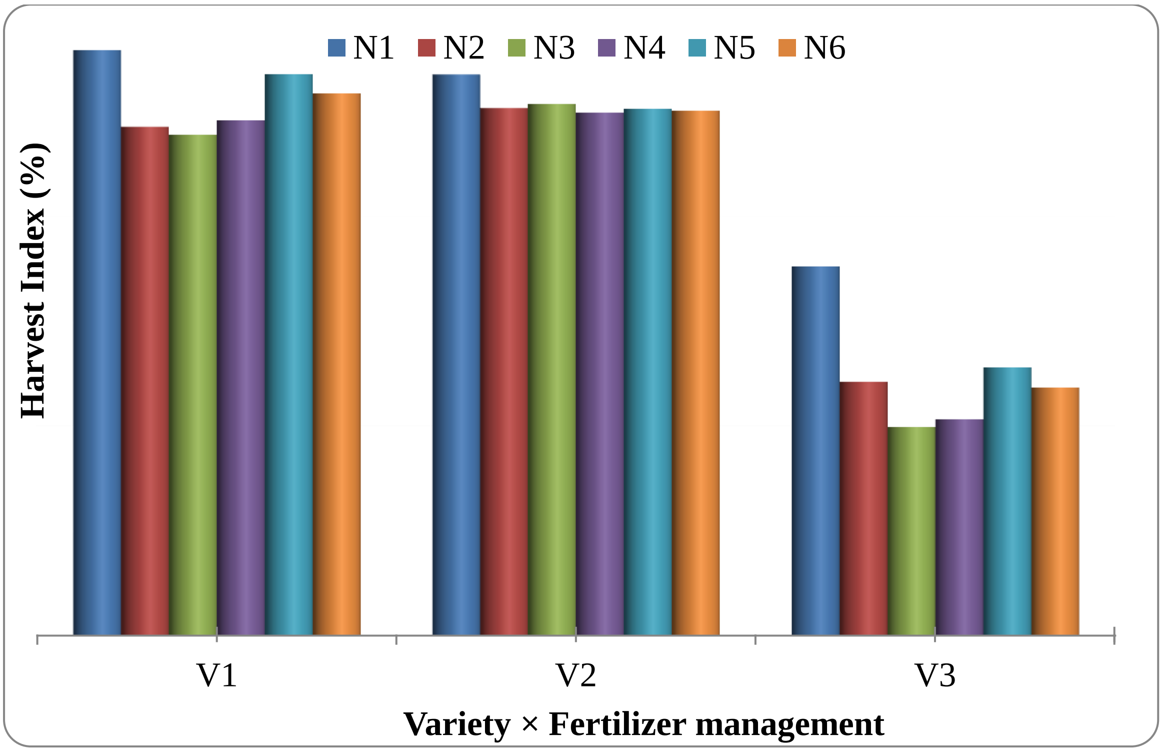
Treatments	Grain yield (tha^{-1})	Straw yield (tha^{-1})	Biological yield (tha^{-1})	Harvest Index (%)
Variety				
V_1	5.39 a	5.15 b	10.54 b	51.35 a
V_2	5.36 a	5.18 b	10.52 b	51.03 a
V_3	2.83 b	8.48 a	11.31 a	24.97 b
LSD (0.05)	0.205	0.495	0.578	1.397
CV (%)	6.40	11.185	7.58	4.66
Fertilizer				
N_1	4.51 b	5.19 c	9.68 c	48.43 a
N_2	4.08 c	6.00 b	10.09 c	41.21 cd
N_3	4.31 b	6.56 a	10.87 b	39.63 d
N_4	4.39 b	6.67 a	11.06 b	40.08 cd
N_5	4.89 a	6.34 ab	11.23 b	43.33 b
N_6	4.98 a	6.83 a	11.82 a	42.01 bs
LSD (0.05)	**0.203**	**0.496**	**0.542**	**2.038**
CV (%)	**5.46**	**9.63**	**6.11**	**5.838**

