INFLUENCE OF FERTILIZER MANAGEMENT ON THE GROWTH AND YIELD OF BORO RICE

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CERTIFICATE

*This is to certify that the thesis entitled **"INFLUENCE OF FERTILIZER MANAGEMENT ON THE GROWTH AND YIELD OF BORO RICE"** 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 results of a piece of bona fide research work carried out by **MD. MAZHARUL ISLAM,** Registration. No. **15-06615** under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

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

Dated:

Dhaka, Bangladesh

(Prof. Dr. A. K. M. Ruhul Amin)
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INFLUENCE OF FERTILIZER MANAGEMENT ON THE GROWTH AND YIELD OF BORO RICE

ABSTRACT

An experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka 1207. Bangladesh during the period from November, 2020 to March, 2021 to observe the effect of different combination of chemical fertilizers and organic materials on the performance of rice varieties grown in boro season. The experiment comprised two factors viz. factor A: Variety – 3; i) BRRI dhan63 (V_1), ii) BRRI dhan81 (V_2) and BRRI hybrid5 (V_3) and factor B: different combinations of chemical fertilizers and organic materials – 5; i) Control (no fertilizer) (F_0), ii) chemical fertilizers T recommended dose (RDF) (F_1), iii) Cow dung + RDF (F_2), iv) Vermicompost + RDF (F3) and v) Rice straw decomposition + RDF (F_4). The experiment was laid out following Split Plot Design with three replications. Data were collected on different aspects of growth, yield attributes and yield of rice. Results revealed that BRRI hybrid5 gave the highest grain yield (7.84 t ha^{-1}). This may be attributed to the highest number of effective tillers $hill^{-1}$ (11.24) and 1000 grain weight (28.78 g) in this variety. Considering different combinations of chemical fertilizers and organic materials, F_4 (rice straw decomposition + RDF) treatment was highest grain yielder (7.59 t ha^{-1}) than other combinations comprised with organic materials and RDF which was due to the highest effective tillers $plant^{-1}$ (11.58), grains $panicle^{-1}$ (85.19) and 1000-grain weight (24.43 g) in this treatment. Regarding the interaction of variety and different combinations of chemical fertilizers and organic materials, the combination of rice variety BRRI hybrid5 x rice straw decomposition + RDF (V_3F_4) was highest yielder among the other interactions which was attributed to higher effective tillers $hill^{-1}$ (12.93) and 1000 grain weight (29.79 g). It may be concluded from the results that for adding organic matter in rice field, rice straw decomposition with recommended dose of chemical fertilizer (RDF) seems promising for cultivation of boro rice.

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LIST OF ACRONYMS

%	=	Percent
^0C	=	Degree Celsius
AEZ	=	Agro-Ecological Zone
AIS	=	Agriculture Information Service
B:C	=	Benefit Cost ratio
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
cm	=	Centi-meter
CV%	=	Percentage of coefficient of variance
cv.	=	Cultivar
DAS	=	Days after sowing
DF	=	Degree of freedom
EC	=	Emulsifiable Concentrate
et al.	=	And others
etc.	=	Etcetera
FAO	=	Food and Agriculture Organization
g	=	Gram
ha^{-1}	=	Per hectare
HI	=	Harvest Index
hr	=	Hour
Kg	=	Kilogram
LAI	=	Leaf area index
LSD	=	Least significant difference
LSD	=	Least Significant Difference
m	=	Meter
Max	=	Maximum
Min	=	Minimum
mm	=	Millimeter
MP	=	Muriate of Potash
N	=	Nitrogen
No.	=	Number
NPK	=	Nitrogen, Phosphorus and Potassium
NS	=	Non-significant
ppm	=	Parts per million
RCBD	=	Randomized complete block design
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
T	=	Ton
TSP	=	Triple Super Phosphate
viz.	=	Videlicet (namely)
WCE	=	Weed Control Efficiency
Wt.	=	Weight

Chapter I

INTRODUCTION

Rice *(Oryza sativa* L.) belongs to the Gramineae family and it is dominant over all other crops in respect of economic and social significance in Bangladesh. It is also largest cereal crop in Bangladesh. Worldwide, 502.98 million metric tons of rice were produced from 165.25 million hectares of land with an average yield of 4.43 t ha^{-1} during the year of 2021-22 (USDA, 2023). Rice is the staple food of about 135 million people in Bangladesh. Rice provides 20% of the world's dietary energy supply, it provides about two-third of total calorie supply and about one-half of the total protein intake of an average person in Bangladesh during the year 2021-22. In Bangladesh, 12.18 million ha area was cultivated for rice production and production was 40.49 million metric tons in 2021-2022 year (BBS, 2022). Bangladesh ranked 3rd position in producing world rice statistic (BARC, 2021). Unfortunately, the yield of rice in this country is low (average 3.4 t ha^{-1}) compared to other rice growing countries like South Korea and Japan where the average yield is 6.00 and 5.6 t ha^{-1}, respectively (FAO, 2019).

There are many reasons behind the lower yield of rice in general and boro rice is particular (Uddin *et al.*, 2018). Excessive or inappropriate use of chemical fertilizers (CFs) is a major cause of nutrient imbalance in soil, leading to high losses, particularly of N from the fertilizer, low N recovery (30%) (Krupnik *et al.*, 2004) and low N use efficiency (about 35%) in rice (*Cao et al.*, 2013) which may be a backdrop of rice production. Organic matter is a key factor for maintaining soil fertility, soil health and sustainable crop productivity. An ideal soil should contain 5% organic matter but most of the cultivated soil in Bangladesh has only less than 1.5%. Evidences from different AEZ of the country have shown a decrease in the content of organic matter by the range of 15 to 30% over the last 20 years (Miah, 2004). In fact, organic manure alone might not meet the plant's requirements due to the relatively low nutrient contents and the slow release of plant nutrients (Miah, 2004).

Thus, there has been a growing interest in the use of organic fertilizers along with chemical fertilizer for production (Reganold *et al.,* 2001). The integrated use of chemical and organic fertilizers improves plant growth and increases rice yield and quality (Masarirambi *et al.*, 2012 and Nambiar 2010). In this situation, vermicompost, cow dung and rice straw can be used to provide nutrients to the plants. Vermicompost has been considered as a soil additive to reduce the use of mineral fertilizers because it provides required nutrient amounts, increases cation exchange capacity and improves water holding capacity (Tejada and Gonzaler, 2009). It can enrich the soil and as a result yield is increased. Vermicompost not only increases yield of rice but can also substitute chemical fertilizer to some extent (Sharma *et al*., 2008). So use of chemical fertilizer can be reduced by adopting the use of vermicompost and a good combination of organic fertilizer and inorganic fertilizer should be followed.

However, after the industrial revolution wide spread introduction of inorganic fertilizers led to a decline in the use of organic material in the cropping systems (Rosegrant and Rournasset, 2008). The impact of increased fertilizer use on crop production has been large and important (Hossain and Singh, 2000). It has been estimated that fertilizer use growth contributed to about 25% of the total increase in rice production in Asia between 2005 and 2010 (Barker *et al.*, 2015*)*. However, in recent years there has been serious concern about long term adverse effect of continuous and indiscriminate use of inorganic fertilizers on deterioration of soil structure, soil health and environmental pollution (Ghosh and Bhat, 2002; Shukla *et al.,* 2003; Singh, 2000). The yield of rice has reached a plateau due to declining factor productivity under increasing intensification. Therefore, farmers are compelled to apply increasing rates of fertilizers to maintain current yield levels (Pagiola, 2005). The reasons for low yield of rice are manifold; some are varietals, others are technological and rests are climatic. Undoubtedly, with the introduction of high yielding varieties the yield of rice has been increased, but the trend of increase is not linear. The yield can be increased by using improved cultural practices like use of quality seed, high yielding varieties, adopting plant protection measures, judicious application of fertilizers, etc. Integrated nutrient management for rice can increase the productivity of rice.

The long-term research of BRRI revealed that the application of cow dung @ 5 t ha^{-1} year improved rice productivity as well as prevented the soil resources from degradation (Bhuiyan, 2010). Rice straw is another good source of nutrients in soil. Meelu and Singh (2008), showed that 4 t ha^{-1} rice straw along with 60 kg N ha^{-1} as urea produce grain yield of crop similar to that with 120 kg N ha^{-1} as urea alone.

Use of organic manures alone, as a substitute to inorganic fertilizer is not profitable and will not be enough to maintain the present levels of crop productivity of high yielding varieties (Garrity and Flinn, 2008). Therefore, integrated nutrient management in which both organic manures and inorganic fertilizers are used simultaneously is probably the most effective method to maintain healthy sustainable soil system can improve soil structure, improve nutrient exchange and maintain soil health has again raised interest in organic farming (Becker *et al.*, 2006: Ayoub, 2015). Vermicompost has been shown to have high levels of total and available nitrogen, phosphorous, potassium (NPK) and micro nutrients, microbial and enzyme activities and growth regulators (Parthasarathi and Ranganathan, 2019) and continuous and adequate use with proper management can increase soil organic carbon, soil water retention and transmission and improvement in other physical properties of soil like bulk density, penetration resistance and aggregation (Zebarth *et al.*, 2018) as well as beneficial effect on the growth of a variety of plants (Atiyeh *et al.*, 2002). Combined applications of both chemical and organic fertilizers need to be applied for the improvement of soil physical properties and supply of essential plant nutrients for high yield. However, it is necessary to carry out studies by using fertilizers and manures in an integrated way in order to obtain sustainable crop yield without affecting soil fertility. In view of limited information on the problems mentioned above, a study was therefore, undertaken with the following objectives:

1. To evaluate the performance of boro rice varieties under different fertilizer practices management.

2. To find out the combination of organic and different chemical fertilizer on boro rice, and

3. To select a suitable combination of boro rice variety and nutrient management on growth and yield of boro rice

Chapter II

REVIEW OF LITERATURE

Rice growth, yield and yield contributing characters are considerably influenced by different dose of chemical fertilizers and manures like cow dung, vermicompost and rice straw and their combined application. Soil organic manure and inorganic fertilizer is the essential factor for sustainable soil fertility and crop productivity because is the store house of plant nutrients. Sole and combined use of cow-dung, vermicompost, rice straw and inorganic manure acts as a source of essential plant nutrients. Experimental evidences in the use of cowdung, vermicompost, and urea, TSP, MOP and zypsum showed an intimate effect on the yield and yield attributes of rice. Yield and yield contributing characters of rice are considerably influenced by different doses of urea, TSP, MOP and zypsum fertilizer and cowdung, rice straw decomposition & vermicompost manure and their combined application. On the other hand cropping pattern also an important factor for the sustainable soil fertility and crop productivity. Literature reviewed in this regards on transplanted boro rice with different rates of inorganic and organic fertilizers have been presented below:

2.1 Effect of variety on growth and yield of rice

Khatun *et al.* (2020) was conducted a field experiment with six rice varieties to determine their growth and yield performance. All the growth and yield contributing attributes varied significantly among the six rice varieties. The results revealed that in all rice varieties maximum growth performance observed at 58-68 Days after transplanting and maximum dry matter production was observed at 68 days after transplanting. Maximum number of filled spikelet observed in Binadhan-17 (164.89/panicle) and that was significantly different from other varieties. Percent of sterile spikelet was highest in BRRI dhan39 (12.9%) and that was statistically similar with Binadhan-16 (11.96%) and BRRI dhan33 (12.36%). Maximum 1000-seed weight was observed in Binadhan-17 (27.25g). Highest grain yield was obtained from Binadhan-17 (6.13 t ha^{-1}) that was significantly different from other varieties. Lowest grain yield observed in BRRI dhan39 (4.49 t ha^{-1}) that was statistically similar to BRRI dhan33 (4.57 t ha^{-1}) and Binadhan-7 (4.86 t ha^{-1}).

At 100 DAT, the highest plant height, maximum number of tillers hill^{-1}, dry matter of shoot hill^{-1} and dry matter of root hill^{-1} were obtained from BRRI dhan29 and the lowest values were found in Binadhan-14. Variety had significant effect on all the crop characters under study except 1000-grain weight. The highest grain yield was obtained from BRRI dhan29 and the lowest value was recorded from Binadhan-14.

Murshida *et al.* (2017) conducted an experiment to examine the effect of variety on the growth and yield performance of boro rice. The experiment consisted of three varieties (cv. BRRI dhan28, BRRI dhan29 and Binadhan-14). Different growth characters, yield and yield contributing characters of boro rice were found to the significantly influenced by variety.

Chamely *et al.* (2015) was conducted an experiment to study the effect of variety on the performance of boro rice. The experiment comprised three varieties viz., BRRI dhan28 (V1), BRRI dhan29 (V2) and BRRI dhan45 (V3). The growth analysis results indicate that the tallest plant (80.88 cm) and the highest number of total tillers hill^{-1} (13.80) were observed in BRRI dhan29 at 70 DATs and the highest total dry matter (66.41 g m^{-2}) was observed in BRRI dhan45. The shortest plant (78.15 cm) and the lowest number of tillers hill^{-1} (12.41) were recorded from BRRI dhan45 and the lowest dry matter (61.24 g) was observed in BRRI dhan29. The harvest data reveal that variety had significant effect on total tillers hill^{-1}, effective tillers hill^{-1}, non-effective tillers hill^{-1}, panicle length, grain yield, straw yield and harvest index. The highest grain yield (4.84 t ha^{-1}) was recorded from BRRI dhan29.

Sarkar *et al.* (2014) was conducted an experiment to study the yield and quality of aromatic fine rice as affected by variety and nutrient management. The experiment comprised three aromatic fine rice varieties viz. BRRI dhan34, BRRI dhan37 and BRRI dhan38. The tallest plant (142.7 cm), the highest number of effective tillers hill^{-1} (10.02), number of grains panicle^{-1} (152.3), panicle length (22.71cm), 1000-grain weight (15.55g) and grain yield (3.71 t ha-1) were recorded in BRRI dhan34. The highest grain protein content (8.17%) was found in BRRI dhan34 whereas the highest aroma was found in BRRI dhan37 and BRRI dhan38.

Vergara *et al.* (2013) reported about the variable effect of variety on the number of grains panicl^{-1}. Choudhury and Ghosh (2012), carried out a number of field trials with 62 line of scented rice cultivars and observed that 1000-grain weight was highly variable that ranged from 9.0 to 23.0 g. But in some varieties, 1000-grain weight was identical in BR3 and BR8 varieties. Sawant *et al.* (2011) conducted an experiment with the new rice cv. R-73- 1 - 1, R-711 and the traditional cv. Ratna and reported that the traditional cv. Ratna was the shortest for the new rice cv. R-73- 1-1, R-711. Babiker (2002) carried out an experiment with rice cv. Giza-171 and Giza- 180 and observed that, total tillers hill^{-1} was significantly affected by the cultivars. The variable effect of cultivar on total number of tillers hill^{-1} was also observed by (Idris and Matin, 2010). Shamsuddin *et al.* (2010) conducted an experiment with 9 different rice varieties and observed that plant height different significantly among the varieties.

Kamal *et al.* (2009) carried out an experiment with BR3, IR20 and Pajam2 and found that number of grains panicle^{-1} were 107.6, 123.0 and 170.9, respectively for the three varieties. Rafey *et al.* (2007) conducted an experiment with different rice cultivars and reported that 1000-grain weight differed among the cultivars studied. Singh and Gangwer (2006) reported from an experiment with four rice cultivar C-14-8, CR-1009, IET-5656 and IET-6314 that grain number panicle, 1000-grain weight and biological yield were the highest for C-14-8 among the varieties. BRRI (2001) reported that the number of effective tillers produced by some transplant *aman* rice ranged from 7 to 14 and it was significantly differed with variety to variety. Khan (2001) conducted a greenhouse pot experiment with rice cv. BR6 and CSR4 and reported that yield was higher in cv. CSR4 than in BR6.

BRRI (2001) also reported that the plant height differed among the varieties. Hossain *et al.* (2003) reported that the growth characters like plan height total tillers hill^{-1} and number of grains panicle^{-1} differed significantly among BR3, BR11, Pajam and Jaguli varieties in boro season. Suprihatno and Sutaryo (2000) evaluated the performances of seven IRRI hybrids and 13 Indonesian hybrids using IR 64 and Way-Seputih as cheek varieties. They concluded that IR 64 was the highest yielding, significantly out yielding then IR 64616H, IR 64610H and JR 62829A/IR 54 which in turn out yielding Way - Seputih.

Chowdhury *et al.* (2001) stated that the cultivar BR23 showed superior performances over Pajam in respect of yield and yield contributing characters viz, number of bearing tiller hill^{-1}, length of panicle, 1000-grain weight, grain and straw yields. On the other hand Pajam produced significantly taller plant, higher number of total spikelets panicle^{-1}, grains panicle^{-1} and sterile spikelets panicle^{-1}. Ali and Murshid (1999) conducted an experiment during July to December 1999 to determine suitable variety for late transplanted aman rice, cv. BR23, BRI I and Kumragoir. They reported that local Kumragoir statistically out yielded the modem two cultivars of BR23 and BR11.

BINA (2000) evaluated the performance of four varieties IRATOM 24, BRI4, BINA 13 and BINA 9. It was found that varieties differed significantly on plant height, panicle length, number of nonbearing tillers, and sterile spikelets panicle^{-1}.

BRRI (1999) reported that Tulsimala produced the highest number of spikelets panicle^{-1} and BR 14 produced the lowest number of spikelets panicle^{-1}. BRRI (1998) conducted an experiment to find out the performance of BR4, BR10, BR11, BR22, BR23 and BR25 cultivars including two local Check Challish and Nizersail planted at 20 cm x 20 cm spacing with 2-3 seedlings hill^{-1}. The results indicated that BR4, BR10, BR11, Challish and Nigersail produced grain yields of 4.38, 3.12 and 2.70 t ha^{-1}, respectively. Challish cultivar followed earlier than all other varieties. BR22 and BR23 showed poor performance.

2.2 Effect of chemical fertilizers on rice

Miah and Eunus (2020) reported that the application of increased doses of NPK tended to produce increased grain yield. Among the 16 NPK treatment combinations, 111 kg of N and 45 kg each of P_20_5 and K_20 ha^{-1} came out to be the best for grain yield. Bhuiya *et al*. (1979) carried out a fertilizer trial in the Bangladesh Agricultural University Farm with IR8, a high yielding rice variety using three rates of N (0, 113 and 135 kg N ha^{-1}), two rates of P (0 and 45 kg P_20_5 ha^{-1}) and two rates of K (0 and 45 kg K_20 ha^{-1}). Application of N and P increased both the grain and straw yield. But the effect of N application was more pronounced than the effect noted due to P application. The application of K slightly decreased the grain and straw yield of rice.

Hossain *et al*, (2019) reported that sulphur application significantly increased the grain and straw yield of rice and Zn + NPK applications increased higher grain and straw yield but were not statistically significant over NPK treatment. Sulphur and Zn content in grain and straw increased considerably due to addition to S and Zn respectively. Greatly boosted up to 5% and 82% over control when sulphur was added with N and NPK treatment, respectively.

Chaudhury and Badiuzzaman (2018) found that grain yield increased significantly due to application of K up to 100 kg ha^{-1} and grain and straw yield also increased due to application of 30 kg ha^{-1} S and highest grain yield (5.9 t ha^{-1}) from combined application of 150 kg K_20 and 30 kg S ha^{-1} as well as applying K favourably influenced yield components while S level had no significant variations on plant hight and straw yield.

Sagwal and Kumar (2017) carried out an experiment on Basmati-370 rice in 1990 during rainy season by applying zero fertilizer, 60 kg N, 30 kg P_20_5, 30 kg K_20 or 25 kg $ZnSO_4$ ha^{-1} as N, NP, NPK or N P K Zn to Basmati-370 and PK and Zn were applied at pudding and N in 2 equal splits 3 and 6 weeks after transplanting. Grain yield ranged from 1.6 t ha^{-1} with no fertilizer to 2.59 t ha^{-1} with NPKZn a financial returns were highest N P K Zn.

Choudhury *at al.*, (2016) conducted a field experiment during dry and wet season with cv. BR3 and BR11 and observed that combined application of N, P, K and S from urea, TSP, MP and gypsum gave similar grain yields of 5.6-5.7 t ha^{-1} in the wet season.

Sajjad (2015) conducted field experiment in Papua New Guinea on rice cv. wantok and Tamba applying on fertilizers or S fertilizers rates between 60-30-30 and 140-70-70 kg NPK ha^{-1}, yield on wantok was 4.7 t ha^{-1} in the control treatment and highest (8.8 t ha^{-1}) at the highest NPK rate but yield increase was significant only up to 100-50-50 kg NPK ha^{-1} (8.1 t ha^{-1}). Yield of Tambu was 5.2 t ha^{-1}without fertilizers and 8.8 t ha^{-1} at the highest application rate, which was not significantly different from 7.5 t ha^{-1} with 120-60-60 kg ha^{-1}.

Gogoi and Lalita (2014) conducted an experiment by applying 3 rates of NPK fertilizer (0-0-0, 20-10-10, or 40-20-20 kg ha^{-1} as N-P_20_5-K_20) on transplanted rice cv. Mahsuri and Badshabhog under flood condition. Cultivar Mahsuri (4.08 t ha^{-1}) significantly out yielded the traditional Baotshabhog (2.75 t ha^{-1}).