In a column, the means having the same letter (s) do not differ significantly, CV = Coefficient of variation, $LSD_{(0.05)}$=Least significant difference at 5% level,
V_1 = BRRI dhan51, V_2 = BRRI dhan72, V_3= Kumragor
N_1= Control, N_2= 50% recommended N + No P, K, S and Zn, N_3= 100% recommended N + No P, K, S and Zn, N_4= 50% recommended N + 50% recommended P, K, S and Zn, N_5= 100% recommended N + 50% recommended P, K, S and Zn and N_6= 100% recommended N + 100% recommended P, K, S and Zn.

4.2.11.3 Interaction effect of variety and fertilizer management

Interaction between variety and fertilizer management had significant effect on harvest index (Figure 18). The highest harvest index (56.13 %) was found in

$V_1N_1$and it was statistically similar with V_1N_5 and V_2N_1. The lowest harvest index (19.95 %) was observed in V_3N_3 which was statistically similar to V_3N_4.



V_1 = BRRI dhan51, V_2 = BRRI dhan72, V_3= Kumragor
N_1= Control, N_2= 50% recommended N + No P, K, S and Zn, N_3= 100% recommended N + No P, K, S and Zn, N_4= 50% recommended N + 50% recommended P, K, S and Zn, N_5= 100% recommended N + 50% recommended P, K, S and Zn and N_6= 100% recommended N + 100% recommended P, K, S and Zn.

Figure 18. Harvest index as influenced by interaction effect of variety and fertilizer management ($LSD_{0.05}$= 3.529).

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in polder 30 at Basurabad village, Batiaghata, Khulna district during the period from July 2016 to January 2017to determine the suitable fertilizer management practices to increase the yield of HYV aman rice in the polder ecosystem of the coastal zone of Bangladesh. The experiment comprised of two factors-Factor-A rice variety: 3, varieties- V1: BRRI dhan51, V2: BRRI dhan72 and V3: Kumragor and Factor B: No N + No P K S Zn (N_1), 50% recommended N + No P K S Zn (N_2), 100% recommended N + No P K S Zn(N_3),50% recommended N + 50% recommended P K S Zn (N_4),100% recommended N + 50% recommended P K S Zn (N_5) and 100% recommended N + 100% recommended P K S Zn (N_6). The experiment was set up following split-plot design with four replications. Results revealed that, variety, fertilizer levels and their interactions had significant effect on plant height at different days after transplanting. At harvest, the tallest plant (179.5 cm) was observed in Kumragor and the shortest plant (111.16 cm) was observed in BRRI dhan51. The tallest plant (147.68 cm) was recorded in N_6 (100% recommended N + 100% recommended P, K, S and Zn) compared to the lower levels of fertilizer at harvest. At harvest, the highest plant height (183.45 cm) was recorded in V_3N_5 which was statistically similar with V_3N_6, V_3N_3 and V_3N_2. The lowest plant height (104.80 cm) was found in V_1N_1.At harvest, the highest tillershill^{-1}(13.08) was observed in N_3 (100% recommended N + No P, K, S and Zn) which was statistically similar with N_6 (100% recommended N + 100% recommended P, K, S and Zn) and N_2 (50% recommended N + No P, K, S and Zn). The lowest tillershill^{-1}(10.52) was found in N_1 (Control). At 85 DAT, the highest tillershill^{-1}(12.14) was recorded in V_1 (BRRI dhan51) which was statistically similar with V_3 (Kumragor). The lowest tillers hill^{-1}(11.28) was found in V_2 (BRRI dhan72). At harvest, the highest tillers hill^{-1}(13.95) was observed in V_3N_6 which was statistically similar with V_1N_3, V_3N_3, V_1N_6, V_3N_2, V_2N_4, V_2N_3, V_1N_2 and V_1N_5. The lowest tillershill^{-1}(10.43) was observed in V_3N_1 which was statistically similar with V_2N_1, V_1N_1, V_1N_4, V_3N_4, V_1N_6, V_3N_5, V_2N_5, V_2N_2 and V_1N_5. The lowest effective tillers (no.) m^{-2} (200.33) was observed in N_1 (control).The highest effective tillers m^{-2} (247.29) was found in V_1 (BRRI dhan51). The lowest effective tillers m^{-2} (225.71) was observed in V_3 (Kumragor). The highest effective tillers m^{-2} (249.42) was observed in N_3 (100% recommended N + No P, K, S and Zn) which was statistically similar with N_6 (100% recommended N + 100% recommended P, K, S and Zn), N_2 (50% recommended N + No P, K, S and Zn) and N_4 (50% recommended N + 50% recommended P, K, S and Zn. The highest effective tiller m^{-2} (281.00) was observed in V_1N_3. The lowest effective tillers m^{-2} (281.00) was recorded in V_2N_1 but it was statistically similar to V_3N_1. Significant difference was observed in producing non-effective tillers hill^{-1} due to fertilizer, variety and their interactions. Among all the treatment maximum non-effective tillers m^{-2} was (13.00) observed in N_2 (50% recommended N + No P, K, S and Zn) which was statistically similar to other treatments. The highest non-effective tillers m^{-2} (14.00) was found in V_2 (BRRI dhan72) and it was statistically similar toV_3 (Kumragor). The lowest no of non-effective tillers m^{-2} (5.88) was observed in V_1 (BRRI dhan51).The highest non-effective tillers m^{-2} (17.50) was recorded inV_3N_2 and the lowest non-effective tillers m^{-2} (5.50) was observed inV1N4. The highest panicle length (26.53 cm) was found in V_2 (BRRI dhan72) and the lowest panicle length (22.41 cm) was observed in V_1 (BRRI dhan51). The highest panicle length (24.85 cm) was recorded in N_6 (100% recommended N + 100% recommended P, K, S and Zn). The lowest panicle length (23.71 cm) was found in N_1 (control). The highest panicle length (26.90 cm) was recorded in V_2N_4 but it was statistically similar with V_2N_3, V_2N_5,V_2N_6 andV_2N_2. The lowest panicle length (21.95 cm) was found in V_1N_3 which was statistically similar with V_1N_4, V_1N_5, V_1N_6, V_1N_2 and V_1N_1.