Lal and Roy (2013) carried out an experiment on rice and applying zero NPK. 2 rates between 2kg N +1kg P_20_5 + 0.5 kg K_20 and 10 kg N +15 kg P_20_5 +2.5 kg K_20/1000 m^2. Grain yield of 3.96 t $ha^{-1}$was obtained when 2 kg N + 1 kg P_20_5 + 0.5 kg K_20. A further increase in the NPK rate did not increase the grain yield significantly.

Naidu *et al.* (2013) reported that the highest growth, yield attributes, lesser spikelet sterility and higher grain yield were obtained with the application of 100–50–50 kg ha^{-1} N, P_2O_5, K_2O and these parameters were at their minimum with the supply of 60– 30–30 kg ha^{-1} of N, P_2O_5, K_2O. The increase in yield with supply of 100–50– 50 kg ha^{-1} N, P_2O_5, K_2O (N3), compared to supply of 60–30–30 kg ha^{-1} N P_2O_5, K_2O (N1) was 15.1 and 15.4% respectively during 2006 and 2007, respectively.

Fageria and Zimmerman (2012) found that grain yield, dry matter production and yield components increased with increasing fertilizer rates. Yoshida *et al.* (2011) viewed that as the amount of nitrogen absorbed by the crop increases, there is an increase in the number of tillers per square meter. Singh *et al.* (2008) reported that surface application of gypsum @ 25 or 50% GR before transplanting of rice gave higher grain yield. Tandon (2007) stated that phosphorus is the second key nutrient element and plays a critical role in the life cycle of plants. It is needed greatly by young, fast growing tissue and performs a number of functions related to growth, development, photosynthesis and utilization of carbohydrate.

BRRI (1990) reported that nitrogen has a positive influence on the production of effective tillers. Saharawat *et al.* (2006) showed that grain yields increased with increasing application of triple superphosphate (TSP). Raju *et al.* (2005) found that phosphorus has marked beneficial impact on seedling establishment, root biomass production, flowering and maturity of the crop. Ahsan *et al.* (2004) observed the negative K balance was observed even up to 60 kg ha^{-1} of the applied K level with diminishing magnitude and suggested that an amount of about 61 kg K ha^{-1} would be required to sustain soil native K for rice cropping.

Stewart *et al.* (2004) observed that plants grown as green manures that are capable of extracting P from rock phosphate have the potential to supply P to a subsequent crop through organic P mineralization.

Zakir *et al.* (2003) was noted that application of FYM with Gypsum was the best in obtaining highest number of filled grains which might be occurred by the reduction of sodium ion concentration in these treatment over control.

Amim *et al.* (2004) conducted an experiment to evaluate the effect of increased plant density and fertilizer dose on yield of rice variety IR-6. He found that increased fertilizer dose of NPK increase plant height. 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.

Satyanarayana *et al.* (2002) observed the significant influence of different inorganic manure levels on grain and straw yield, tiller numbers, filled grains per panicle and 1000-grain weight of rice. Application of 120:60:45 kg N:P_2O_5 :K_2O ha^{-1} produced significantly greater grain yield (3.63 t ha^{-1}) as compared to that obtained with lower fertilizer levels of N:P_2O_5 :K_2O ha^{-1} (3.17 t ha^{-1}). Behera *et al.* (2009) stated that application of higher fertilizer level of 160:80: N: P_2O_5:K_2O ha^{-1} produced grain yield of 3.76 t ha^{-1}, which was statistically similar to that obtained with application of 120:60:45 kg N: P_2O_5:K_2O ha^{-1}. Similar effects were also observed for straw yield, number of tillers, filled grains per panicle and 1000-grain weight. These effects were due mainly to low available N and P in the soil.

Ali *et al.* (2001) stated that addition of gypsum initially increases the EC of the soil, they recommended that either extra irrigation should be applied or high delta crop should be grown. Haq *et al.* (2001) various amendments like gypsum, sulphur, acids, press mud and farm yard manure (FYM) may be used for reclamation of these soils. Sudhakar *et al.* (2001) found that there was a significant increase grain yield, straw yield, net return and B:C ratio with each increment of nitrogen application up to 125 kg ha^{-1}. Kumar *et al.* (2001) during their study mentioned that using of phosphate fertilizer increased grain yield. Bayan *et al.* (2002) claimed that tillers $hill^{-1}$ increased with the application of nitrogen fertilizer.

Peng *et al.* (2000) claimed that higher level of nitrogen through effect on yield components specifically the number of panicle and the number of seed per panicle and also effect on traits such as panicle length and increase in flag leaf area causes more increment in total dry matter accumulation. Hassan *et al.* (2001) found that the pH of the leachates collected from control pots did not show any significant decrease even after ninth collection, however by adding and increasing the level of gypsum, the average value of pH decreased moderately i.e. from 9.07 (control) to 8.18 (T6, 200% yield of 25.3 gm pot-1 was produced by the treatment No. 6 which had received 200% gypsum of the soil requirement. It was followed by the treatment No.5 that had received 100 % gypsum of the soil requirement. The grain yield in this treatment was recorded 24.70 gm pot^{-1} the percent increase over control for T_5 and T_6 were noted as 44.2 and 47.7 respectively.

Singh *et al.* (1999) conducted a field experiment to study the effect of sources of phosphorus (0, 30 and 60 kg P205 ha^{-1}) on growth, grain yield and phosphorus use-efficiency of rice and residual effects which revealed that the grain yield of rice increased with up to 30kg P_20_5 ha^{-1}.

Dobermann *et al.* (1998) found that increase in soil available K due to straw application. Thakur *et al.* (1999) found that potassium performs many functions in plant metabolism, promoting photosynthesis, harnessing the interaction of K with N, and hence could have increased the nutrient uptake. Chopra *et al.* (2000) reported that effective tillers $hill^{-1}$ N ha^{-1} increased with the application of 80 or 120 kg.

2.3 Effect of cow dung on rice

Islam *et al*. (2013) studied to evaluate the effect of nitrogen supplied from organic sources (cowdung, poultry manure and compost) and inorganic source (urea) on the yield and nitrogen use efficiency of BRRI dhan28. The treatments were T0 (Control), T_1 (100% N from RFD), T_2 (70% N from RFD, RFD + 30% N from CD), T_3 (70% N from RFD + 30% N from PM), T_4 (70% N from RFD + 30% N from CoM), T_5 [70% N from RFD + 30% N from (CD + PM + CoM)], T_6 [100% N from (CD + PM + CoM), T_7 [100% N from RFD + 30% N from (CD + PM + CoM)].

Rifat-E-Mahbuba (2013) found that the Application of N as PU, USG alone or in combination with cowdung significantly increased yield components, grain and straw yields of BRRI dhan28 rice. The treatment T3 (78 kg N ha^{-1} from USG) produced the highest grain yield of 5.85 t ha^{-1} and straw yield of 5.50 t ha^{-1} due to the treatment T_6. The treatment T_2 (104 kg N ha^{-1} from USG) performed better than T_1 and T_4, indicating the superiority of USG over PU. The N, P and K uptake by BRRI dhan28 rice were influenced profoundly due to the application of USG alone or in combination with cowdung. The overall results indicate that application of USG in combination with cowdung could be considered more effective in rice production.

Buri *et al*. (2006) concluded in an experiment with poultry manure, cattle manure, and rice husks, applied solely or in combination with mineral fertilizer (using urea or sulphate of ammonia as N source) that a combination of a half rate of organic amendments and a half rate of mineral fertilizer significantly contributed to the growth and yield of rice. Nyalemegbe *et al*. (2010) found that combining 10 t ha^{-1} of cowdung with 45 kg N ha^{-1} urea, or 10 t ha^{-1} poultry manure with 60 kg N ha^{-1}, gave yields comparable to those under high levels of nitrogen application (i.e., 90 and 120 kg N ha^{-1}) applied solely. The highest grain yield of 5847 kg ha^{-1} was observed in the treatment T_7 and the lowest grain yield of 2426 kg ha^{-1} was found in T_0. The highest N uptake (138.9 kg ha^{-1}) was found in T_7 followed by T_1 (119.8 kg ha^{-1}). The highest nitrogen use efficiency was observed in T_6 and the lowest value was noted in T_5.

Solaiman *et al*. (2006) found that the highest plant height and dry weight of shoot, the maximum number of clusters of flowers and fruits $plant^{-1}$as well as the greatest fruit size and fruit yield/plant, fruit yield/ha were obtained from the application of the recommended dose of nutrients viz. 200 kg N + *35* kg P + 80 kg K + 15 kg S ha^{-1} , but similar results were obtained from the treatment receiving 5 t ha^{-1} cowdung along with half of the recommended doses of nutrients (100 kg N+ 17.5 kg P + 40 kg K + *7,5* kg S ha^{-1}). The effect of l0t cow dung per ha, along with one third of the recommended dose of nutrients, was also comparable to the effect of employing the recommended dose of nutrients. It was further observed, from an economic standpoint, that the combination of 5 t ha^{-1} cowdung along with half of the recommended doses of nutrients appeared to be a viable treatment which would offer the maximum benefit concerning cost ratio (4.38) for tomato production in the shallow redbrown terrace soil (AEZ-28) of Bangladesh.

Adeoye *et al*. (2004) demonstrated that cow dung has a reasonably high content of N, K and fibrous materials that favorably regulates soil moisture, temperature and even prevents multiplication effects of weeds on soil surfaces.Glaser *et al*. (2004) found that losses of soil organic matter can only be replenished in the short term by application of organic matter such as manure.

Bhuiyan (2010) implied that application of cowdung @ 5 t ha^{-1} yr^{-1} improved rice productivity as well as prevented the soil resources from degradation. Parham *et al*. (2002) observed that cattle manure-P is relatively more mobile than inorganic fertilizer-P and promotes microbiological activities and P cycling.

Abe *et al*. (2001) reported that cattle manure applied to the rice crop increased root density and enhanced root growth to deeper soil layers. Mannan *et al*. (2000) showed that straw yield was highest from BR23 and lowest from BR11 for cowdung application. Grain protein content was similar and higher in BR11 and BR23 than the other varieties. Among the fertilizer application treatments, F_5 and F_3 produced the highest and F_1 the lowest grain and straw yields. Grain protein content was higher in F_5, F_4 and F_1 treatments receiving 5 or 10 t ha^{-1} cow dung and late N application. Manu ring with cow dung up to 10 t ha^{-1} in addition to recommended inorganic fertilizers with late N application improved grain and straw yields and quality of transplant autumn rice over inorganic fertilizers alone.

Rashid and Siddique (2001) reported that cattle manure at high rates increased grain yields. Kuppuswamy *et al*. (1992) conducted a field trials in 1989 at Anna-malainagan, Tamil Nadu with rice cv. lR-20 were application of lot Farmyard manure (FYM) gave grain yields of 7.33 t ha^{-1}. Rajput and Warsi (1992) reported that maximum rice yield was obtained when 100 kg N + farmyard manure was applied at the rate of 10 t ha^{-1}. The grain and straw yields were 34.7 and 52.5 t ha^{-1}, respectively.

Kant and Kumar (2000) reported that the increasing rates of amendments with FYM increased the number of effective tillers $hill^{-1}$ significantly and number of grains $panicle^{-1}$, 1000-grain weight was also increased over the control.

At the maximum level of FYM (30 t ha^{-1}, increase of 48% tillers $hill^{-1}$, 14% of grains $panicle^{-1}$ and 4.5% weight of 1000-grains over the control were recorded. They have also reported that higher rate of FYM (30 t ha^{-1}) resulted 22.0% increase in grain yield over the untreated plots. Gupta (1995) found that the application of pig manure (10 t ha^{-1}) produced The highest grain yield *(*4.5 t ha^{-1} followed by poultry manure and FYM which produced yield of 4.10 and 3.90 t ha^{-1} of rice grain, respectively. The increase of rice yield with organic manure was 34 to 55% higher over the control of 5 to 22% higher over NPK fertilizer, it was concluded that application of organic manures like pig manure and FYM are beneficial to rice cultivation in Altisoils.

Bhattacharya *et al*. (1999) carried out an experiment in plastic pots of 5 kg capacity with no hole and filled with 4 kg soil. They have reported that the Application of 2.59 kg ha^{-1} of FYM could produce about 2 g pot^{-1} grain as well as straw yield than no FYM treated soil.

2.4 Effect of vermicompost on rice

Sudhakar (2016) reported that increased availability of nutrients in vermicompost compared to non-ingested soil resulted in significantly better growth and yield of rice. Earthworms can live in decaying organic wastes and can degrade it into fine particulate materials, which are rich in nutrients. Vermicomposting is the application of earthworm in producing vermin-fertilizer, which helps in the maintenance of better environment and results in sustainable agriculture, earthworm make the soil porous and help in better aeration and water infiltration.

The importance of composts as a source of humus and nutrients to increase the fertility of soil and growth of plant has been well recognized. Vermicompost and fertilizer management were taken first for chemical analysis and then to find the effect of these composts on the growth of SRI Rice Cultivation. It was found that the vermicompost was rich in nutrients like potassium, nitrate, sodium, calcium, magnesium, and chloride and have the potential for improving plant growth than Fertilizer. The optimal growth of SRI Rice in the study conducted for a period of four month. The study also showed distinct differences between vermicompost and fertilizer management in terms of their nutrient content and their effect on SRI Rice plant growth (Kandan and Subbulakshmi, 2015).

Kumar *et al*. (2014) carried out field experiment during kharif season of 2011 to study the effect of organic and inorganic sources of nutrient on yield, yield attributes and nutrient uptake of rice cv. PRH-10. Application of organic and inorganic sources of nutrient in combination remarkably increased yield, yield attributes and nutrient uptake of rice than alone. 125% RDF + 5 t ha^{-1} vermicompost recorded significantly higher yield, yield attributes and nutrient uptake in comparison to other treatments and this was followed by 100% RDF + 5 t ha^{-1} vermicompost. 125% RDF + 5 t ha^{-1} vermicompost was increased the number of panicles (20.50%), panicle length (23.12%), panicle wt. (13.02%), 1000 grain wt. (12.90%), grain yield (31.15%), straw yield (37.12%), protein content (18.77%), N uptake in grain (36.81%) and straw (42.81%), P uptake in grain (32.62%) and straw (31.56%) and K uptake in grain (35.46%) and straw (25.39%) over control. The lower yield, yield attributes, gross return and nutrient uptake was recorded in control.

Barik *et al*. (2006) demonstrated that during wet (kharif) seasons of 2000 and 2001 under red and lateritic soil at agricultural research farm, Institute of Agriculture. Visva-Bharati, Sriniketan. West Bengal to assess the efficiency of verrnicompost over farmyard manure in integrated nutrient management of rice *(Orvza saliva* L.) during wet season. The highest grain and straw yields were obtained in crops under 50% recommended fertilizer & vermicompost 10 t ha^{-1} which was significantly higher than 100% recommended NPK fertilizers.

Murali and Setty (2004) conducted a field experiment during wet season of 1997 to study the response of scented rice (cv. Pusa basmati-1) to different levels of NPK, vermicompost and growth regulator at ARS, Siraguppa. The results revealed that application of 150:75:75 NPK kg ha^{-1} has recorded significantly higher growth, yield attributes and yield (5261 kg ha^{-1}) as compared to lower levels of NPK. Scented rice Pusa Basmati-1 responded significantly to the organic manure. Application of vermicompost @ 5 t ha^{-1} resulted in significantly higher yield (4889 kg ha^{-1}) as compared to no vermicompost application. Significantly response was observed from spraying of triacontanol (GR) @ 500 ml ha^{-1} with respect to growth, yield attributes and yield (4861 kg ha^{-1}) as compared to spraying @ 250 ml ha^{-1} and water spray.

Vermicomposting is the bioconversion of organic waste materials into nutritious compost by earthworm activity and is an important component of organic farming package. Upedrarao and Srinivasulureddy (2004) reported that conjuctive use of vermicompost @ 2 t ha^{-1} along with 50 per cent N ha^{-1} enabled hybrid rice to produce grain yield at par that obtained by application of recommended dose of fertilizer along.

Meena (2003) reported multifarious effects of vermicompost on growth and yield of crops. In a recent field experiment conducted at Kerala Agricultural University, vermicompost @ 6 t ha^{-1} was tried as an organic manure for short duration rice variety in Kanchana. It was found that vermicompost addition had a positive influence on growth and yield attributes of rice to result in a better grain yield of 4.54 t ha^{-1} and straw yield of 5.15 t ha^{-1} along with the NPK dose of 105: 52.5: 52.5 kg ha^{-1} supplied through inorganic sources. Apart from the improvement in fertilizer use efficiency, vermicompost ensured a steady supply of secondary nutrients like Mg as well as micronutrients throughout the growth period, which improved the chlorophyll content of leaves and reduced the chaff percentage. Vermicompost can be prepared from different organic materials like sugarcane trash, coir pith, pressmud, weeds, cattle dung, bio digested slurry etc.

Atiyeh *et al*. (2001) concluded that vermicomposts, whether used as soil additives or as components of greenhouse bedding plant container media, have improved seed germination, enhanced seedling growth and development and mci-eased overall plant productivity. Cavender *et al*. (2003) showed that nutrients present in vermicomposts stimulated the fungal colonization, but at the expense of plant growth. Basnet (2006) found that vermicompost sample of cowdung contain organic matter (50.25%), nitrogen (1.96%), phosphorus (2.33%) and potassium (4.99%). The vermicompost sample contained several times more nitrogen, phosphorus and potassium than the soil sample. These added mineral nutrients may be the factors responsible for the enhanced growth of the vermicompost treated plants. Singh *et al*. (2008) investigate that vermicompost is made up primarily of C, H and 0 contains nutrients such as NO, PO4, Ca, K, Mg S and micronutrients which exhibit similar effects on plant growth and yield as inorganic fertilizers applied to soil.

Das and Patra (2001) reported that vermicompost contained 0.47% N compared to 0.35% N in the surrounding soil. Nitrogen contribution from mucus, dead earthworm tissue and wormcasts amounted to 180 kg ha^{-1} $year^{-1}$. Jeyabal and Kuppuswamy (2001) observed that application of vermicompost with fertilizer N and bio-fertilizer increased the rice yield by 16 per cent over the application of fertilizer N alone. On the other hand, vermicompost applied with FYM recorded higher grain and straw yield of rice. Ravi and Srivastava (2001) reported that combined application of vermicompost and inorganic manures recorded signiicantly higher plant height, effective tillers per hill, seed and straw yield of rice, compared to application of inorganic manure alone. Gopal Reddy (2000) reported that vermicompost contains 1.98 per cent nitrogen 1.23 per cent phosphorus, 1.59 per cent potassium and 132, 70.5, 1440.2 and 317.5 mg per kg of total Zn, Cu, Fe and Mn, respectively. Senapathi *et al*. (1999) reported that paddy crop applied with vermicompost resulted in highest grain and straw production.

Edward and Burrows (1999) concluded that seedlings emergence of tomato, cabbage, and radish was much better in vermicompost than in thermophilically composted animal waste. Sylvia *et al*. (1998) estimated that as much as 20% of the total carbon assimilated by the plant may be allocated to mycrorrhizal fungi. Thus, application of composts used in the studies at higher concentrations was antagonistic, rather than synergistic to plant growth. Compost and vermicompost showed improvement in plant growth at concentration of 2.5 and 5 t ha^{-1}. Nethra *et al*. (1999) observed the increase in stem girth and number of branches in china ester by using vermicompost with recommended NPK in different proportions. The study suggests nutrient concentration based application of vermicompost likely to be a more effective proposition than using this material on the basis of total weight, as is generally done for different organic manures.

2.5 Effect of rice straw decomposition on rice

Poithanee *et al*. (2011) was found that the application of different types of organic fertilizer combined with rice straw had a significant effect on plant height, but did not show any significant effect on leaf area and above ground dry weight at 30 days after transplanting and at panicle initiation growth stage. At harvest, total aboveground dry weight and panicle number were significantly affected by the application of different types of organic fertilizer.

The treatment of rice straw combined with cattle manure and bio extract fertilizer gave the maximum panicle number. The treatment of rice straw Combined with cattle manure gave maximum grain yield, but did not show any significant difference from the treatment of rice straw combined with cattle manure and bio-extracted fertilizer.

Nyalemegbe *et al*. (2009) found that rice straw surpassed poultry manure and cowdung in the Vertisols of the Accra Plains of Ghana. Hossain *et al.* (2015) conducted an experiment to evaluate rice yield and quality of soil using different organic and inorganic amendments. Each treatment was received recommended doses of chemical fertilizers. Based on these results, 50% of rice straw and gypsum amendments could be recommended to mitigate soil salinity thereby, improving the crop productivity of the salt affected lands. Maximum plant height, panicle length, total and effective tillers hill^{-1} and filled grains per panicle were observed in 50% (rice straw + gypsum) treated plots. Nutrients uptake were increased in grain and straw using different treatments compared to control and rice straw alone treated plots. In post-harvest soil, there was a slight change of salinity and pH as affected by different treatments. Addition of rice straw and gypsum showed positive impact on organic carbon in soil.

Sharma *et al*. (2008) reported that wheat straw, rice straw and water hyacinth were applied at 4 rates and on 4 dates before transplanting to rice cv. Ratna. Grain yield increased significantly within organic FYM or with rates up to the equivalent of 15 t ha^{-1}. With wheat straw and rice straw. Application yield was highest 10 t ha^{-1}. Yield increased significantly when wheat straw and rice straw were applied up to 30 days before transplanting (DBT), but such increases were less pronounced with FYM water hyacinth. The effects of higher rate (10 and 15 t ha^{-1}) were higher with early application of organic materials per 20 and 30 DBT.