Fertilizer, variety and their interactions exhibited significant differences variation in producing filled grains panicle^{-1}. The highest total filled grains panicle^{-1} (124.71) was observed in V_1 (BRRI dhan51) and it was statistically similar to V_2 (BRRI dhan72). The lowest filled grains panicle^{-1}(67.33) was recorded in V_3 (Kumragor).The highest total filled grains panicle^{-1} (109.42) was recorded in N_6 (100% recommended N + 100% recommended P, K, S and Zn) where as the lowest total filled grains panicle^{-1} (98.92) was recorded in N_1 (Control) but it was statistically with N_3(100% recommended N + No P, K, S and Zn), N_2 (50% recommended N + No P, K, S and Zn) and N_4 (50% recommended N + 50% recommended P, K, S and Zn). The highest filled grains panicle^{-1} (137.75) was observed in V_1N_5 but it was statistically similar with V_1N_6. The lowest filled grains panicle^{-1} (58.25) was observed in V_3N_5 but it was statistically similar with V_3N_4 and V_3N_2. The highest unfilled grains panicle^{-1} (27.92) was recorded in N_3 (100% recommended N + No P, K, S and Zn) and the lowest unfilled grains panicle^{-1} (20.42) was found in N_5 (100% recommended N + 50% recommended P, K, S and Zn). BRRI dhan72 produced the highest number of unfilled grains panicle^{-1} (29.42) and the lowest number of unfilled grains panicle^{-1} (7.21) was observed in Kumragor. The highest unfilled grains panicle^{-1} (36.50) was found in V_2N_1 which was statistically similar to V_1N_3 and V_2N_2. The lowest unfilled grains panicle^{-1} (8.75) was recorded in V_3N_1 which was statistically similar toV_3N_2.

Variety, fertilizer and their interaction had significant effect on the production of spikelet sterility of rice. The highest spikelet sterility (21.58 %) was recorded in N_3 (50% recommended N + No P, K, S and Zn) which was statistically similar with N_4(50% recommended N + 50% recommended P, K, S and Zn). The lowest spikelet sterility (18.00 %) was recorded in N_5 (100% recommended N + 50% recommended P, K, S and Zn). The maximum spikelet sterility (20.21 %) was observed in V_3(Kumragor) and the minimum spikelet sterility (18.17 %) was found in V_1 (BRRI dhan51). The highest spikelet sterility (27.00 %) was recorded in $V_3N_4$and the lowest spikelet sterility (11.00 %) was found V_3N_1 and it was statistically similar to V_1N_5. Bottom portion of panicle produced the maximum sterility (%) whereas, the top portion of panicle produced minimum sterility (%) for all nitrogen treatments.

Fertilizer, variety and their interaction was observed significant in case of weight of 1000 grain.The highest thousand seeds weight (27.15 g) was observed in V_3 (Kumragor) and the lowest (17.75 g) was recorded in V_1 (BRRI dhan51). The maximum thousand seeds weight (23.93 g) was observed in N_2 (50% recommended N + No P, K, S and Zn) and the minimum (23.42 g) was recorded in N_5 (100% recommended N + 50% recommended P, K, S and Zn). The highest thousand seeds weight (27.88 %) was recorded in V_3N_1 which was statistically similar to V_3N_2, V_3N_3,V_2N_6,V_3N_6 andV_3N_4. The lowest thousand seeds weight (17.38 %) was recorded in V_1N_6.

Grain yield varied significantly due to variety, fertilizer management and their interaction. The highest grain yield (5.39 tha^{-1}) was observed in V_1 (BRRI dhan51) which was statistically similar to V_2 (BRRI dhan72). The lowest grain yield (2.83 tha^{-1}) was observed inV_3 (Kumragor). The highest grain yield (4.98 tha^{-1}) was observed in N_6 whereas the lowest grain yield (4.08 tha^{-1}) was found in N_2 (50% recommended N + No P, K, S and Zn). The highest grain yield (6.30 tha^{-1}) was found in V_1N_6 which was statistically similar with V_1N_5. The lowest grain yield (2.18 tha^{-1}) was recorded in V_3N_3 and it was statistically similar with V_3N_4. The highest straw yield (8.48 tha^{-1}) was found in V_3 (Kumragor). The lowest straw yield (5.15 tha^{-1}) was recorded in V_1 (BRRI dhan51).).The highest straw yield (6.83 tha^{-1}) was observed in $N_{6.}$ The lowest straw yield (5.19 $tha^{-1}$was found in N_1 (Control). The highest straw yield (8.98 tha^{-1}) was observed in V_3N_4 which was statistically similar to V_3N_6, V_3N_3 and V_3N_2. The lowest straw yield (3.60 tha^{-1}) was found in $V_1N_{1.}$). The highest biological yield (11.31 t ha^{-1}) was observed in V_3 (Kumragor). The lowest biological yield (10.52 tha^{-1}) was found in $V_{2.}$The highest biological yield (11.82 tha^{-1}) was recorded in $N_{6.}$The lowest biological yield (9.68 t/ha) was observed in $N_{1.}$ The highest biological yield (12.35 tha^{-1}) was observed in V_3N_1

which was statistically similar to V_1N_6, V_2N_6, V_3N_6 andV_2N_5. The lowest biological yield (8.15 tha^{-1}) was found in V_1N_1 which was statistically similar to V_2N_1.