2.6 Effect of different nutrient combination on growth and yield of rice

Atman *et al.* (2018) was conducted this research aimed at investigating the effect of dosage of cowdung as organic fertilizer on growth, yield component and production of organic rice. The treatment was organic fertilizer of cow dung composted using local microbial organisms with four dosage levels, namely: a) 2 t ha^{-1}; b) 4 t ha^{-1}; c) 6 t ha^{-1}; and d) 8 t ha^{-1}. It was found that there was a positive relationship between the dosages of organic fertilizer of cow dung with the grain yield.

The addition of cow dung as the organic fertilizer as much as 1 t ha^{-1} to the soil could cause an increase in the yield of grain by 0.097 t ha^{-1}.

Kakraliya *et al*. (2017) conducted a field experiment during rabi season of 2011-12 and 2012-13 at C.S. Azad University of Agriculture and Technology, Kanpur to find out the combined effect of organic and inorganic fertilizers on grain yield, fertilizer use efficiency and grain quality of wheat crop. The treatments were -Control (T_1), RDF (150:60:40 NPK Kg ha^{-1}) (T_2),125% RDF (T_3), RDF + Vermicompost (VC) at 2.5 t ha^{-1} (T_4), RDF + VC at 5 t ha^{-1} (T_5), RDF + FYM at 5 t ha^{-1} (T_6), RDF + FYM at 10 t ha^{-1} (T_7), RDF + VC at 2.5 t ha^{-1} + Azotobacter (T_8), RDF + FYM at 5 t ha^{-1} + Azotobacter (T_9), and RDF + VC at 2.5 t ha^{-1} + FYM at 5 t ha^{-1} + Azotobacter (T_{10}). Result showed that the treatment T_{10} produced higher grain yield than the other treatments. All the fertilizer use efficiency was maximum in treatment T_{10} followed by treatment T_9 and the minimum value was quantified in T_3, T_2, T_1 (control). The highest grain protein content was obtained from the application of organic and inorganic fertilizer along with azotobacter and lowest from control as well as NPK fertilizer alone.

Kumar *et al.* (2017) were conducted two field experiments to observe the effect of timing of vermicompost application and different level of NPK on growth, yield attributing characters and yield of rice in rice-wheat cropping. The maximum and significantly higher numbers of tillers per meter row length were recorded in 100% NPK followed by vermicompost with 75% N, 100% P and K before sowing. Maximum plant height was recorded with the application of 100% NPK. Recommended dose of NPK were significant in case of dry matter yield at maximum tillering and panicle initiation. Maximum grain yield during both the years was recorded with the application of 100% NPK.

Lukman *et al.* (2016) conducted a field trial to evaluate the effect of Nitrogen, Phosphorus and Potassium (NPK 20-10-10) and cow dung on the performance of rice. The combined application of cow dung and NPK fertilizer significantly ($p < 0.05$) increased most of the results obtained with regards to locations compared to the control plots. Application of 8 t ha^{-1} of cow dung in combination with 400 kg ha^{-1} NPK 20:10:10 gave the highest grain yield (5.77 t ha^{-1}) at Sokoto, while application of 12 t ha^{-1} of cow dung in combination with 300 kg ha^{-1} NPK 20:10:10 gave the highest grain yield (6.50 t ha^{-1}) at Talata Mafara.

Pal *et al.* (2016) conducted a field trial to evaluate the effect of integrated use of inorganic fertilizers with cowdung on the yield and quality of fine aromatic rice. The experiment consisted of three varieties of aromatic fine rice viz. Kalizira, Binadhan-13 and BRRI dhan38. The highest grain yield (3.92 t ha^{-1}) and grain protein content (9.88%) were obtained from Binadhan-13 fertilized with 75% inorganic fertilizers + cowdung 10 t ha^{-1} while the lowest grain yield (1.52 t ha^{-1}) and grain protein content (6.42%) was found in control treatment (no manures and no fertilizers) in Kalizira. Maximum benefit cost ratio (1.94) was found from Binadhan-13 with the combination of 75% inorganic fertilizers + cowdung 5 t ha^{-1}, which was similar (1.93) to the treatment combination of 75% inorganic fertilizers + cowdung 10 t ha^{-1}.

Mahmud *et al.* (2016) conducted an experiment with vermicompost and different doses of fertilizers. Different levels of vermicompost and NPKS fertilizers showed significant effect on growth, yield and yield contributing characters of BRRI dhan29. Results showed that application of medium level of chemical fertilizer with 4 t ha^{-1} vermicompost gave the maximum yield. It was observed that over dose of NPKS fertilizers from chemical source decreased rice yield. Results also revealed that the highest plant height, effective tillers $hill^{-1}$, flag leaf length, panicle length, filled grains $panicle^{-1}$, 1000-grain weight, grain yield, straw yield and biological yield were obtained from the combination of 4 t ha^{-1} vermicompost with 100 kg ha^{-1} N, 16 kg ha-1 P, 66 kg ha^{-1} K, 12 kg ha^{-1} S. It was observed that yield of rice can be increased substantially with the judicious application of organic fertilizer with chemical fertilizer.

Oahiduzzaman *et al.* (2014) conducted a field trial to study the effect of cowdung on yield and nutrient content of transplanted Aman rice (BRRI dhan33). The experiment consisted 4 levels of cowdung, viz., C_0: 0 ton cowdung ha^{-1} (control), C_1: 4.5 ton cowdung ha^{-1}, C_2: 5.0 ton cowdung ha^{-1} and C_3: 5.5 ton cowdung ha^{-1}. Tallest plant (88.6 cm at harvest), maximum number of effective tillers $hill^{-1}$ (13.4), maximum grain yield ha^{-1} (5.2 ton) was found from C_3 while minimum from C_0. On the other hand, maximum N (1.39%), P (0.29%), K (0.65%), S (0.13%) and Zn (0.026%) Content in grain was found from C_3 which was statistically similar with the C_2 whereas minimum from C_0.

Gosh *et al.* (2014) conducted an experiment to investigate the effect of integrated nutrient management on nutrient uptake by rice cv. NERICA 10 and economization of inputs. Six treatments viz. T_1 = Control, T_2 = RFD for MYG + cowdung @ 5 t ha^{-1}, T_3 = RFD for HYG, T_4 = RFD for HYG + cowdung @ 5 t ha^{-1}, T_5 = RFD for HYG + cowdung @ 5 t ha^{-1} based on IPNS, and T_6 = RFD for HYG + 10% excess fertilizer of HYG were used. The experiment was laid out in a randomized complete block design with three replications. Results showed that the uptake of N, P, K, S, Ca and Mg by both grain and straw of rice were statistically significant due to use of integrated nutrient management. The highest nutrient uptake was recorded from the treatment T_5 and the lowest value was obtained from control.

Liza *et al.* (2014) conducted a field experiment to evaluate the residual effects of organic manures and different level of recommended fertilizer dose (RFD) on the yield and nutrient uptake of BBRI dhan29. The manures viz. cowdung (CD), poultry manure (PD) and compost (Com.) was applied to the previous crop (T. Aman rice). The recommended doses of fertilizers were used to supply N, P, K and S @ 140, 15, 60 and 15 kg ha^{-1}, respectively to the present crop. Residual effects of organic manure with inorganic fertilizers significantly increased the yield attributes as well as grain and straw yields of rice. Treatment 50% RFD + residual effect of CD 2.5 t ha^{-1}, PM 1.5 t ha^{-1}, and Com. 2.5 t ha^{-1} produced the highest grain yield (6.87 t ha^{-1}) and straw yield (7.24 t ha^{-1}). The lowest grain yield (3.22 t ha^{-1}) and straw yield (4.55 t ha^{-1}) were found in control.

Kumar *et al.* (2014) conducted an experiment to study the effect of organic and inorganic sources of nutrient on yield, yield attributes and nutrient uptake of rice cv. PRH-10. Application of organic and inorganic sources of nutrient in combination remarkably increased yield, yield attributes and nutrient uptake of rice than alone. 125% RDF + 5 t ha^{-1} vermicompost recorded significantly higher yield, yield attributes and nutrient uptake in comparison to other treatments and this was followed by 100% RDF + 5 t ha^{-1} vermicompost The lower yield, yield attributes, gross return and nutrient uptake was recorded in control.

Garai *et al.* (2014) conducted a field experiment to study the effect of inorganic fertilizer, vermicompost, phosphate solubilizing bacteria (PSB) and *Azotobacter* on the yield of boro rice (winter rice) and its impacts upon soil nutrient status and grain uptake.

The highest yield attributes were recorded with full recommended dose of inorganic fertilizer along with vermicompost at 2.5 t ha^{-1}, PSB and *Azotobacter*, which was at par with 75% of inorganic fertilizer along with vermicompost at 2.5 t ha^{-1} and PSB and *Azotobacter*. Application of PSB and Azotobacter significantly increased available phosphorus and nitrogen in soil. Micronutrient status in soil was also significantly influenced by the different doses of inorganic, organic and bio fertilizers.

Dekhane, *et al*. (2014) conducted a trial with three replications and six treatments was laid out in Randomized Block Design to assess the performance of different organic and inorganic manure on growth and yield of paddy crop during Kharif season. Different doses of fertilizers were applied to all the plots except untreated control. Application of 50 % N through RDF + 50% N through vermicompost recorded higher growth attributes like plant height was 42.2 cm and 118.1 cm, no. of tillers per plant was 8.7 and 12.1 at 45 DAT and at harvest time respectively, panicle length (22.3 cm), grains per panicle (128.0), 1000-grain weight (19.7 g) and grain yield (4.97 t ha^{-1}) and straw yield (5.77 t ha^{-1}.) of rice variety GR 11. The data clearly revealed that the yield obtained with treatment T_5 (50% RDF + 50% N through vermicompost) was recorded significantly higher growth as well as yield attributes than all other treatments.

Islam *et al.* (2013) was conducted a field experiment in the Sher-e-Bangla Agricultural University research farm to study the effect of fertilizer and manure with different water management on the growth, yield and nutrient concentration of BRRI dhan28. 50% RDCF + 4 ton poultry manure ha^{-1} showed the highest effective tillers $hill^{-1}$, plant height, panicle length, 1000 grain wt., grain yield (5.92 kg $plot^{-1}$) and straw yield (5.91 kg $plot^{-1}$). The higher grain and straw yields were obtained organic manure plus inorganic fertilizers than full dose of chemical fertilizer and manure.

Zayed *et al.* (2013) conducted an experiment to show the response of rice yield at different level of integrated fertilization. He observed that application of chemical nitrogen fertilizer at the rate of 165 kg N ha^{-1} gave the highest values of growth parameter values, as well as yield and yield component values. However, it did not produce significantly more yield than the 5 t ha^{-1} composted rice straw + 110 kg N ha^{-1}. Application of *Azospirillum brasilense* culture + 110 kg N ha^{-1} had the second best results.

The treatment with a combination of farmyard manure, rice straw compost and *Azospirillum brasilense* culture significantly increased rice grain yield and yield components over the control.

Haque *et al*. (2012) conducted a research to evaluate the integrated management of organic and inorganic fertilizers to reduce CH_4 emission and increase rice productivity (rice cultivar BRRI dhan 28) in Boro season during the period of January to May 2012 at the experimental field, Department of Environmental Science, Bangladesh Agricultural University, Mymensingh. Six different treatments such as, urea only (no organic amendments), urea + rice straw compost, urea + charcoal, urea + $CaSiO_3$, urea + rice straw compost + $CaSiO_3$, urea + charcoal + $CaSiO_3$ were applied in different plots in this experiment. The highest seasonal CH_4 flux 25.54 mg ha^{-1} was found from the urea + rice straw compost treatment and lowest seasonal CH_4 flux 17.47 mg ha^{-1} was produced in urea only (no organic amendments).

Dong *et al.* (2012) conducted a research to examine the effects of five fertilization treatments [these were: no fertilizer (CK), rice straw return (SR), chemical fertilizer (NPK), organic manure (OM) and green manure (GM)] on soil pH, soil organic carbon (SOC), total nitrogen (TN), C/N ratio and available nutrients (AN, AP and AK) contents in the plowed layer (0–20 cm) of paddy soil. Results showed that the soil pH was the lowest with an average of 5.33 units in CK and was significantly higher in NPK (5.89 units) and OM (5.63 units) treatments ($P<0.05$). The application of fertilizers have remarkably improved SOC and TN values compared with the CK, Specifically, the OM treatment resulted in the highest SOC and TN concentrations (72.5% and 51.2% higher than CK) and NPK treatment increased the SOC and TN contents by 22.0% and 17.8% compared with CK.

Farid *et al.* (2011) conducted a field experiment to study the combined effect of cowdung, poultry manure, dhaincha and chemical fertilizers on the yield and nutrient uptake of BRRI dhan41. The maximum grain yield was 4.49 t ha^{-1}1 recorded in 70% NPKS + Poultry manure @ 5 t ha^{-1} and minimum grain yield of 2.69 t ha^{-1} in control. The dhaincha or cowdung along with 70% NPKS increase the grain yield significantly over 70% NPKS application. The relative performances of organic manures were in the order of PM>DH>CD.

Hossaen *et al.* (2011) conducted a research to evaluate the efficacy of different organic manure and inorganic fertilizer on the yield and yield attributes of boro rice. At 30, 50, 70, 90 DAT and at harvest stage the tallest plant (24.18, 31.34, 44.67, 67.05 and 89.00 cm) and the greatest number of total tiller per hill (5.43, 11.64, 21.01 and 17.90) at same DAT was recorded from 70% NPKS + 2.4 t poultry manure ha^{-1} and the lowest was observed from control in every aspect. Although the highest biological yield was recorded from 70% NPKS + 2.4 t poultry manure ha^{-1} treatment but statistically similar result were found from 70% NPKS + 3 t cowdung ha^{-1}, 50% NPKS + 4 t poultry manure ha^{-1} and 70% NPKS + 3 t vermicompost ha^{-1}. The highest harvest index also recorded for 70% NPKS + 2.4 t poultry manure ha^{-1}. It was obvious that yield of rice can be increased substantially with the judicious application of organic manure with chemical fertilizer.

Chaudhary *et al.* (2011) was conducted a field experiment to study the effect of inorganic fertilizer in combination with organic sources, viz. vermicompost, poultry manure, FYM and green manuring under four dates of transplanting on rice. Rice "Rajendra Suwasani" recorded significantly higher values of yield attributes, yields and nutrient accumulation under integrated source of nutrients than inorganic fertilizer alone. Maximum grain yield (4.12 t ha^{-1}) was with 75% recommended dose of nitrogen (RDN) + 25% N from dhaincha (*Sesbaniaaculata L.*) and it was 14.8 and 26.1% higher over 100 and 75% RDN, respectively.

Siavoshi (2011) conducted a field experiment in order to study the effect of organic fertilizer on growth and yield components in rice. The chicken manure, cow manure and paddy rice were mixed together in 1:1:0.5 ratio to form organic mixed fertilizer and treatments were at 5 levels (0.5, 1.0, 1.5, 2.0 and 2.5 t ha^{-1}). The plants without treatments were served as control. Grain yield and its components were significantly increased in all the treatments over control. The maximum grain yield in 2008 (4335.88 kg ha^{-1}) was noted in plants treated with 2 t ha^{-1} organic fertilizer and it was (4662.71 kg ha^{-1}) for 2009 for plant treated with combination of chemical fertilizer + 1.5 t ha^{-1} organic fertilizer.

Rahman (2010) conducted a pot experiment to quantify the effect of different organic wastes in rice yield and to determine the effect on soil fertility. The maximum sustainable yield index (SYI) was found 0.91 when 10% poultry manure and 30% cow dung were applied. But the SYI was 0.67 when 30% HW was applied. Post-harvest chemical analysis of pot soil indicated that OM, N and P contents in soils significantly increased over the control which indicated the enhancement of soil fertility with the application of different organic wastes. The highest application rates of organic wastes attributed to maximum accumulation of organic matter and nitrogen in soil.

Ashrafi *et al.* (2010) conducted a pot experiment to study the effects of organic manures on nitrogen, phosphorus, potassium and sulphur concentrations in grain, husk, stem and root of rice grown in an arsenic contaminated soil. N, P, K and S concentration in grain, husk, straw and root of rice plant were increased with organic manure application compared to control treatment. This study considered rice husk and root along with grain and straw as they have value to increase soil nutrient by recycling. This study concluded that organic manure is effective in arsenic contaminated soil to increase N, P, K and S concentration in rice plant.

Hossain *et al.* (2010) conducted a research to evaluate the effect of urea-N, poultry manure (PM) and cowdung (CD) on the nutrient content and uptake by BRRI dhan29. The P, K and S fertilizers were applied at the rate of 15, 50, and 10 kg/ha, respectively as a basal dose during the final land preparation. The N, P, K and S contents and uptake were profoundly influenced by the application of different doses of urea-N in combination with poultry manure and cowdung. The overall results indicate that application of PM @ 3 t ha^{-1} in combination with N 100 kg ha^{-1} can reduce the use of N fertilizer at a substantial level which ultimately reduce the cost of production. The findings of the study suggest that integrated use of manure and fertilizer is more important for sustainable production of BRRI dhan29.

Rahman *et al.* (2009) was made a study on integrated nutrient management in the Bush bean −T. Aus −T. Aman cropping pattern over three years at BRRI Farm, Gazipur (AEZ-28). Different packages of chemical fertilizers in combination with organic materials (cowdung and rice straw/bush bean stover) were evaluated to find out a suitable combination for obtaining higher yield of crops. There was a positive effect of crop residue recycling and residual effect of cowdung on the yield of the next crops. For T. Aus rice, the highest yield was obtained with the treatment where bush bean stover was used along with chemical fertilizer. Again the highest yield of T.

Aman rice was observed in the residual effect of cowdung with reduced amount of fertilizer. An excess N uptake was recorded where N was added as fertilizer only. The apparent balance (nutrient added through manures and fertilizers minus nutrient removed by crops) for both N and K was negative while that for P & K was mostly positive.

Ali *et al.* (2009) conducted a field experiment to evaluate the suitability of different sources of organic materials for integrated use with chemical fertilizers for the Boro-Fallow-T. Aman rice cropping pattern. Organic manure or crop residue was applied to T. Aman rice and their residual effects were observed in the following Boro rice. Application of 70% NPKS + PM produced the highest grain yield of T. Aman rice, which was identical to that obtained with 100% NPKS with no manure. In boro season. Application of 100% NPKS produced the highest grain yield of 6.87 t ha^{-1}, which was identical with the application of 70% NPKS + PM (6.57 t ha^{-1}). The total grain yield in the cropping pattern ranged from 5.14 t ha^{-1} in control treatment to 12.29 t ha^{-1} in the 100% NPKS. It appears that the application of 3 t ha^{-1} PM once in a year with 70% NPKS can reduce the use of 30% NPKS as fertilizers.

Yadav *et al.* (2008) conducted a field experiment to evaluate the effect of integrated nutrient management on production and economic efficiency of rice under Upland Drilled Condition. The treatment S_4- Recommended dose of fertilizer (80: 50: 50 kg NPK ha^{-1}) has recorded the significantly higher production and economic efficiency in case of inorganic nutrient levels. While *Glyricidia* @ 10 t ha^{-1} recorded maximum production efficiency and gross monetary returns, but treatment S_3 biofertilizers (*Azospirillum* @ 1.5 kg + PSB 5 kg ha^{-1}) recorded higher net monetary returns and economic efficiency among organic sources. In case of interaction, treatment RDF + *Glyricidia* @ 10 t ha^{-1} recorded significantly more grain yield, production efficiency and gross monetary returns, while treatment M3S3 - RDF + biofertilizers (*Azospirillum* @ 1.5 kg ha^{-1} + PSB @ 5 kg ha^{-1}) recorded higher net monetary returns and economic efficiency.

Saha *et al.* (2007) a 7-year-long field trial conducted on integrated nutrient management for a dry season rice (Boro)–green manure (GM)–wet season rice (T. Aman) cropping system. The application of chemical fertilizers along with the organic manures increased soil organic carbon by (C) 0.71%.

The highest concentration of total N was observed where CD was applied in Boro season and dhaincha, GM was incorporated in T. Aman season. The sixfold increase in soil-available P in due to the addition of CD. Dhaincha, GM with the combination of chemical fertilizer helps to mobilize soil-available P by 3 to 6 ppm. The application of CD and dhaincha GM along with chemical fertilizers not only increased organic C, total N, available P, and available S but also increased exchangeable K, available Zn, available iron (Fe), and available manganese (Mn) in soil.

Banik *et al.* (2006) studied the effect of organic sources of nutrients and inorganic fertilizers, on grain yield of lowland rice. The highest mean grain yield was 3.53 t ha^{-1} and maximum agronomic efficiency was 60.3% with the application of inorganic fertilizer followed by cow dung, where 3.47 t ha^{-1} grain yield was recorded with an agronomic efficiency of 57.5%. Grain yield of rice recorded under organic sources of nutrients was not significantly different from that of inorganic fertilization though there was improvement in soil quality parameters under organic sources.

Raju *et al.* (2005) observed, in rice field in the rainy season by applying 0, 50, 75 or 100% of the recommended NPK fertilizer rate, 50% of the recommended NPK rate + 7.5 t FYM, 6 t rice straw or 4.48 + sesbanai cannabania ha^{-1}, 75% of the recommended NPK rate + 3.757 FYM, 3 t rice straw or 2.24 + S. cannabania or 60 kg N ha^{-1} as urea, 17.5 kg P as single super phosphate and 33.3 kg K as Muriate of potash. The recommended fertilizer rate gave the highest grain yield of 5.23 t had which was not significantly different from 5. 15 t and 4.47 t with 75% of the recommended rate + 3 t rice straw or 2.24 t ha^{-1}. cannabania, respectively. Application of 60 kg N gave 4.35 t and the control yield was 2.71 t ha^{-1}.

Saleque *et al.* (2004) conducted a research, to determine the effect of different doses of chemical fertilizers alone or in combination with cow dung (CD) and rice husk ash (ash) on yield of lowland rice. Six treatments—absolute control (T_1), one-third of recommended fertilizer doses (T_2), two-thirds of recommended fertilizer doses (T_3), full doses of recommended fertilizers (T_4), T_2+5 t CD and 2.5 t ash ha−1 (T_5) and T_3+5 t CD and 2.5 t ash ha^{-1} (T_6) were compared. The CD and ash were applied on dry season rice only. The 10-year mean grain yield of rice with T_1 was 5.33 t ha^{-1} per year, while the yield with T_2 was 6.86 t ha^{-1} per year. Increased fertilizer doses with T_3 increased the grain yield to 8.07 t ha^{-1} per year, while the application of recommended chemical fertilizer doses (T_4) gave 8.87 t ha^{-1} per year. The application of CD and ash (T_5 and T_6) increased rice yield by about 1 t ha^{-1} per year over chemical fertilizer alone (T_2 and T_3, respectively).

Rahman *et al*. (2000) conducted a research on integrated nutrient management in the Bush bean−T. Aus −T. Arnan cropping pattern during 2000-02. Different packages of chemical fertilizers in combination with organic materials (cowdung and rice straw/bush bean stover) were evaluated to find out a suitable combination for obtaining higher yield of crops. There was a positive effect of crop residue recycling and residual effect of cowdung on the yield. Both the soil test-based fertilizer and the cowdung with IPNS basis fertilizer treatments gave higher yield. For T. Aus rice, the highest yield was obtained with the treatment where bush bean stover was used along with IPNS based chemical fertilizer. The highest yield of T. Aman rice was observed in the residual effect of cowdung with reduced amount of fertilizer.

Jeony *et al*. (2000) observed that rice was given 110 kg N + 120 kg P + 130 kg K ha^{-1} (100% NPK) alone or with 5 t rice straw ha^{-1} or half these NPK rate (50% NPK) alone or 5 t rice straw. 20 t compost + 20 t fermented pig manure, Pig manure + compost, 3 t oil cake or 5 t fermented chicken manure ha^{-1}. Application of organic manure + 50% NPK gave grain yield of 9 to 17% lower than these were obtained with 100% NPK rate. Grain content alkali digestion value and gel consistency were unaffected by treatments. Amylase content of grain was lower in plant given straw, compost or compost + pig manured compared with 100 % NPK treatment. In general, organic fertilizer did not improve rice cooking quality and tests. From the reviews cited above it is clear that manuers and fertilizers have positive influence on yield of rice, and combination of them produces better yield in most of the cases.

2.7 Interaction effect of variety and different nutrient combination on growth and yield of rice

Mamun *et al*. (2018) conducted a field experiment to evaluate the effects of organic and inorganic sources of nitrogen on the post-harvest fertility status and yield of BRRI dhan29. Incorporation of recommended dose of nitrogen (RDN) @ 150 kg ha^{-1} from cow dung as organic nitrogen source and urea as inorganic nitrogen source along with a control was performed.

All the treatments under study also received P20, K65, S18 and Zn1.3 through inorganic sources of fertilizers. The grain and straw yields as well as the yield contributing characteristics like plant height, number of tillers hill^{-1}, number of effective tillers hill^{-1}, panicle length, number of grains panicle^{-1} and number of filled grains panicle^{-1} were significantly influenced by the different treatments. Significantly highest grain (5.89 t ha^{-1}) and straw (6.14 t ha^{-1}) yields were recorded from the treatment T_1 where 100% RDN provided from urea that was closely followed by the treatment T6 (80% RDN from urea + 20% RDN from cowdung). Considering the results, treatment T_6 (80% RDN from urea + 20% RDN from cowdung) may be suggested for adequate substitute in reducing the chemical nitrogen usage for sustained boro rice cultivation.

Sharada and Sujathamma (2018) conducted a research aimed to test the effect of the different organic fertilizer and combinations of organic and inorganic fertilizers on the qualitative and quantitative parameters of two cultivars of rice as DRR Dhan39 and RP.BIO.226. The results indicated that the variety DRR Dhan39 gave the statistically significant ($P<0.0001$) higher grain yield of 8713 kg ha^{-1} and straw yield of 9483 kg ha^{-1} with 50% organic fertilizers of Vermicompost, Jeevamrutha 5% and Panchagavya 3% and 50% inorganic fertilizer of NPK. On the other hand, the variety of RP.BIO.226 gave the highest grain yield of 6390 kg ha^{-1} with Vermicompost, Jeevamrutha 5% and Panchagvya 3% (8 t ha^{-1}, foliar spray and 500 litres ha^{-1}) and highest straw yield of 7430 kg ha^{-1} with T_{10} treatment (50% organic fertilizers of Vermicompost, Jeevamrutha 5% and Panchagavya 3% and 50% inorganic fertilizer of NPK). Both varieties of rice poorly responded to inorganic fertilizers with lower grain and straw yield.

Sarker *et al.* (2017) conducted a research to evaluate the impact of organic and inorganic sources of nitrogen (N) on growth dynamics, yield, N content, N uptake and agronomic efficiency (AE) of irrigated rice. Four high yielding Boro (dry season irrigated) rice cultivars viz. BRRI dhan29, BRRI dhan59 Binadhan-8 and Binadhan-10 along with six N management combinations viz. Control (no N application), 140 kg N ha^{-1} from Prilled Urea (PU), 83 kg N ha^{-1} from Urea Super Granule (USG), 105 kg N ha^{-1} from PU + 3 t ha^{-1} Poultry manure, 112 kg N ha^{-1} from PU + 5 t ha^{-1} Cowdung and 77 kg N ha^{-1} from PU + 4 t ha^{-1} vermicompost were used in the study. The cultivar Binadhan-8 had a higher yield than all other cultivars. AE were highest with 105 kg N ha^{-1} from PU + 3 t ha^{-1} Poultry manure application.

The highest N uptake in grain and straw (120.1 kg ha^{-1} and 96.14 kg ha^{-1}, respectively) was shown by rice cultivar Binadhan-8. Therefore, the combined application of N sources in the form of PU + Poultry manure can produce good performances in terms of growth and yield of HYV rice under irrigated condition.

Jahan *et al.* (2017) conducted an experiment to investigate the effect of spacing and fertilizer management on the yield of transplanted aman rice cv. BRRI dhan39. 75% recommended dose of inorganic fertilizers + cow dung at 5 t ha^{-1} superseded other treatments in terms of plant height (107.50 cm), number of total tillers $hill^{-1}$ (10.40), number of effective tillers $hill^{-1}$ (7.68), panicle length (22.26 cm), grains $panicle^{-1}$ (111.70) and grain yield (4.14 t ha^{-1}). The control treatment (no manures and no fertilizers) gave the lowest values for all these parameters.

Shaha (2014) reported that the different rates of cowdung with inorganic manures showed significant effect on all growth parameters viz. plant height and tillers $hill^{–1}$. Among the cowdung levels with BRRI RD of inorganic manures, highest grain yield (5.62 t $ha^{–1}$) was obtained from cowdung 7.5 t $ha^{–1}$ with inorganic manures and lowest (5.07 t $ha^{–1}$) was recorded in control. Similarly, the highest grain yield (6.25 t ha^{-1}) was obtained from the treatment combination of (BR11 and cowdung 7.5 t $ha^{–1}$) with inorganic manures which was statistically identical with all BR11 in cowdung treated plot.

Sarkar (2014) found that the application of 75% RD of inorganic manures + 50% cowdung showed superiority in terms of plant height (123.3 cm) and total tillers $hill^{–1}$ (13.87) where those were also highest in combination of BRRI dhan34 × 75% RD of inorganic manures + 50% cowdung. Nutrient management of 75% RD of inorganic manures + 50% cowdung (5 t $ha^{–1}$) gave the highest grain yield (3.97 t $ha^{–1}$) and the lowest grain yield (2.87 t $ha^{–1}$) was found in control. The highest grain yield (4.18 t $ha^{–1}$) was found in BRRI dhan34 coupled with 75% RD of inorganic manures + 50% cowdung and the lowest grain yield (2.7 t $ha^{–1}$) was found in BRRI dhan37 in control.

Liza *et al*. (2014) found that the treatment T6 50% RFD + Effect of residual CD 2.5 t $ha^{–1}$, PM 1.5 t $ha^{–1}$, and Com. 2.5 t $ha^{–1}$ produced the highest grain yield (6.87 t $ha^{–1}$) and straw yield (7.24 t $ha^{–1}$). The lowest grain yield (3.22 t $ha^{–1}$) and straw yield (4.55 t $ha^{–1}$) were found in T0.

Treatment T6 receiving 50% RFD along with the Effect of residual 2.5 t ha^{-1} cowdung, 1.5 t ha^{-1} poultry manure and 2.5 t ha^{-1} compost was found to be the best combination of organic and inorganic nitrogen for obtaining the maximum yield of BRRI dhan29 and nutrient content and uptake by grain and straw. Haque (2013) evaluated the use of manures and fertilizers for maximizing the growth and yield of BRRI dhan28. The maximum grain yield of 5651 kg ha^{-1} and straw yield of 6572 kg ha^{-1} were recorded in T_3 [(PM) + STB–CF]. The lowest grain and straw yields were found for T_0. The NPKS content and uptake by BRRI dhan28 were also influenced significantly due to integrated use of manures and fertilizers.

Islam *et al*. (2013) studied the fertilizer and manure effect on the growth, yield and nutrient concentration of BRRI dhan28 at Sher-e-Bangla Agricultural University research farm, Dhaka. They observed that T5 (50% RDCF + 4 ton PM ha^{-1}) showed the highest effective tillers $hill^{-1}$, plant height, panicle length, 1000 grain wt., grain yield (5.92 kg $plot^{-1}$) and straw yield (5.91 kg $plot^{-1}$). The higher grain and straw yields were obtained organic manure plus inorganic manures than full dose of fertilizer management and manure. Hossain *et al*. (2010) conducted an experiment to evaluate the effect of Urea, poultry manure (PM) and cowdung (CD) on the nutrient content and uptake by BRRI dhan29. The experiment was laid out in a RCBD with eight treatments in three replications. Application of poultry manure, cowdung and Urea significantly influenced the yield and yield components of BRRI dhan29 and N, P, K and S contents and uptake. The overall results indicate that application of PM @ 3 t ha^{-1} in combination with N 100 kg ha^{-1} can reduce the use of N fertilizer at a substantial level. The findings of the study suggest that integrated use of manure and fertilizer is more important for sustainable production of BRRI dhan29.

Islam (2008) showed that the highest plant height (109.49 cm), number of effective tillers $hill^{-1}$ (9.43), number of total tillers $hill^{-1}$ (13.33), grain yield (6.13 t ha^{-1}) and harvest index (46.04%) were obtained from the combination of 50% recommended fertilizer with 5 t ha^{-1} cowdung. Saleque *et al*. (2004) studied with six treatments viz. absolute control (T_1), 1/3 of RFD (T_2), 2/3 of RD (T_3), full doses of RF (T_4), T_2 + 5 t cowdung and 2.5 t ash ha^{-1} (T_5) and T_3 + 5 t cowdung ha^{-1} + 2.5 t ash ha^{-1} (T_6) were compared.

The results showed that application of cowdung and ash (T_5 and T_6) increased rice yield by about 1 t ha^{-1} $year^{-1}$ over that obtained with fertilizer management alone.

Sarkar *et al.* (2007) conducted a field experiment to examine the effect of combined level of poultry manure and inorganic fertilizer on two varieties of transplanted aman rice viz. (i) BRRI dhan31 and (ii) BRRI dhan32. The performance of BRRI dhan31 was better than that of BRRI dhan32. But both the variety (BRRI dhan31 and BRRI dhan32) performed the best in respect of yield and yield parameters in 5 t ha^{-1} of poultry manure coupled with 75% N p K S Zn. Thus transplant aman rice (variety BRRI dhan31 and BRRI dhan32) can be cultivated successfully with 75% recommended fertilizers when poultry manure will be applied at 5t ha^{-1}.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to assess three Boro rice varieties under different fertilizer managements. The details of the materials and methods i.e. experimental period, location, soil and climatic condition of the experimental area, materials that was used for the experiment, treatment and design of the experiment, data collection procedure and data analysis etc. have been presented under the following headings:

3.1 Description of the experimental site

3.1.1 Experimental period

The experiment was conducted during November to April 2020-21.

3.1.2 Experimental location

The experiment was conducted in the Sher-e-Bangla Agricultural University farm, Dhaka, under the agro-ecological zone of Modhupur Tract, AEZ-28 during the Boro season of 2020. The location of the site is 23074/N latitude and 90035/E longitude with an elevation of 8.2 meter from sea level. Experimental location presented in Appendix I.

3.1.3 Soil characteristics

The soil of the experimental field belonged to "The Modhupur Tract" AEZ-28 (FAO, 1988). Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. The experimental area having available irrigation and drainage system and situated above flood level. The soil having a texture of silty clay composed of 26% sand, 43% silt and 31% clay. Details morphological, physical and chemical properties of the experimental field soil are presented in Appendix II.

3.1.4 Climatic condition

The geographical location of the experimental site was under the subtropical climate and its climatic conditions is characterized by three distinct seasons, namely winter season from the month of November to February, the pre-monsoon period or hot season from the month of March to April and monsoon period from the month of May to October (Edris *et al*., 1979). During the experimental period the maximum temperature (36.40C), highest relative humidity (82%) and highest rainfall (573 mm) was recorded for the month of July, 2020, whereas the minimum temperature (25.60C), minimum relative humidity (77%) and no rainfall was recorded for the month of December, 2020. Details of the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during study period has been presented in Appendix IV.

3.2 Experimental details

3.2.1 Treatment of the experiment

Factor A: Variety (3)

i) BRRI dhan63 (V_1)

ii) BRRI dhan81 (V_2)

iii) BRRI hybrid5 (V_3)

Factor B: Fertilizer management (5)

i) Control (no fertilizer) (F_0)

ii) Recommended dose of chemical fertilizers (RDCF) (F_1)

iii) Cow dung + RDCF (F_2)

iv) Vermicompost + RDCF (F_3)

v) Rice straw decomposition + RDCF (F_4)

Recommended dose of organic and inorganic fertilizer has been mentioned in section 3.3.4.

There were in total 15 (3×5) treatment combinations such as V_1F_0, V_1F_1, V_1F_2, V_1F_3, V_1F_4, V_2F_0, V_2F_1, V_2F_2, V_2F_3, V_2F_4, V_3F_0, V_3F_1, V_3F_2, V_3F_3 and V_3F_4.

3.2.2 Design and layout

The experimental treatments were tested under Split Plot Design (SPD) (factorial) with three replications. Each block was sub-divided into 15 unit plots. The treatments were randomly distributed to the unit plots in each block. The total number of plots was 45 (15×3). The unit plot size was 2.25 m × 2 m. Block to block distance was 1 m and plot to plot distance was 0.6 m. The layout of the experiment has been shown in Appendix III.

3.2.3 Description of rice varieties

BRRI dhan63

Among the Boro rice cultivars BRRI dhan63 was developed by Bangladesh Rice Research Institute (BRRI) and released in the year 2014. It is recommended for Boro seasons and growth duration is about 150 days. On an average it produced yield of 6.5-7.0 t ha^{-1} and plant height is about 117 cm. Its grain is short, coarse.

BRRI dhan81

BRRI dhan81 is a rice variety which was developed by BRRI through hybridization and released in the year 2017. It is recommended for a Boro season. Average plant height of the variety is around 110 cm at the ripening stage. The grains are medium coarse and free from stickiness, 1000 grain weight 20.3 g and crop duration 140-145 days with an average grain yield of around 6-6.5 t ha^{-1}.

BRRI hybird5

BRRI hybrid5 is a rice variety which was developed by BRRI through hybridization and released in the year 2016. It is recommended for a Boro season. Average plant height of the variety is around 110 cm at the ripening stage. The grains are medium slender and white, 1000 grain weight 26.2 g and crop duration 144 days with an average grain yield of around 8.5-9.0 t ha^{-1}.

3.3 Growing of crops

3.3.1 Seed collection and sprouting

Seeds were collected from BRRI just 20 days ahead of the sowing of seeds in seed bed. For seedling raising clean seeds was immersed in water in a bucket for 24 hours. The imbibed seeds were then taken out of water and kept in gunny bags. The seeds started sprouting after 48 hours which was suitable for sowing in 72 hours.

3.3.2 Raising of seedlings

The nursery bed was prepared by puddling with repeated ploughing followed by laddering. The sprouted seeds were sown on beds as uniformly as possible. Irrigation was gently provided to the bed as and when needed to bring favorable condition for seedling growth. No fertilizer was used in the nursery bed. Seeds were sawn at 2nd December, 2020 in the seed beds.

3.3.3 Land preparation

The plot selected for conducting the experiment was ploughed in the 1st January 2021 with a power tiller, and left exposed to the sun for a week. After three days the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good puddle condition. Weeds and stubbles were removed.

3.3.4 Fertilizers incorporation

According to BRRI recommended dose of fertilizer for BRRI dhan63 is NPKSZn – 258, 100, 120, 112, 11 (kg ha^{-1}) respectively and for BRRI dhan81 is NPKSZn – 224, 98, 150, 112, 11 (kg ha^{-1}) respectively and for BRRI hybrid5 is NPKSZn – 270, 127, 120, 68, 8 (kg ha^{-1}) respectively. The amounts of N, P, K, S and Zn fertilizers required per plot were calculated. The entire amount of TST, MP, gypsum and zinc sulphate was applied during the final preparation of experimental plot. Urea was applied in three equal installments at 15 DAT, 30 DAT, and 45 DAT, respectively as recommended by BRRI.

3.3.5 Organic manure incorporation

Three types of organic manure viz. cow-dung, vermicompost and rice straw were used. Cow-dung vermicompost and rice straw generally required 10 t ha^{-1}, 5 t ha^{-1} and 5 t ha^{-1}, respectively and they were applied in each plot as per calculation before two days of final land preparation. Chemical compositions of the manures used have been presented in Table 1.

Table 1. Chemical compositions of the cow dung, vermicompost and rice straw (oven dry basis)

Manure	Nutrient content			
	N%	P%	K%	S%
Cow dung	1.57	1.47	0.69	0.22
Vermicompost	2.1	1.50	0.60	0.25
Rice straw	1.98	1.02	0.52	0.19

3.3.6 Transplanting of seedling

40 day old seedlings were carefully uprooted from the seed BED and transplanted on 10th January, 2021 in well puddled plot. Two seedlings were transplanted in each hill. After one week of transplanting all plots was checked for any missing hill, which was filled up with extra seedlings of the same source.

3.3.7 Intercultural operations

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

3.3.7.1 Irrigation and drainage

In the early stages to establishment of the seedlings irrigation was provided to maintain a constant level of standing water up to 6 cm.

No water stress was encountered in reproductive and ripening phase. The plot was finally dried out at 15 days before harvesting.

3.3.7.2 Weeding

Weeding was done to keep the plots free from weeds, which ultimately ensured better growth and development. Weed may cause 80% of yield loss. So weeding done frequently in primary stages of rice plant growth.

3.3.7.3 Insect and pest control

There was no infection of diseases in the field but leaf roller (*Chaphalocrosis medinalis*) was found in the field and sprayed Malathion @ 1.12 L ha^{-1} at 30 DAT with using a hand sprayer.

3.4 Harvesting, threshing and cleaning

The crop was harvested at full maturity based on variety when 80-90% of the grains were turned into straw colored. Five plants were selected and harvested from each plot for taking growth and yield attributes data. For taking yield data, plants of whole plot were harvested. The harvested crop was bundled separately, properly tagged and brought to threshing floor. Enough care was taken during threshing and cleaning period of rice grain. The grains were dried, cleaned and weighed for individual plot. Yields of rice grain and straw was recorded from each plot and converted and expressed as t ha^{-1}.

3.5 Collection of data

3.5.1 Crop growth characters

The growth characters data were

i. Plant height (cm)

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

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

iv. SPAD value

v. Leaf area leaf^{-1} (mm^2)

3.5.2 Yield contributing characters and yield data

The following data were recorded:

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

ii. Grains panicle^{-1} (no.)

iii. Weight of 1000 grain (g)

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

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

vi. Harvest index (%)

3.5.3 Plant height

The height of plant was recorded in centimeter (cm) at 25, 45, 65, 85 DAT and at harvest. Data was recorded as the average of 5 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the panicle or flag leaf.

3.5.4 Tillers hill^{-1}

Number of tillers hill^{-1} was recorded at 25, 45, 65, 85 DAT and at harvest. Data was recorded as the average of 5 plants selected at random from the inner rows of each plot.

3.5.5 Dry weight plant^{-1}

Dry weight plant^{-1} was recorded at 25, 45, 65, 85 DAT and at harvest. Data was recorded as the average of 5 plants selected at random from the inner rows of each plot.