Variety, Nitrogen and the interaction of fertilizer management and variety showed significant variation on harvest index. The highest harvest index (51.35 %) was observed in V_1 (BRRI dhan51) which was statistically similar withV_2 (BRRI dhan72). The lowest harvest index (24.97 %) was found in V_3 (Kumragor).The highest harvest index (48.43 %) was found in N_1 (Control). The lowest harvest index (39.63 %) was recorded in $N_{3.}$ The highest harvest index (56.13 %) was found in V_1N_1 and it was statistically similar with V_1N_5 and V_2N_1. The lowest harvest index (19.95 %) was observed in V_3N_3 which was statistically similar to V_3N_4.

From the result discussed above it can be concluded that reduction of 50% others fertilizers along with recommended nitrogen fertilizer could be cost effective fertilizer management in the polder ecosystem of the coastal zone.

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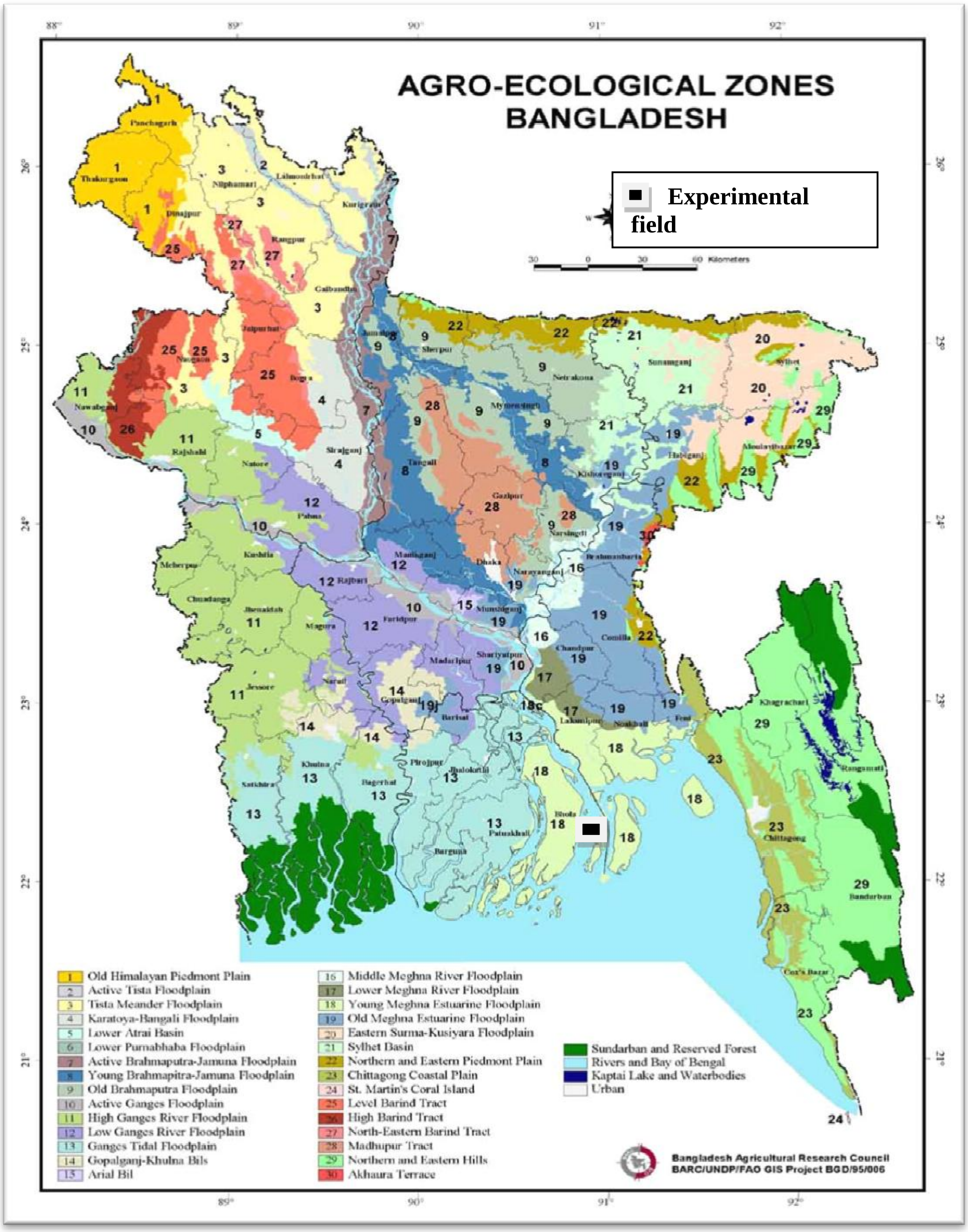
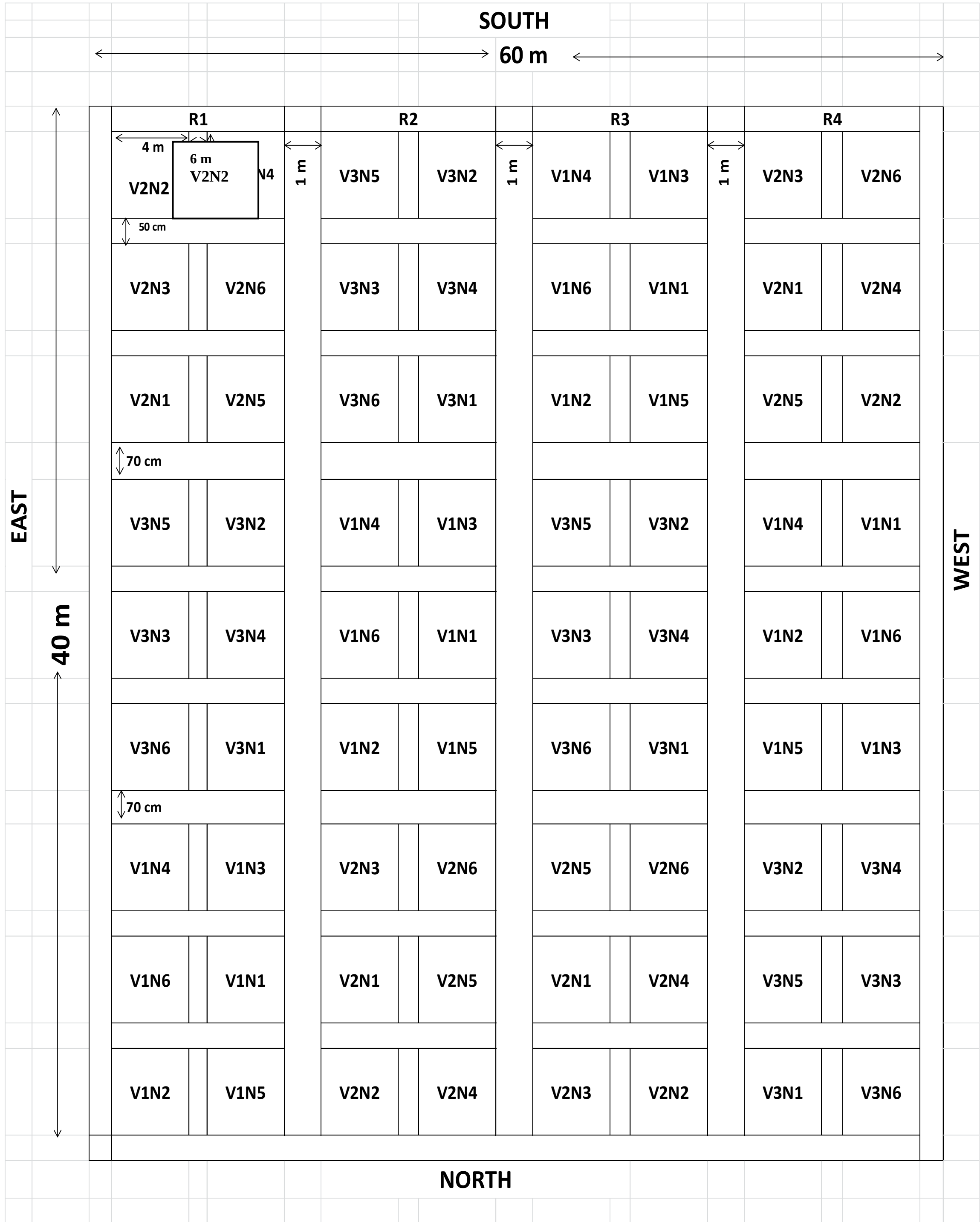
APPENDICES