3.5.6 SPAD value

The SPAD value data was measured at 25. 45 and 65 DAT. Three leaves of three plants for each plot were used for taking SPAD value data. The chlorophyll meter Sat Plant Analysis Development (SPAD 502) in a simple and portable diagnostic tool that measures the greenness of the relative chlorophyll concentration of leaves. SPAD value was measured by using portable chlorophyll meter (SPAD-502, Minolta, Japan).

3.5.7 Leaf area leaf^{-1}

Leaf area leaf^{-1} data was measured from three leaves collected from three plants of each plot. Middle leaf of the plant was collected for taking data.

The leaf area was measured by using leaf area meter (AM 350, ADC Bio scientific ltd. UK). The leaf area plant^{-1} value data was taken at 25, 45 65 and 85 DAT. The leaf area plant^{-1} value was taken by multiplying the average value of single leaf into total leaf plant^{-1}.

3.5.8 Effective tillers hill^{-1}

The total number of effective tillers hill^{-1} was counted as the number of panicle bearing tiller during harvesting. Data on effective tillers hill^{-1} was counted from 5 selected hills and average value was recorded.

3.5.9 Grains panicle^{-1}

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

3.5.10 grain weight of 1000

One thousand grains were counted randomly from the total cleaned harvested grains and then weighed in grams and recorded and expressed in gram.

3.5.11 Grain yield

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

3.5.10 Straw yield

Straw obtained from each unit plot was sun-dried and weighed carefully. The dry weight of straw from each plot was taken and finally converted to ton hectare^{-1}(t ha^{-1}).

3.5.13 Harvest index

Harvest index was calculated from the grain and straw yield of rice for each plot and expressed in percentage.

$$\text{Harvest index (\%)} = \frac{\text{Grain yield (t ha}^{-1}\text{)}}{\text{Biological yield (t ha}^{-1}\text{)}} \times 100$$

3.6 Statistical analysis

The data obtained for different characters was statistically analyzed following STATISTIX 10 software. The significant difference among the treatment means values was adjudged by the Least Significant Difference (LSD) test at 5% level of probability.

CHAPTER IV

RESULTS AND DISCUSSION

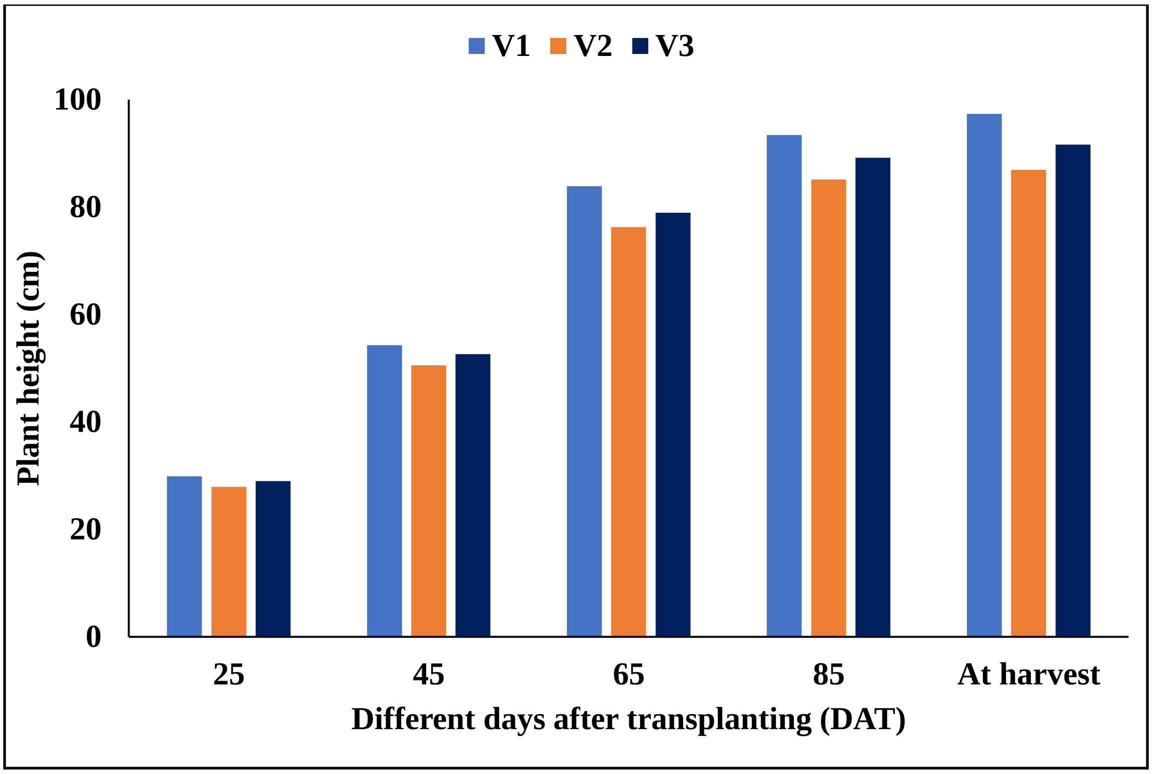
Results found from the present study concerning the effect of cultivar and various treatment combinations of organic and inorganic fertilizers on growth, yield and yield attributes of Boro rice are presented and discussed in this chapter. The results have been presented and discussed under discrete heads and sub-heads as follows:

4.1 Growth characters of Boro rice

4.1.1 Plant height

4.1.1.1 Effect of variety

Plant height is one of the most effective characters for better yield of rice which was also directly allied to straw yield. Plant height was recorded at 25, 45, 65, 85 DAT (days after transplanting) and at harvest showed statistically significant variations due to varietal differences (Figure 1). At 25, 45, 65, 85 DAT and harvest, the tallest plant (29.86, 54.31, 83.86, 93.42 and 97.36 cm respectively) was observed in V_1 (BRRI dhan63) variety that was followed by V_3 (BRRI hybird5) and the shortest plant (27.90, 50.57, 76.24, 85.12 and 86.94 cm respectively) was found in V_2 (BRRI dhan81) variety. Similar results were found by Islam *et al*., (2013) who observed significant and genetic variation between the varieties concerning height of plant. Mahamud *et al*., (2013) observed that the variation in height was specified by the differentiation of genetic characteristics and their genotype makeup.

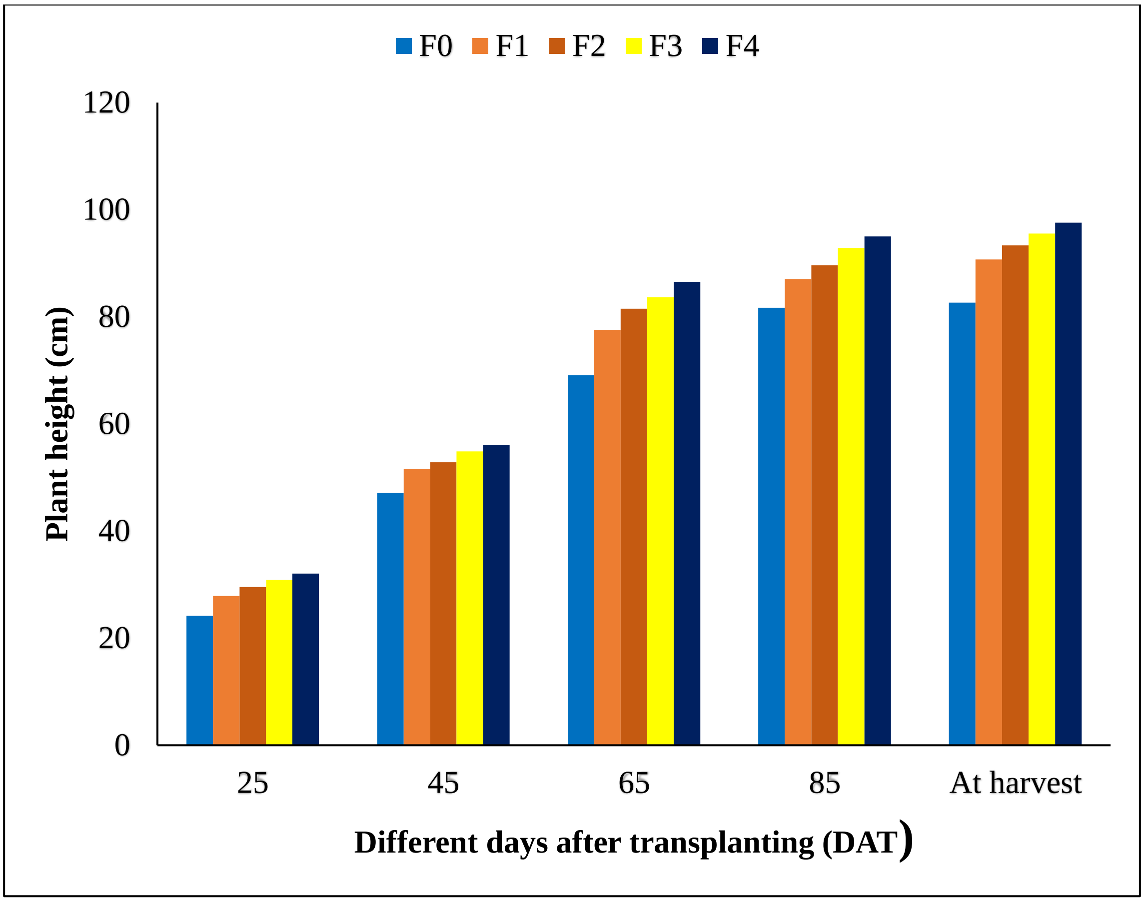


Here, V_1 = BRRIdhan63, V_2 = BRRI dhan81 and V_3 = BRRI hybrid5

Figure 1. Effect of rice varieties on plant height at different days after transplanting (LSD $_{0.05}$ = 1.90, 2.96, 12.45, 13.13, 13.73 at 25, 45, 65, 85 DAT and at harvest, respectively)

4.1.1.2 Effect of different nutrient combination

Plant height was varied significantly at different stages due to variation in different nutrient combination (Figure 2). At 25, 45, 65, 85 DAT and harvest, the tallest plant (32.08, 56.05, 86.53, 94.99 and 97.60 cm, respectively) was observed in F_4 (Rice straw decomposition + RDCF) where 5 t ha^{-1} rice straw and recommended dose of chemical fertilizer was applied and the second tallest plant (30.89, 54.90, 83.65, 92.88 and 95.55 cm, respectively) was found in F_3 where 5 t ha^{-1} vermicompost and recommended dose of fertilizer was applied, whereas the shortest plant height (24.18, 47.08, 69.09, 81.69 and 82.65 cm, respectively) was found in F_0 (Control) where no fertilizer was applied. Mondal *et al.* (2015) opined that the combination of integrated fertilizer affect significantly on plant height.



Here, F_0 = Control (no fertilizer), F_1 = Recommended dose of chemical fertilizers (RDCF), F_2 = Cow dung + RDCF, F_3 = Vermicompost + RDCF and F_4 = Rice straw decomposition + RDCF

Figure 2. Effect of different nutrient combination on plant height at different days after Transplanting (LSD $_{0.05}$ = 1.29, 1.65, 2.96, 3.20, 3.72 at 25, 45, 65, 85 DAT and at harvest, respectively)

4.1.1.3 Interaction effect of variety and different nutrient combination

Interaction effect of variety and different nutrient combination showed significant differences for plant height (Table 2). At 25, 45, 65, 85 DAT and harvest, the tallest plant (33.27, 58.11, 90.02, 99.44 and 103.19 cm respectively) was observed in V_1F_4 (BRRI dhan63 and Rice straw decomposition + RDCF i.e. (recommended dose of chemical fertilizer) and the second highest plant height (31.85, 56.58, 87.16, 93.98 and 96.87 cm) was observed in V_3F_4 while the shortest plant height (22.62, 45.53, 66.53, 75.44 and 76.40 cm respectively) was recorded in V_2F_0 (BRRI dhan81 and Control (no fertilizer).Uddin and Amin (2009) found that variety and integrated fertilizer management affect plant height significantly.

Table 2. Interaction effect of variety and different nutrient combination on plant height at different Days after transplanting (DAT)

Treatment combinations	Plant height (cm) at different days after transplanting (DAT)				
	25	45	65	85	At harvest
$V_1 \times F_0$	25.59	48.47 e-g	72.11 f-h	87.07 e-g	86.97 e-g
$V_1 \times F_1$	29.02	52.99cd	82.07 bc	90.05 c-f	96.35 b-d
$V_1 \times F_2$	30.18	54.21 a-d	86.81 a-c	93.44 b-d	99.20 a-c
$V_1 \times F_3$	31.22	57.78 ab	88.26 ab	97.09 ab	101.08 ab
$V_1 \times F_4$	33.27	58.11 a	90.02 a	99.44 a	103.19 a
$V_2 \times F_0$	22.62	45.53 g	66.53 h	75.44 h	76.40 h
$V_2 \times F_1$	26.43	50.06 d-f	74.22 e-g	83.45 fg	85.17 fg
$V_2 \times F_2$	28.88	51.42 d-f	77.66 d-f	85.73 e-g	89.41 d-g
$V_2 \times F_3$	30.43	52.36 c-e	80.38 c-e	89.42 c-f	90.96 d-g
$V_2 \times F_4$	31.11	53.46 b-d	82.41 a-d	91.56 b-e	92.74 c-e
$V_3 \times F_0$	24.32	47.25 fg	68.62 gh	82.57 g	84.59 g
$V_3 \times F_1$	28.24	51.75 de	76.48 e-f	87.63 d-g	90.63 d-g
$V_3 \times F_2$	29.56	52.98 c-e	80.15 c-e	89.68 c-f	91.36 c-f
$V_3 \times F_3$	31.01	54.57 a-d	82.30 a-d	92.13 b-e	94.61 b-e
$V_3 \times F_4$	31.85	56.58 a-c	87.16 a-c	93.98 a-c	96.87 a-d
LSD $_{(0.05)}$	**2.24**	**2.85**	**3.94**	**5.13**	**6.44**
CV (%)	**4.01**	**4.97**	**5.23**	**3.77**	**4.31**

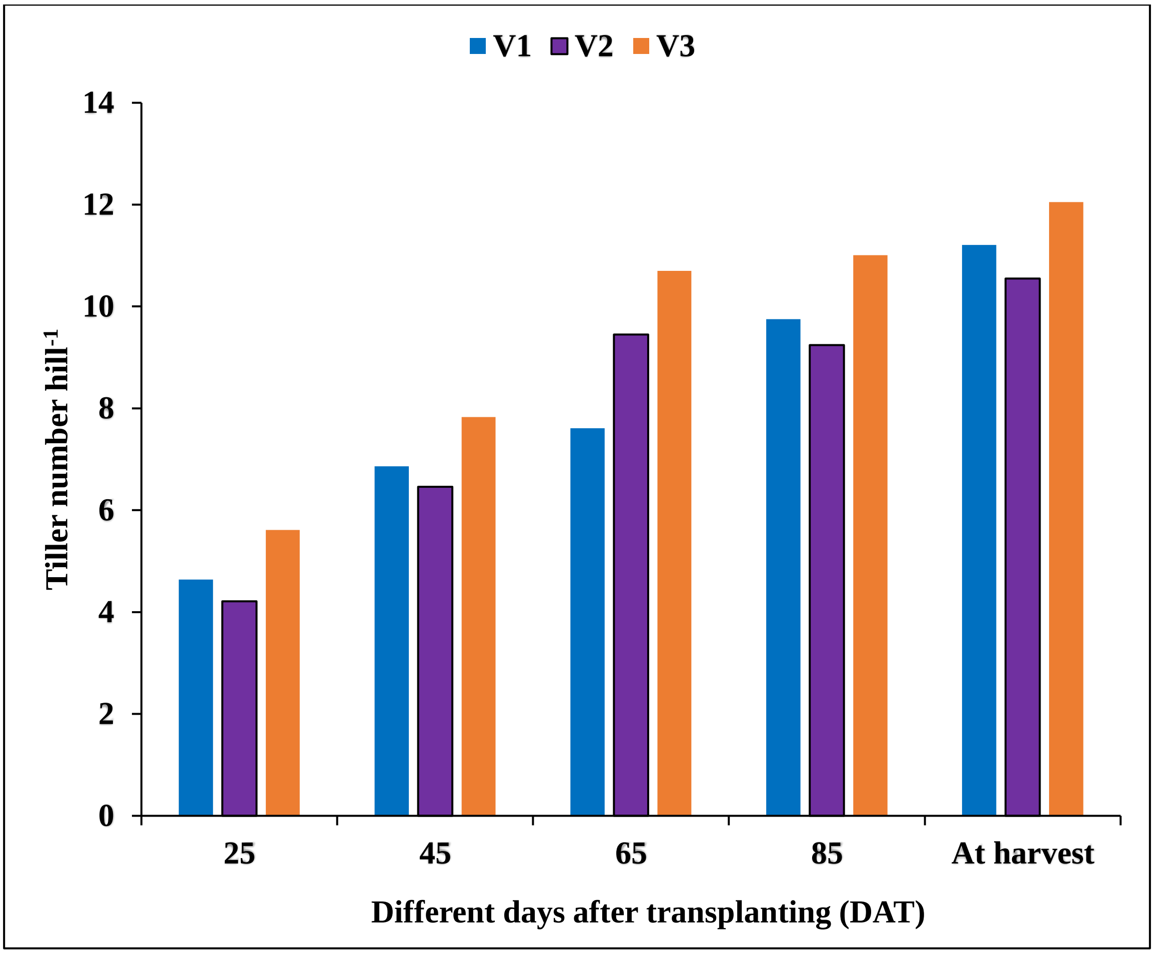
In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of significance

Here, V_1 = BRRIdhan63, V_2 = BRRI dhan81and V_3 = BRRI hybrid5; F_0 = Control (no fertilizer), F_1 = Recommended dose of chemical fertilizers (RDCF), F_2 = Cow dung + RDCF, F_3 = Vermicompost + RDCF and F_4 = Rice straw decomposition + RDCF

4.1.2 Tillers number hill^{-1}

4.1.2.1 Effect of variety

A significant variation in number of tillers hill^{-1} were observed due to variation in variety at 25, 45, 65, 85 DAT and at harvest (Figure 3). At 25, 45, 65, 85 DAT and harvest, the highest no. of tillers (5.62, 7.83, 10.70, 11.01 and 12.05, respectively) was observed in V_3 (BRRI hybrid5) that was followed by V_1 and lowest no. of tillers (4.21, 6.46, 9.45, 9.24 and 10.55 respectively) was observed in V_2 (BRRI dhan81). Fukushima (2019) also observed that tiller no. can vary due to varietal differences.

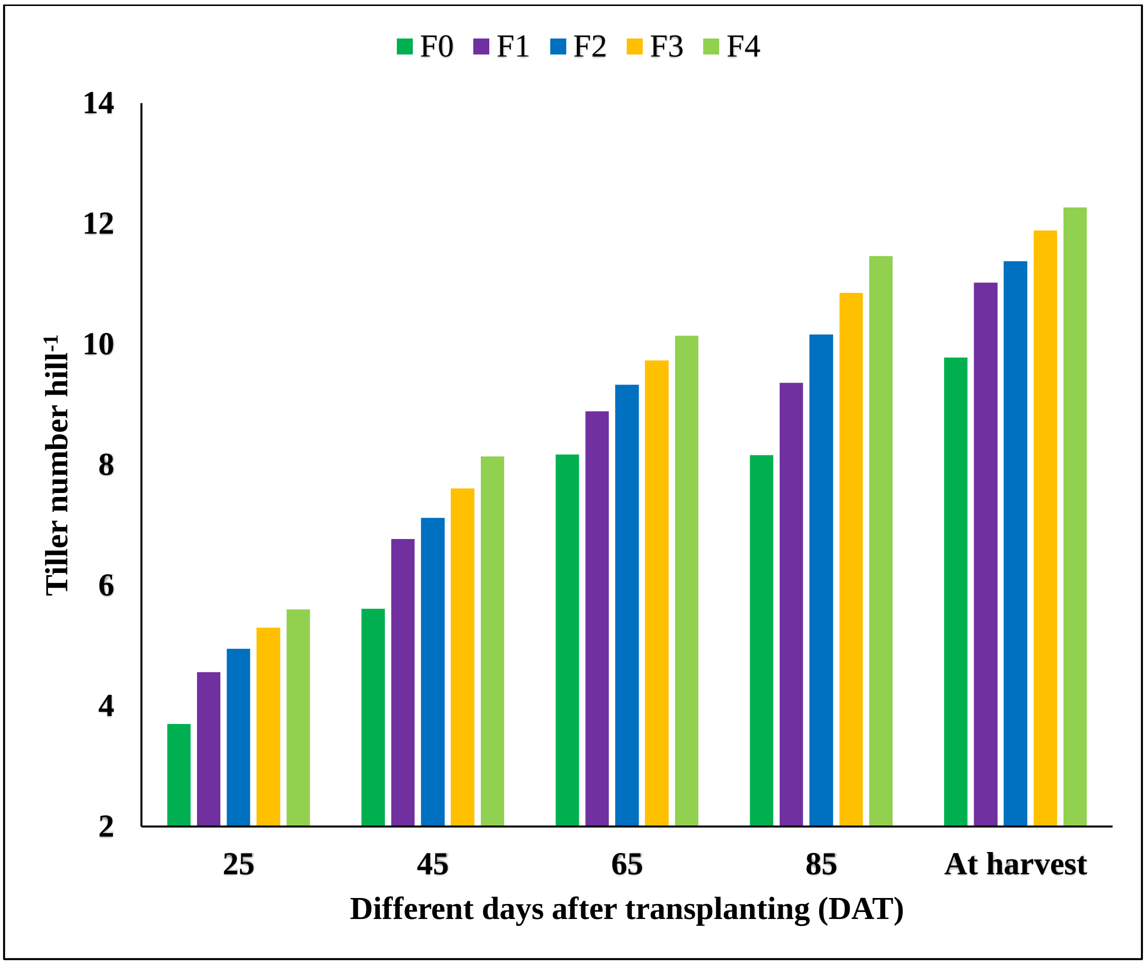


Here, V_1 = BRRIdhan63, V_2 = BRRI dhan81and V_3 = BRRI hybrid5

Figure 3. Effect of rice varieties on tillers number hill^{-1} at different days after transplanting (LSD $_{0.05}$ = 0.09, 0.87, 2.67, 3.57, 1.74 at 25, 45, 65, 85 DAT and at harvest, respectively)

4.1.2.2 Effect of different nutrient combination

Different nutrient combination showed different no. of tillers hill^{-1} which varied significantly (Figure 4). At 25, 45, 65, 85 DAT and harvest, the highest no. of tillers (5.60, 8.14, 1014, 11.46 and 12.27 respectively) was observed in F_4 (Rice straw decomposition + RDCF) which was followed by (5.30, 7.61, 9.73, 10.85 and 11.89, respectively) in F_3 (Vermicompost + RDCF). The lowest no. of tillers (3.70, 5.61, 8.17, 8.16 and 9.78, respectively) was observed in F_0 = Control (no fertilizer). *Roy et al.*, (2016) reported that integrated fertilizer management effect the no. of tillers hill^{-1}.