Appendix I. Experimental location on the map of Agro-ecological Zones of Bangladesh



Appendix II. Layout of the experimental field



Appendix III. The mechanical and chemical characteristics of soil of the experimental site as observed prior to experimentation

Constituents	Percent
Sand	26
Silt	45
Clay	29
Textural class	Silty clay

Chemical composition:

Soil characters	Value
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.027
Phosphorus	6.3 µg/g soil
Sulphur	8.42 µg/g soil
Magnesium	1.17meq/100 g soil
Boron	0.88 µg/g soil
Copper	3.54 µg/g soil
Zinc	1.54 µg/g soil
Potassium	0.10 µg/g soil

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

Appendix IV. Mean square values of the data on plant height of rice as influenced by variety and fertilizer management

Source Of variation	Degrees of freedom	Mean square values at					
		25DAT	40DAT	55DAT	70DAT	85DAT	At Harvest
Replication	3	2.13	36.65	26.21	13.65	35.05	64.17
Factor A	2	12010.1*	15467.8*	23493.4*	20411.6*	28366.0*	28071.4*
Error (a)	6	9.93	20.36	37.19	19.19	17.98	11.51
Factor B	5	67.17*	122.61*	281.58*	187.130*	184.72*	171.12*
AB	10	4.79*	8.57*	9.13*	27.06*	31.62*	24.53*
Error (b)	45	4.19	7.19	15.90	15.30	15.55	18.03

* = Significant at 5% level of probability

Appendix V. Mean square values of the data on total tillers hill^{-1} of rice as influenced by variety and fertilizer management

Source Of variation	Degrees of freedom	Mean square values at					
		25DAT	40DAT	55DAT	70DAT	85DAT	At Harvest
Replication	3	2.83	25.88	1.74	4.57	1.58	.91
Factor A	2	40.48*	15.55*	4.47*	2.82*	5.00*	1.33*
Error (a)	6	4.84	11.37	4.07	1.48	.33	.496
Factor B	5	17.66*	31.40*	25.83*	9.58*	7.22*	9.92*
AB	10	2.74*	5.64*	2.97*	.96^NS^	1.32^NS^	1.23^NS^
Error (b)	45	4.44	8.22	5.02	1.25	1.30	1.79

* = Significant at 5% level of probability
NS= Non Significant

Appendix VI. Mean square values of effective tiller no., ineffective tiller no., filled grains per panicle, unfilled grains per panicle, total grains per panicle and 1000grain weight of rice as influenced by variety and fertilizer management

Source of variation	Degree of freedom	Effective tillers hill^{-1}	Ineffective tiller hill^{-1}	Filled grains panicle	Unfilled grains panicle	1000 grains weight
Replication	3	189.87	2.66	0.64	24.09	0.52
Factor A	2	3275.54*	525.43*	23854.0*	1043.04*	655.65*
Error (a)	6	204.634	11.76	125.26	10.13	0.467
Factor B	5	3521.30*	10.35*	164.21*	72.63*	0.38^NS^
AB	10	504.34*	4.53*	327.73*	166.57*	1.07^NS^
Error (b)	45	228.60	12.26	53.55	12.46	.55