Here, F_0 = Control (no fertilizer), F_1 = Recommended dose of chemical fertilizers (RDCF), F_2 = Cow dung + RDCF, F_3 = Vermicompost + RDCF and F_4 = Rice straw decomposition + RDCF

Figure 4. Effect of different nutrient combination on tillers number hill^{-1} at different days after transplanting (LSD $_{0.05}$ = 0.07, 0.78, 1.16, 1.46, 1.41 at 25, 45, 65, 85 DAT and at harvest, respectively)

4.1.2.3 Interaction effect of variety and different nutrient combination

Interaction effect of variety and different nutrient combination showed significant differences in tillers number hill^{-1} (Table 3). At 25, 45, 65, 85 DAT and harvest, the highest no. of tillers (6.33, 8.93, 11.87, 12.83 and 13.46, respectively) were produced from the variety BRRI hybrid5 receiving rice straw decomposition + recommended dose of chemical fertilizer (V_3F_4) that is followed by the tillers no. (6.24, 8.33, 11.16, 12.38 and 13.08 respectively) produced from the variety BRRI hybrid5 receiving vermicompost + RDCF (V_3F_3). At 25, 45, 65, 85 DAT and harvest, the lowest no. of tillers (3.22, 5.17, 8.67, 7.75 and 9.47 respectively) was observed where BRRI dhan81 + Control (no fertilizer) (V_2F_0) were applied. Sarker *et al.,* (2017) observed that tillers number hill^{-1} is affected due to combined effect of variety and different dose of different nutrient combination.

Table 3. Interaction effect of variety and different nutrient combination on tillers number hill^{-1} at different days after transplanting (DAT)

Treatment combinations	Tiller number hill^{-1} at different days after transplanting (DAT)				
	25	**45**	**65**	**85**	**At harvest**
$V_1 \times F_0$	3.56 ij	5.33 h	6.17 j	7.87 ef	9.71 fg
$V_1 \times F_1$	4.35 gh	6.66 ef	7.33 i	9.38 d	11.06 b-e
$V_1 \times F_2$	4.67 fg	6.83 ef	7.83 hi	9.93 cd	11.40 b-d
$V_1 \times F_3$	5.10 d-f	7.52 cd	8.17 g-i	10.56 bc	11.84 b
$V_1 \times F_4$	5.53 cd	7.96 bc	8.53 f-h	11.03 b	12.02 b
$V_2 \times F_0$	3.22 j	5.17 h	8.67 e-h	7.75 f	9.47 g
$V_2 \times F_1$	3.98 hi	5.97 g	9.17 d-g	8.87 de	10.49 d-f
$V_2 \times F_2$	4.34 gh	6.67 ef	9.53 d-f	9.42 d	10.68 c-f
$V_2 \times F_3$	4.56 fg	6.97 de	9.87 cd	9.62 cd	10.76 c-e
$V_2 \times F_4$	4.93 ef	7.52 cd	10.01 cd	10.53 bc	11.33 b-d
$V_3 \times F_0$	4.33 gh	6.33 fg	9.67 de	8.87 de	10.15 e-g
$V_3 \times F_1$	5.35 c-e	7.67 c	10.17 cd	9.83 cd	11.51 bc
$V_3 \times F_2$	5.83 bc	7.87 bc	10.63 bc	11.12 b	12.05 b
$V_3 \times F_3$	6.24 ab	8.33 b	11.16 ab	12.38 a	13.08 a
$V_3 \times F_4$	6.33 a	8.93 a	11.87 a	12.83 a	13.46 a
LSD (0.05)	**0.1213**	**1.351**	**2.212**	**2.523**	**2.447**
CV (%)	**6.12**	**5.01**	**6.13**	**6.10**	**4.51**

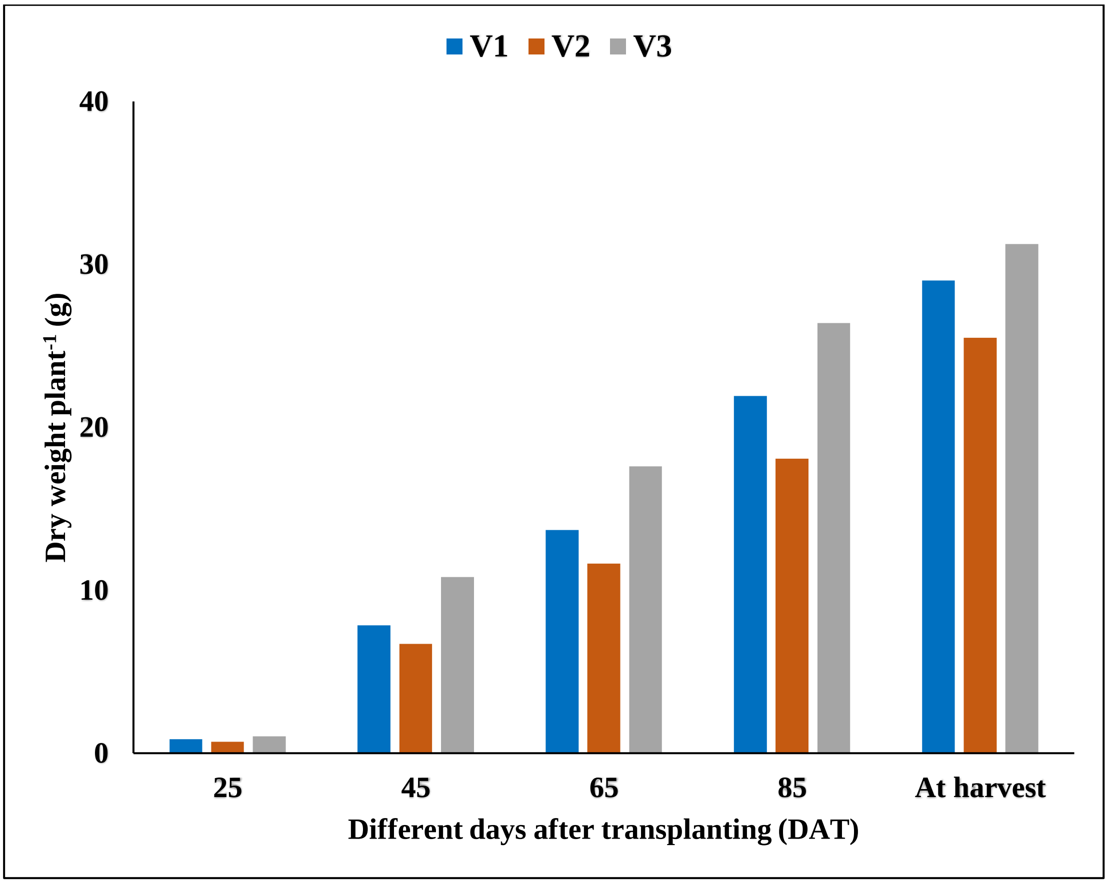
In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of significance

Here, V_1 = BRRIdhan63, V_2 = BRRI dhan81and V_3 = BRRI hybrid5; F_0 = Control (no fertilizer), F_1 = Recommended dose of chemical fertilizers (RDCF), F_2 = Cow dung + RDCF, F_3 = Vermicompost + RDCF and F_4 = Rice straw decomposition + RDCF.

4.1.3 Dry weight plant^{-1}

4.1.3.1 Effect of variety

Significant variations were observed in dry weight plant^{-1} (g) study as influenced due to variety of rice (Figure 5). Results showed that at 25, 45, 65, 85 DAT and harvest, the highest dry weight (1.04, 10.81, 17.61, 26.40 and 31.24 g, respectively) was observed in V_3 (BRRI hybrid5) that was followed by the variety V_1 (BRRI dhan63) and lowest dry weight (0.70, 6.71, 11.63, 18.08 and 25.49 g, respectively) was observed in V_2 (BRRI dhan81).

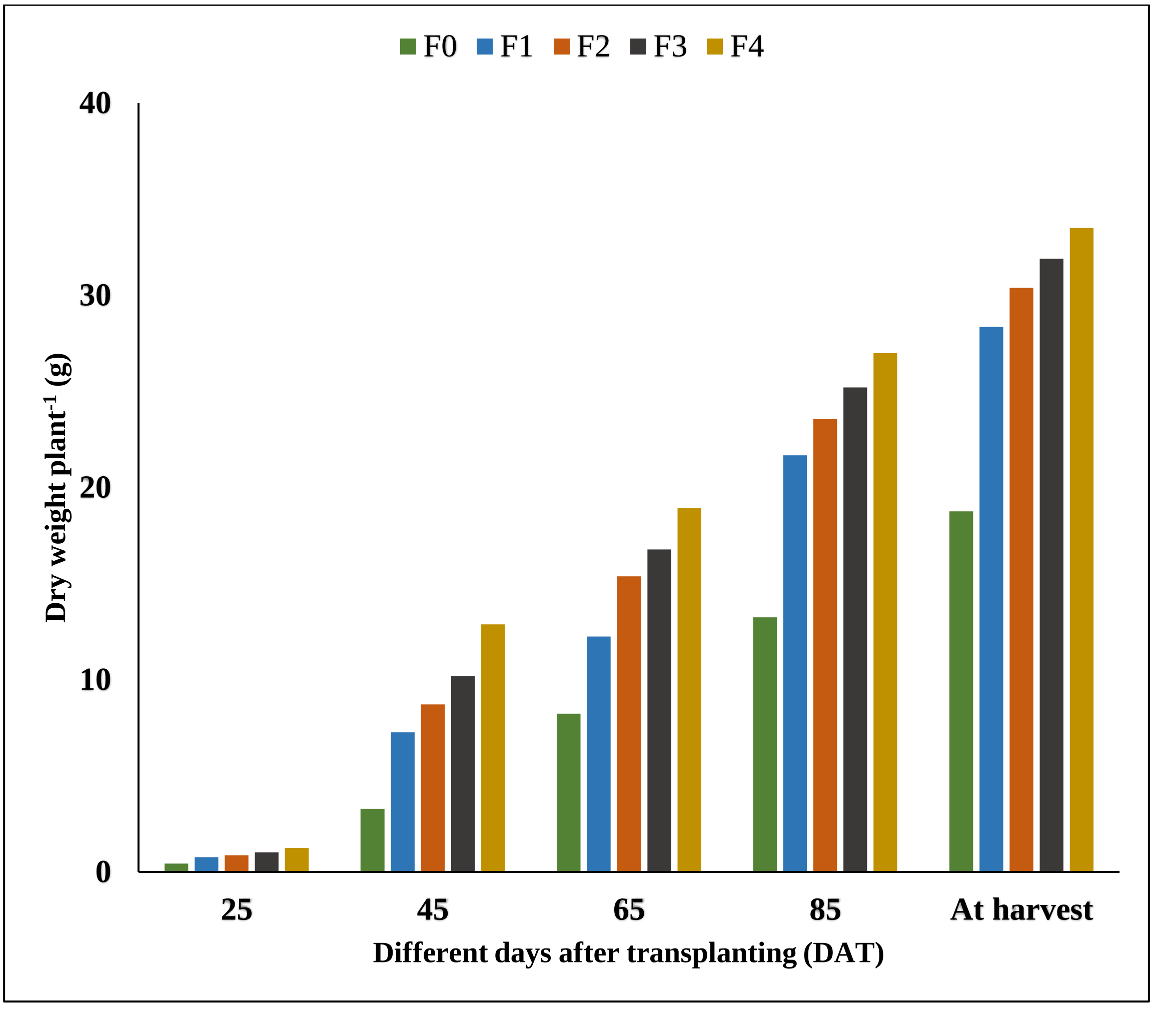


Here, V_1 = BRRIdhan63, V_2 = BRRI dhan81and V_3 = BRRI hybrid5

Figure 5. Effect of rice varieties on dry weight plant^{-1} at different days after transplanting (LSD $_{0.05}$ = 0.06, 0.61, 1.15, 1.71, 2.41 at 25, 45, 65, 85 DAT and at harvest, respectively)

4.1.3.2 Effect of different nutrient combination

Dry weight plant^{-1} vary significantly due to different nutrient combination treatments (Figure 6). It was observed t 25, 45, 65, 85 DAT and harvest, F_4 treatment (Rice straw decomposition + RDCF) showed highest dry weight plant^{-1} (1.25, 12.87, 18.93, 26.99 and 33.50 g, respectively) that is closely followed (1.01, 10.19, 16.78, 25.21 and 31.90 g, respectively) by F_3 (Vermicompost + RDCF). On the other hand, results obtained by F_0 (Control) showed the lowest dry weight plant^{-1} (0.43, 3.29, 8.23, 13.25 and 18.75 g, respectively).



Here, F_0 = Control (no fertilizer), F_1 = Recommended dose of chemical fertilizers (RDCF), F_2 = Cow dung + RDCF, F_3 = Vermicompost + RDCF and F_4 = Rice straw decomposition + RDCF

Figure 6. Effect of different nutrient combination on dry weight plant^{-1} at different days after transplanting (LSD $_{0.05}$ = 0.06, 0.63, 1.09, 1.34, 1.41 at 25, 45, 65, 85 DAT and at harvest, respectively)

4.1.3.3 Interaction effect of variety and different nutrient combination

Interaction effect of variety and different nutrient combination had significant influence on dry weight plant^{-1} at different growth stages of boro rice (Table 4). Result indicated that at 25, 45, 65, 85 DAT and harvest, the highest dry weight plant^{-1} (1.43, 15.33, 22.38, 31.90 and 35.82 g, respectively) was found in the variety BRRI hybrid5 receiving rice straw decomposition + recommended dose of chemical fertilizer (V_3F_4) that was closely followed (1.28, 12.91, 20.96, 29.85 and 34.88 g respectively) by the variety BRRI hybrid5 receiving vermicompost + RDCF (V_3F_3) which was statistically similar with V_3F_3. On the other hand, V_2F_0 (BRRI dhan81 and Control (no fertilizer)) showed the lowest dry weight plant^{-1} (0.33, 2.26, 6.23, 10.50 and 15.16 g at 25, 45, 65, 85 DAT and at harvest, respectively) which was statistically similar with V_1F_0. Sarker *et al.,* (2017) observed that dry weight plant^{-1} is affected due to combined effect of variety and different dose of different nutrient combination.

Table 4. Interaction effect of variety and different nutrient combination on dry weight plant^{-1} at different days after transplanting (DAT)

Treatment combinations	Dry weight plant^{-1} (g) at different days after transplanting (DAT)				
	25	45	65	85	At harvest
$V_1 \times F_0$	0.42 i	2.90 i	8.27 i	12.53 k	19.16 j
$V_1 \times F_1$	0.74 fg	6.98 g	11.90 gh	22.07 f-h	29.07 f-h
$V_1 \times F_2$	0.86 e	7.62 fg	14.21 d-f	23.37 d-f	30.62 d-g
$V_1 \times F_3$	0.93 de	9.12 e	15.83 d	25.20 c-e	32.53 b-e
$V_1 \times F_4$	1.32 b	12.65 b	18.29 c	26.50 c	33.66 a-c
$V_2 \times F_0$	0.33 i	2.26 i	6.23 j	10.50 k	15.16 k
$V_2 \times F_1$	0.64 g	5.33 h	9.58 i	17.26 ij	25.57 i
$V_2 \times F_2$	0.71 g	7.05 g	12.67 fg	19.46 hi	27.39 hi
$V_2 \times F_3$	0.83 ef	8.53 ef	13.56 e-g	20.57 gh	28.28 gh
$V_2 \times F_4$	1.00 cd	10.39 cd	16.11 d	22.58 e-g	31.03 c-e
$V_3 \times F_0$	0.53 h	4.71 h	10.18 hi	16.72 j	21.93 j
$V_3 \times F_1$	0.93 de	9.46 de	15.27 de	25.72 cd	30.43 f-h
$V_3 \times F_2$	1.05 c	11.46 c	19.26 bc	27.83 bc	33.12 b-d
$V_3 \times F_3$	1.28 b	12.91 b	20.96 ab	29.85 ab	34.88 ab
$V_3 \times F_4$	1.43 a	15.53 a	22.38 a	31.90 a	35.82 a
LSD $_{(0.05)}$	**0.0956**	**1.0988**	**1.8957**	**2.3225**	**2.4480**
CV (%)	**6.55**	**7.71**	**7.86**	**6.23**	**5.08**

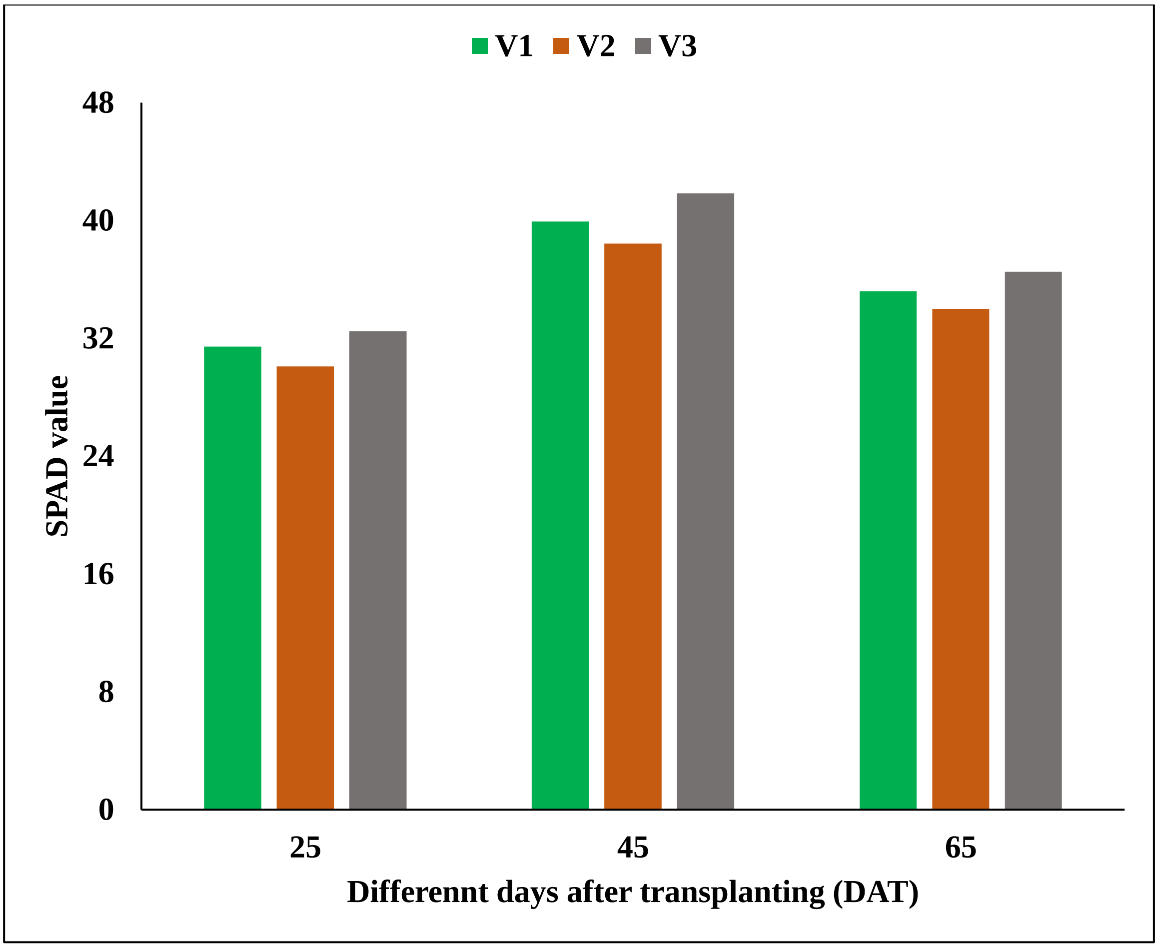
In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of significance

Here, V_1 = BRRIdhan63, V_2 = BRRI dhan81and V_3 = BRRI hybrid5; F_0 = Control (no fertilizer), F_1 = Recommended dose of chemical fertilizers (RDCF), F_2 = Cow dung + RDCF, F_3 = Vermicompost + RDCF and F_4 = Rice straw decomposition + RDCF

4.1.4 SPAD value

4.1.4.1 Effect of variety

Significant variation was observed in SPAD value study as influenced due to variety of Boro rice (Figure 7). Results showed that at 25, 45 and 65 DAT (days after transplanting), the highest SPAD value (32.48, 41.84 and 36.51, respectively) was observed in V_3 (BRRI hybrid5) that is followed by the variety V_1 (BRRI dhan63) and lowest SPAD value (30.10, 38.43 and 34.01 respectively) was observed in V_2 (BRRI dhan81). Sultana *et al.*, (2018) observed the significant variation in SPAD value due to varietal differences.