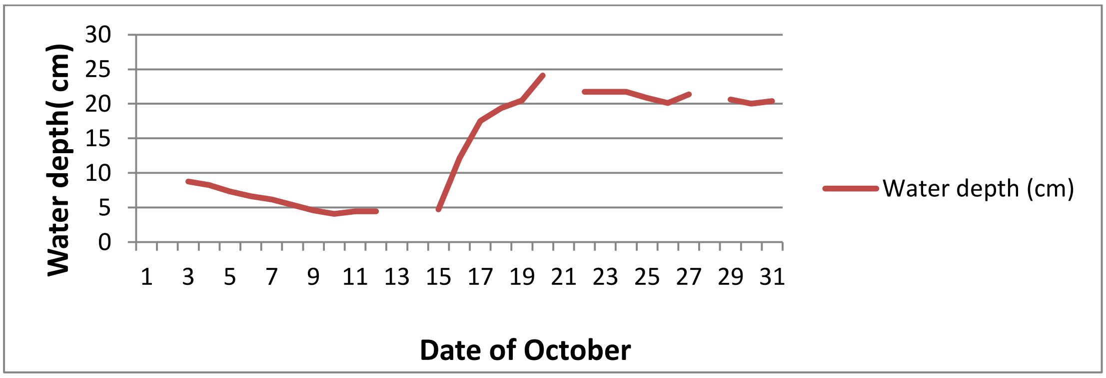
* = Significant at 5% level of probability
NS = Non Significant

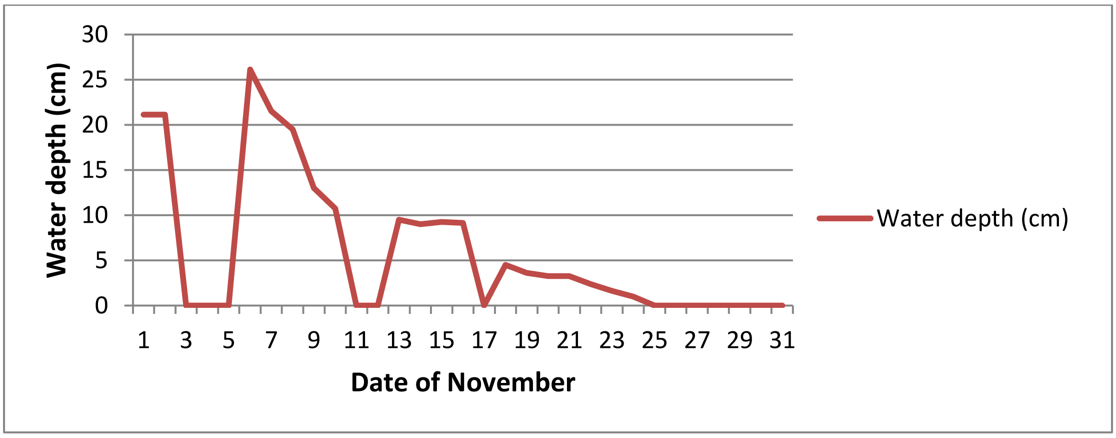
Appendix VII. Analysis of variance of the data on yield of rice as influenced by Variety and fertilizer management

Source of variation	Degree of freedom	Grain yield	Straw yield	Biological yield	Harvest index
Replication	3	0.11	0.15	0.26	8.34
Factor A	2	51.86*	87.90*	4.83*	5499.14*
Error (a)	6	0.85	0.49	0.67	3.91
Factor B	5	1.47NS	4.31*	7.34*	124.54*
AB	10	2.08	0.56	4.06	23.75
Error (b)	45	0.61	0.36	0.43	6.14

*Significant at 5% level of probability,
NS= Non Significant

Appendix VIII. Daily water depth (cm) of the experimental plots





PLATES

1. Field view of experimental field during transplanting

2. Field view of the differences among variety at vegetative stage

3. Field view of HYV and Kumragor (local) varieties at vegetative stages

4. Field view of tidal flood water in the experimental plots

5. Field view of taking green seeker reading

6. Field view of physiological maturity stage of BRRI dhan51