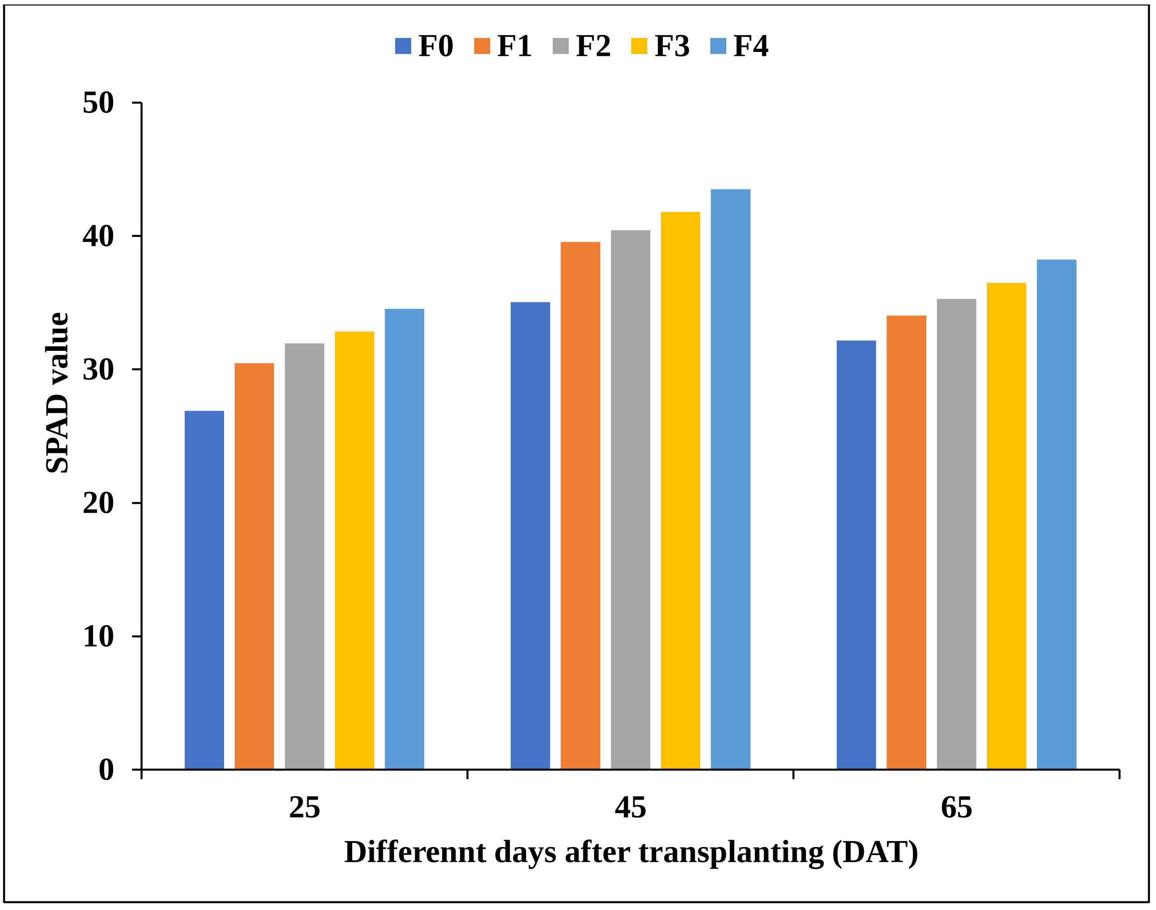


Here, V_1 = BRRIdhan63, V_2 = BRRI dhan81and V_3 = BRRI hybrid5

Figure 7. Effect of rice varieties on SPAD value at different days after transplanting (LSD $_{0.05}$ = 1.69, 2.08, 1.89, at 25, 45, and 65 DAT, respectively)

4.1.4.2 Effect of different nutrient combination

SPAD value as influenced by different nutrient combination of boro rice was significant at different growth stages after transplantation (Figure 8). It was observed at 25, 45, and 65 DAT, F_4 (Rice straw decomposition + RDCF) showed highest SPAD value (34.54, 43.51 and 38.24, respectively) that is closely followed (32.85, 41.80 and 36.49, respectively) by F_3 (Vermicompost + RDCF) which was statistically similar with F_2. On the other hand, results obtained by F_0 Control (no fertilizer), showed the lowest SPAD value (26.90, 35.05 and 32.16 DAT, respectively). Apon *et al.*, (2018) also observed the variation in SPAD value due to different nutrient combination.



Here, F_0 = Control (no fertilizer), F_1 = Recommended dose of chemical fertilizers (RDCF), F_2 = Cow dung + RDCF, F_3 = Vermicompost + RDCF and F_4 = Rice straw decomposition + RDCF

Figure 8. Effect of different nutrient combination on SPAD value at different days after transplanting (LSD $_{0.05}$ = 1.95, 1.60, 1.70 at 25, 45 and 65 DAT, respectively)

4.1.4.3. Interaction effect of variety and different nutrient combination

Interaction effect of variety and different nutrient combination had significant influence on SPAD value at different growth stages of boro rice (Table 5). Results indicated that the highest SPAD value (35.95, 45.25 and 39.82 at 25, 45 and 65 DAT, respectively) was found V_3F_4 that was closely followed (34.43, 43.46 and 38.25, respectively) by V_1F_4 (BRRI dhan63 and Rice straw decomposition + RDCF) which was statistically similar with V_3F_3. On the other hand, V_2F_0 (BRRI dhan81 and Control (no fertilizer)) showed the lowest number of SPAD value (25.24, 33.37 and 31.07 at 25, 45 and 65 DAT, respectively) which was statistically similar with V_1F_0.

Table 5. Interaction effect of variety and different nutrient combination on SPAD value at different days after transplanting (DAT)

Treatment combinations	Spade value at different days after transplanting (DAT)		
	25	45	65
$V_1 \times F_0$	27.28 ef	34.55 ef	32.12 fg
$V_1 \times F_1$	30.54 c-f	39.40 cd	34.02 d-g
$V_1 \times F_2$	32.04 b-d	40.12 cd	35.18 c-f
$V_1 \times F_3$	32.91 a-c	42.12 a-c	36.45 b-e
$V_1 \times F_4$	34.43 ab	43.46 ab	38.25 ab
$V_2 \times F_0$	25.24 g	33.37 f	31.07 g
$V_2 \times F_1$	29.28 d-f	37.81 d	32.85 fg
$V_2 \times F_2$	30.92 c-e	39.35 cd	34.25 d-f
$V_2 \times F_3$	31.84 b-d	39.81 cd	35.24 b-f
$V_2 \times F_4$	33.23 a-c	41.81 bc	36.64 a-d
$V_3 \times F_0$	28.19 e-g	37.23 de	33.28 e-g
$V_3 \times F_1$	31.58 b-d	41.45 bc	35.26 b-f
$V_3 \times F_2$	32.89 a-c	41.82 bc	36.42 b-e
$V_3 \times F_3$	33.80 a-c	43.46 ab	37.77 a-c
$V_3 \times F_4$	35.95 a	45.25 a	39.82 a
LSD (0.05)	**3.3704**	**2.7790**	**2.9384**
CV (%)	**6.38**	**4.12**	**4.95**

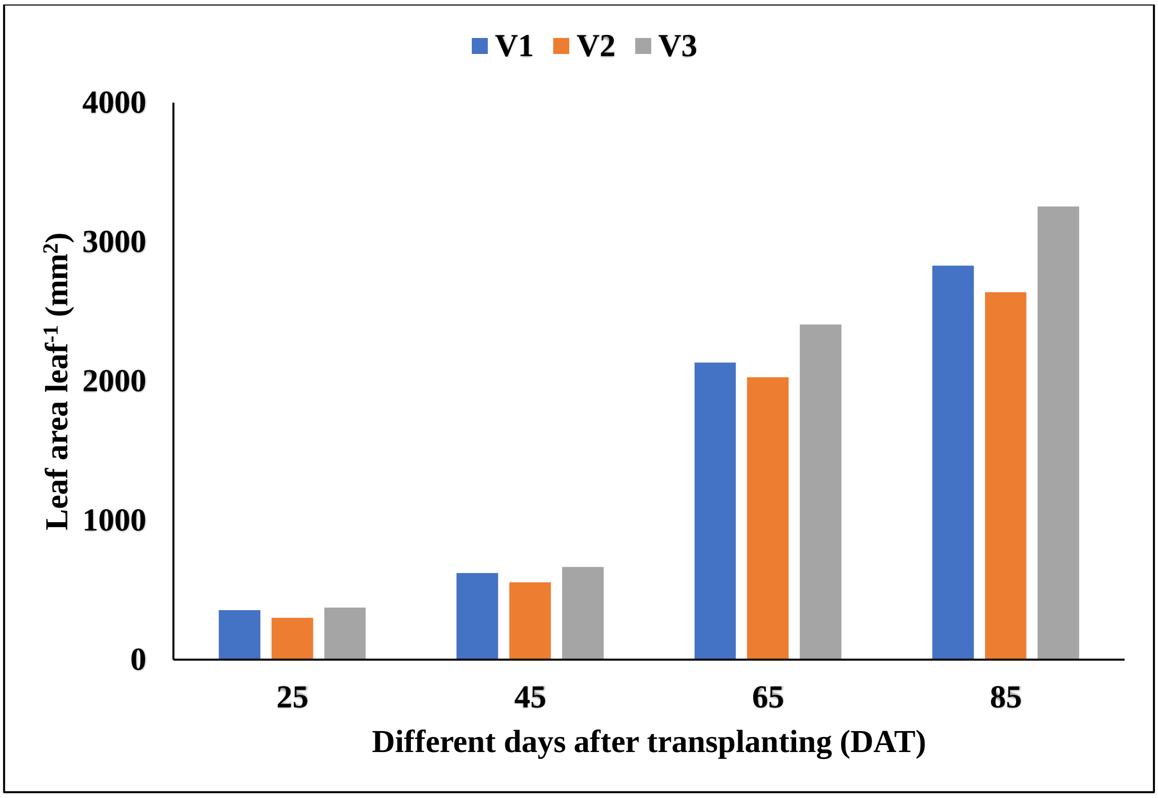
In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of significance

Here, V_1 = BRRIdhan63, V_2 = BRRI dhan81and V_3 = BRRI hybrid5; F_0 = Control (no fertilizer), F_1 = Recommended dose of chemical fertilizers (RDCF), F_2 = Cow dung + RDCF, F_3 = Vermicompost + RDCF and F_4 = Rice straw decomposition + RDCF

4.1.5 Leaf area leaf^{-1}

4.1.5.1 Effect of variety

Significant variations were observed in leaf area leaf^{-1} study as influenced due to variety of Boro rice (Figure 9). Results showed that at 25, 45, 65 and 85 DAT (days after transplanting), the highest leaf area leaf^{-1} (373.40, 664.80, 2406.2 and 3254.0 mm^2, respectively) was observed in V_3 (BRRI hybrid5) that is followed by the variety V_1 (BRRI dhan63) and lowest leaf area leaf^{-1} (300.80, 556.67, 2027.3 and 2638.6, respectively) was observed in V_2 (BRRI dhan81). Sultana *et al.*, (2018) observed the significant variation in leaf area leaf^{-1} due to varietal differences.

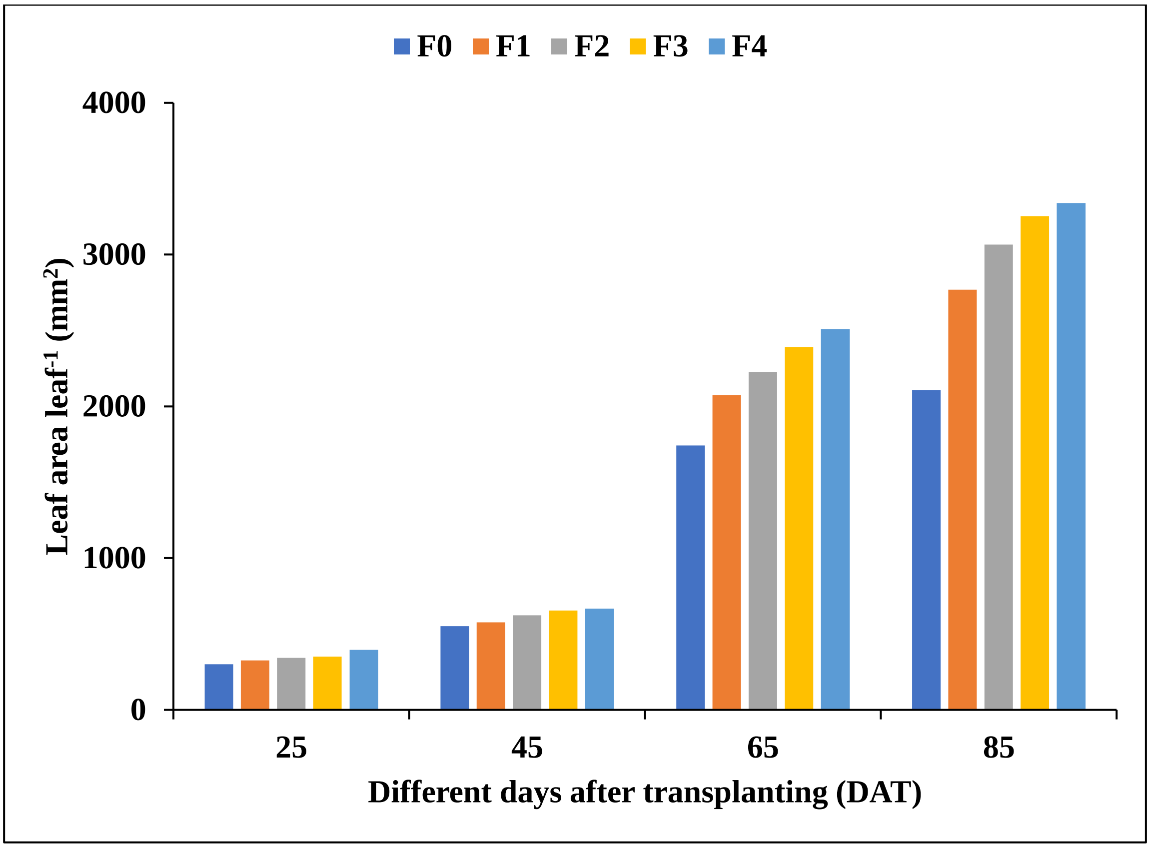


Here, V_1 = BRRIdhan63, V_2 = BRRI dhan81and V_3 = BRRI hybrid5

Figure 9. Effect of rice varieties on leaf area leaf^{-1} (mm^2) at different days after transplanting (LSD $_{0.05}$ = 14.44, 41.44, 93.76, 200.95 at 25, 45, 65 and 85 DAT respectively)

4.1.5.2 Effect of different nutrient combination

Leaf area leaf^{-1} as influenced by different nutrient combination of boro rice was significant at different growth stages after transplantation (Figure 10). It was observed at 25, 45, 65 and 85 DAT, F_4 (Rice straw decomposition + RDCF) showed highest leaf area leaf^{-1} (395.67, 667.78, 2509.8 and 3340.3 mm^2 respectively) that is closely followed (351.33, 654.00, 2390.7 and 3253.0 mm^2 respectively) by F_3 (Vermicompost + RDCF) which was statistically similar with F_2. On the other hand, results obtained by F_0 Control (no fertilizer), showed the lowest leaf area leaf^{-1} (301.33, 550.44, 1742.3 and 2107.7 mm^2, respectively). Apon *et al.*, (2018) also observed the variation in leaf area leaf^{-1} due to different nutrient combination.



Here, F_0 = Control (no fertilizer), F_1 = Recommended dose of chemical fertilizers (RDCF), F_2 = Cow dung + RDCF, F_3 = Vermicompost + RDCF and F_4 = Rice straw decomposition + RDCF

Figure 10. Effect of different nutrient combination on leaf area leaf^{-1} (mm^2) at different days after transplanting (LSD $_{0.05}$ = 17.21, 32.77, 110.12, 182.28 at 25, 45, 65 and 85 DAT respectively)

4.1.5.2 Interaction effect of variety and different nutrient combination

Interaction effect of variety and different nutrient combination iknfluenced significantly on leaf area leaf^{-1} at different growth stages of boro rice (Table 6). Results indicated that the highest leaf area leaf^{-1} (442.0, 778.0, 2826.0 and 3791.0 mm^2 at 25, 45, 65 and 85 DAT, respectively) was found with V_3F_4 that was closely followed (378.0, 709.0, 2688.0 and 3663.0 mm^2, respectively) by V_3F_3 (BRRI hybird5 and vermicompost + RDCF) which was statistically similar with V_3F_2. On the other hand, V_2F_0 (BRRI dhan81 and Control (no fertilizer)) showed the lowest leaf area leaf^{-1} value (271.0, 536.33, 1578.0 and 1982.0 mm^2 at 25, 45, 65 and 85 DAT, respectively) which was statistically similar with V_1F_0.

Table 6. Interaction effect of variety and different nutrient combination on leaf area leaf^{-1} at different days after transplanting (DAT)

Treatment combinations	Leaf area leaf^{-1} (mm^2) at different days after transplanting (DAT)			
	25	**45**	**65**	**85**
$V_1 \times F_0$	297.00 fg	543.00 hi	1672.0 h	2123.0 i
$V_1 \times F_1$	341.00 cd	610.00 d-g	2031.0 e-g	2612.0 fg
$V_1 \times F_2$	347.00 cd	650.00 b-e	2279.0 b-d	2995.0 de
$V_1 \times F_3$	367.00 bc	677.00 bc	2306.0 b-d	3173.0 cd
$V_1 \times F_4$	428.00 a	630.33 c-f	2376.0 b	3243.0 cd
$V_2 \times F_0$	271.00 g	536.33 hi	1578.0 h	1982.0 i
$V_2 \times F_1$	289.00 fg	525.00 i	1929.0 g	2506.0 gh
$V_2 \times F_2$	318.00 d-f	551.00 g-i	2124.0 e-f	2795.0 e-g
$V_2 \times F_3$	309.00 ef	576.00 f-i	2178.0 c-e	2923.0 d-f
$V_2 \times F_4$	317.00 d-f	595.00 e-h	2327.3 bc	2987.0 de
$V_3 \times F_0$	336.00 de	572.00 f-i	1977.0 fg	2218.0 hi
$V_3 \times F_1$	345.00 cd	597.00 e-h	2261.7 b-d	3190.0 cd
$V_3 \times F_2$	366.00 bc	668.00 b-d	2278.3 b-d	3408.0 bc
$V_3 \times F_3$	378.00 b	709.00 b	2688.0 a	3663.0 ab
$V_3 \times F_4$	442.00 a	778.00 a	2826.0 a	3791.0 a
LSD $_{(0.05)}$	**29.801**	**56.761**	**190.74**	**315.73**
CV (%)	**5.15**	**5.48**	**5.17**	**6.44**

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of significance

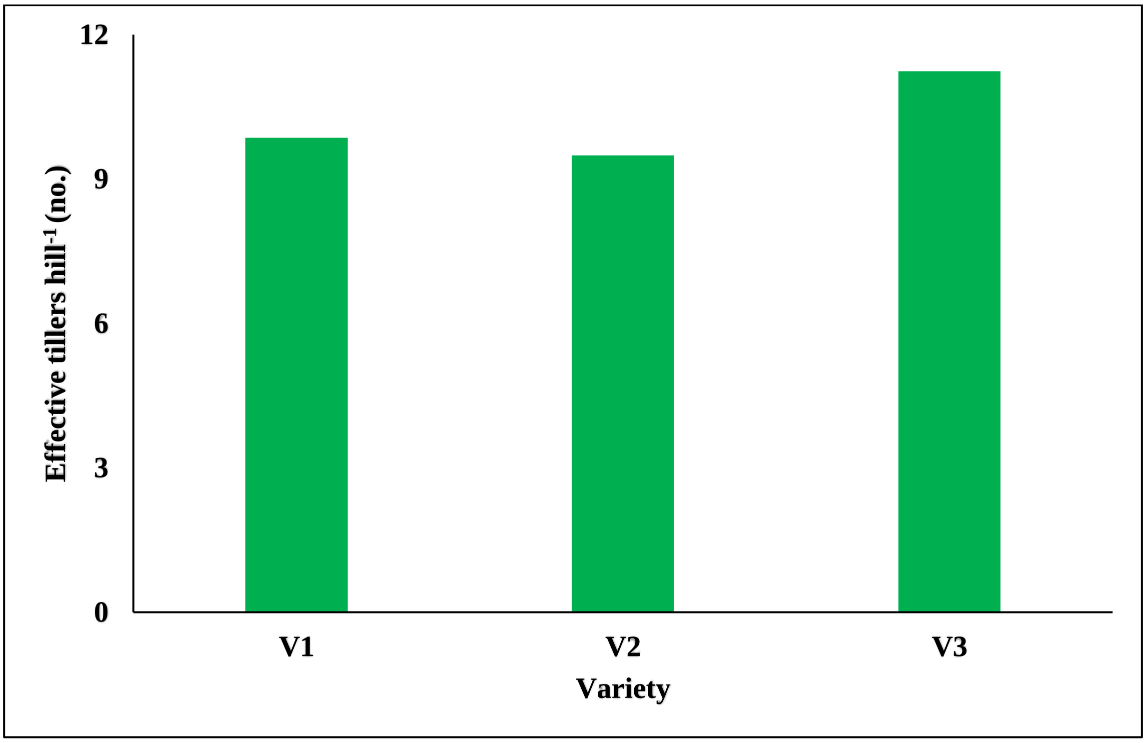
Here, V_1 = BRRIdhan63, V_2 = BRRI dhan81and V_3 = BRRI hybrid5; F_0 = Control (no fertilizer), F_1 = Recommended dose of chemical fertilizers (RDCF), F_2 = Cow dung + RDCF, F_3 = Vermicompost + RDCF and F_4 = Rice straw decomposition + RDCF

4.2 Yield characters of Boro Rice

4.2.1 Effective tillers hill^{-1}

4.2.1.1 Effect of variety

Number of effective tillers hill^{-1} of boro rice varied significantly due to variation of different rice varieties (Table 11). The highest number of effective tillers hill^{-1} (11.24) was found from V_3 (BRRI hybrid5) which was followed by effective tillers hill^{-1} (9.86) from V_1 (BRRI dhan63), whereas the lowest number (9.49) was observed from V_2 (BRRI dhan81). Chamely and Islam (2015) also observed the variation effect of variety on effective tillers of rice.

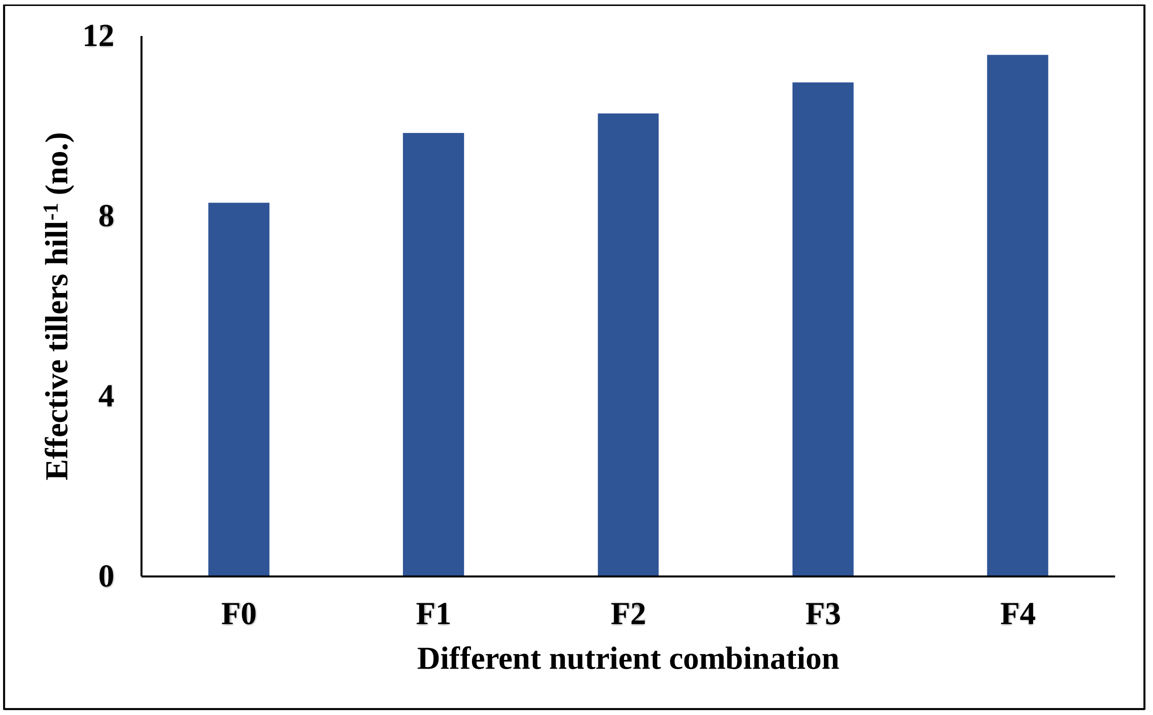


Here, V_1 = BRRIdhan63, V_2 = BRRI dhan81and V_3 = BRRI hybrid5

Figure 11. Effect of rice varieties on effective tiller hill^{-1} at harvest of rice (LSD $_{0.05}$ = 0.57 at harvest)

4.2.1.2 Effect of different nutrient combination

Different levels of integrated nutrient combination showed significant variations in terms of effective tillers hill^{-1} of boro rice (Table 12). The highest number of effective tillers hill^{-1} (11.58) was recorded from F_4 (Rice straw decomposition + RDCF) that was followed by effective tillers hill^{-1} (10.97 and 10.28) from F_3 and F_2 and they were statistically similar, while the lowest number recorded (8.30) from F_0 (Control (no fertilizer)) that was statistically similar (9.85) to F_1. Hossaen *et al.* (2011) observed the significant variations in effective tillers number with fertilizer managements.



Here, F_0 = Control (no fertilizer), F_1=Recommended dose of chemical fertilizers (RDCF), F_2 = Cow dung + RDCF, F_3 = Vermicompost + RDCF and F_4 = Rice straw decomposition + RDCF

Figure 12. Effect of different nutrient combination on effective tiller hill^{-1} at harvest of rice (LSD $_{0.05}$ = 0.68 at harvest)

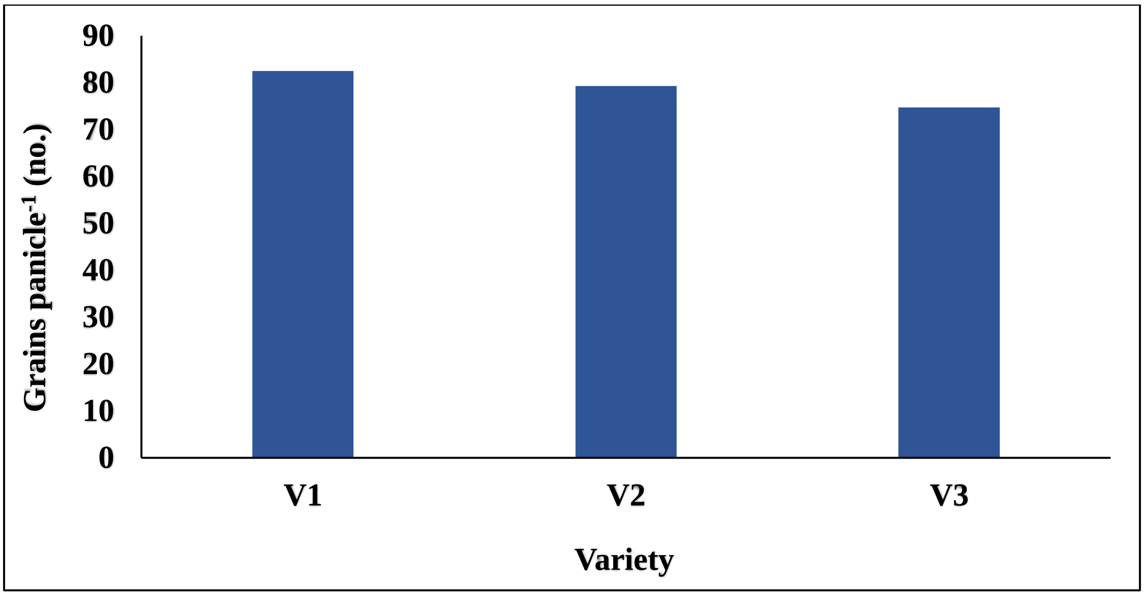
4.2.1.3 Interaction effect of variety and different nutrient combination

Statistically significant variation was recorded on number of effective tillers hill^{-1} of boro rice due to the combined effect of rice varieties and different levels of integrated fertilizer management (Table 7). The highest number of effective tillers hill^{-1} (12.93) was recorded from V_3F_4 (BRRI hybrid5 and Rice straw decomposition + RDCF) that was followed (12.43 and 11.27) by V_3F_3 (BRRI hybrid5 and Vermicompost + RDCF) and V_3F_2 (BRRI hybrid5 and Cow dung + RDCF) and the lowest number (7.91) was found from V_2F_0 (BRRI dhan81 and Control (no fertilizer)) that was statistically similar to V_1F_0.

4.2.2 Grains panicle^{-1}

4.2.2.1 Effect of variety

Different rice varieties varied significantly in terms of grains panicle^{-1} of boro rice (Figure 13). The highest number of grains panicle^{-1} (82.74) was observed from V_1 (BRRI dhan63) which was followed (79.31) by V_2 (BRRI dhan81), whereas the lowest number (74.68) was recorded from V_3 (BRRI hybrid5). Hoque *et al.,* (2003) also found the varietal effect on grains panicle^{-1}.

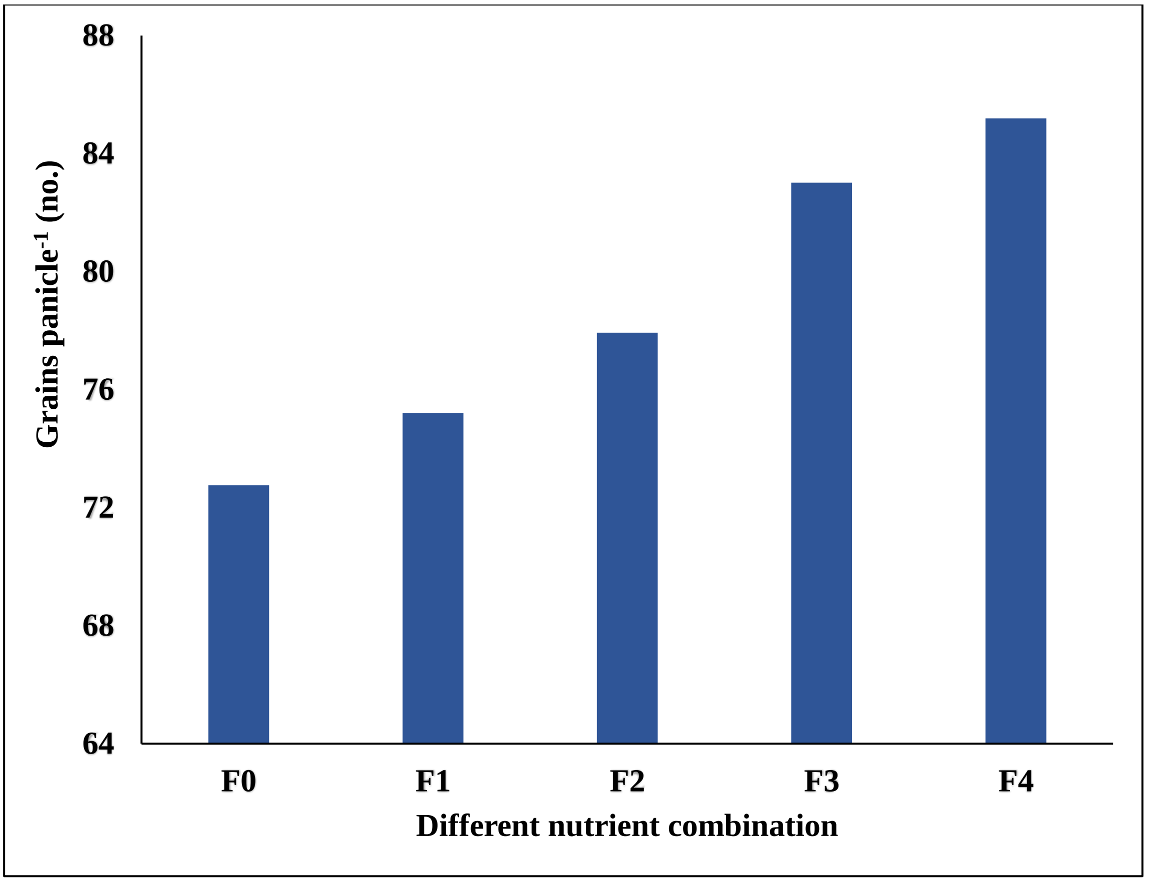


Here, V_1 = BRRIdhan63, V_2 = BRRI dhan81and V_3 = BRRI hybrid5

Figure 13. Effect of rice varieties on grains panicle^{-1} at harvest of rice (LSD $_{0.05}$ = 4.79)

4.2.2.2 Effect of different nutrient combination

Statistically significant variations were recorded in terms of grains panicle^{-1} of boro rice due to different nutrient combination (Figure 14). The highest number of grains panicle^{-1} (85.19) was found from F_4 (Rice straw decomposition + RDCF) that was statistically similar (83.01) to F_3. While the lowest number (72.76) was from F_0 (Control (no fertilizer)) which was followed by F_2 and F_1 (77.93 and 75.21, respectively) that was statistically similar. Satyanarayana *et al.,* (2002) observed the varied effect of fertilizer management on grains panicle^{-1} in rice.



Here, F_0 = Control (no fertilizer), F_1=Recommended dose of chemical fertilizers (RDCF), F_2 = Cow dung + RDCF, F_3 = Vermicompost + RDCF and F_4 = Rice straw decomposition + RDCF

Figure 14. Effect of different nutrient combination on grains panicle^{-1} at harvest of rice (LSD $_{0.05}$ = 4.20)

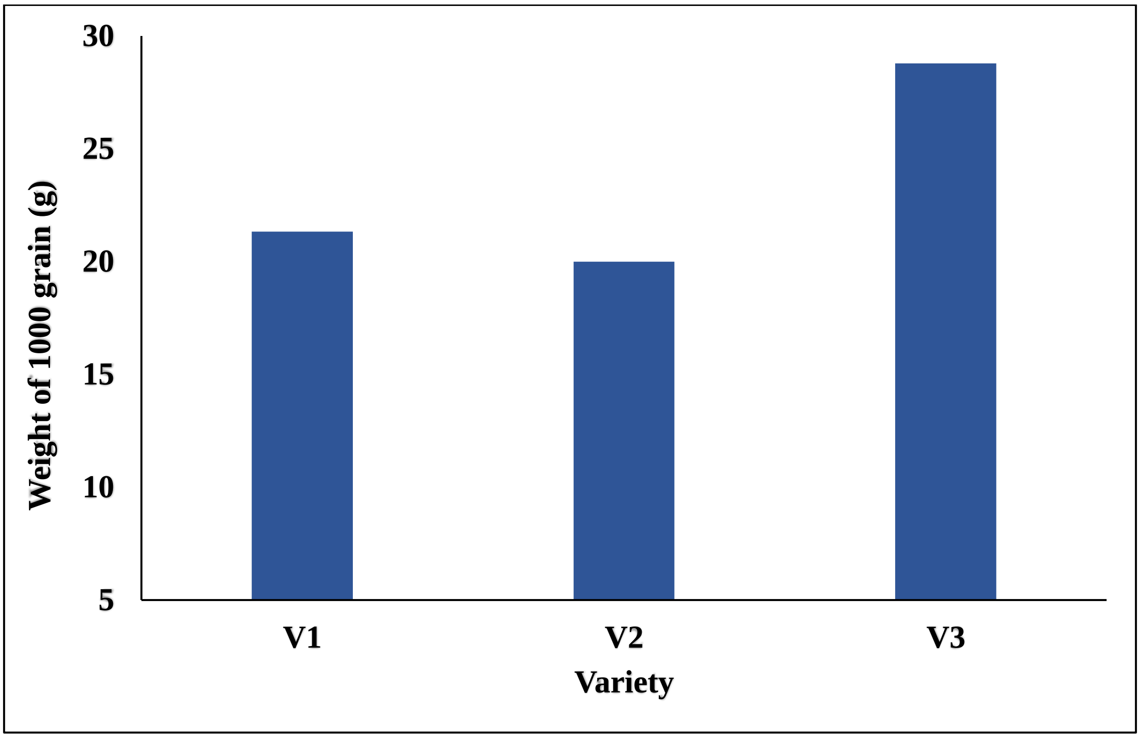
4.2.2.3 Interaction effect of variety and different nutrient combination

Statistically significant variation was recorded on number of grains panicle^{-1} of boro rice due to the interaction effect of rice varieties and different levels of integrated fertilizer management (Table 7). The highest number of grains panicle^{-1} (88.88) was recorded from V_1F_4 (BRRI dhan63 and Rice straw decomposition + RDCF) that was followed (86.60 and 86.37) by V_2F_4 (BRRI dhan81 and Rice straw decomposition + RDCF) and V_1F_3 (BRRI dhan63 and vermicompost + RDCF) and the lowest number (69.86) was found from V_3F_0 (BRRI hybrid5 and Control (no fertilizer)) that was statistically similar to V_2F_0.

4.2.3 Weight of 1000 grain

4.2.3.1 Effect of variety

Different rice varieties varied significantly in terms of weight of 1000 grain of boro rice (Figure 15). The highest weight of 1000 grain of boro rice was recorded (28.78g) from V_3 (BRRI hybrid5), whereas the lowest number (20.0g) was recorded from V_2 (BRRI dhan81) which was followed (21.33) by V_1 (BRRI dhan63).



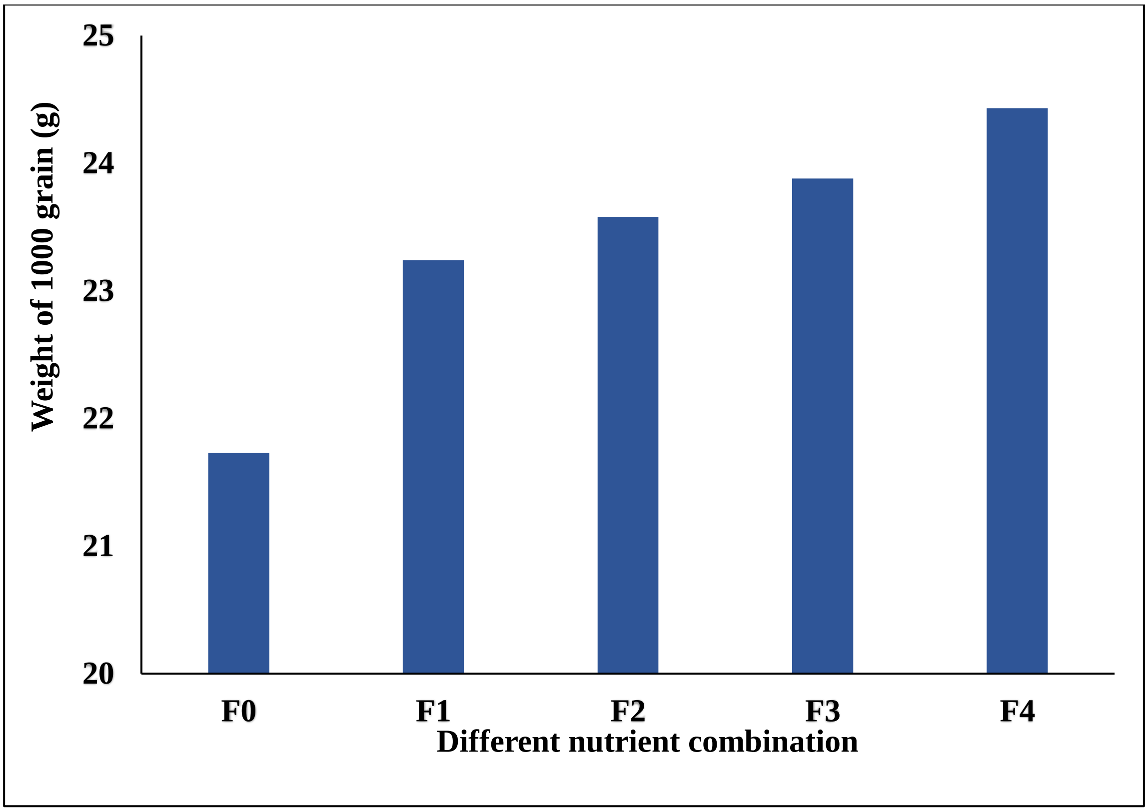
Here, V_1 = BRRIdhan63, V_2 = BRRI dhan81and V_3 = BRRI hybrid5

Figure 15. Effect of rice varieties on weight of 1000 grain at harvest of rice (LSD $_{0.05}$ = 2.11)

4.2.3.2 Effect of different nutrient combination

Weight of 1000-grain of boro rice showed statistically significant variations due to different levels of fertilizer management (Figure 16). The highest weight of 1000-grain (24.43 g) was observed from F_4 that was followed by F_3 and F_2 (23.88g and 23.58g respectively),

whereas the lowest weight (21.73 g) was recorded from F_0 that was statistically similar to F_1 (23.24g). Satyanarayana *et al.*, (2002) observed the effect of fertilizer management on 1000-grains weight of rice.



Here, F_0 = Control (no fertilizer), F_1=Recommended dose of chemical fertilizers (RDCF), F_2 = Cow dung + RDCF, F_3 = Vermicompost + RDCF and F_4 = Rice straw decomposition + RDCF

Figure 16. Effect of different nutrient combination on weight of 1000 grain at harvest of rice (LSD $_{0.05}$ = 1.00)

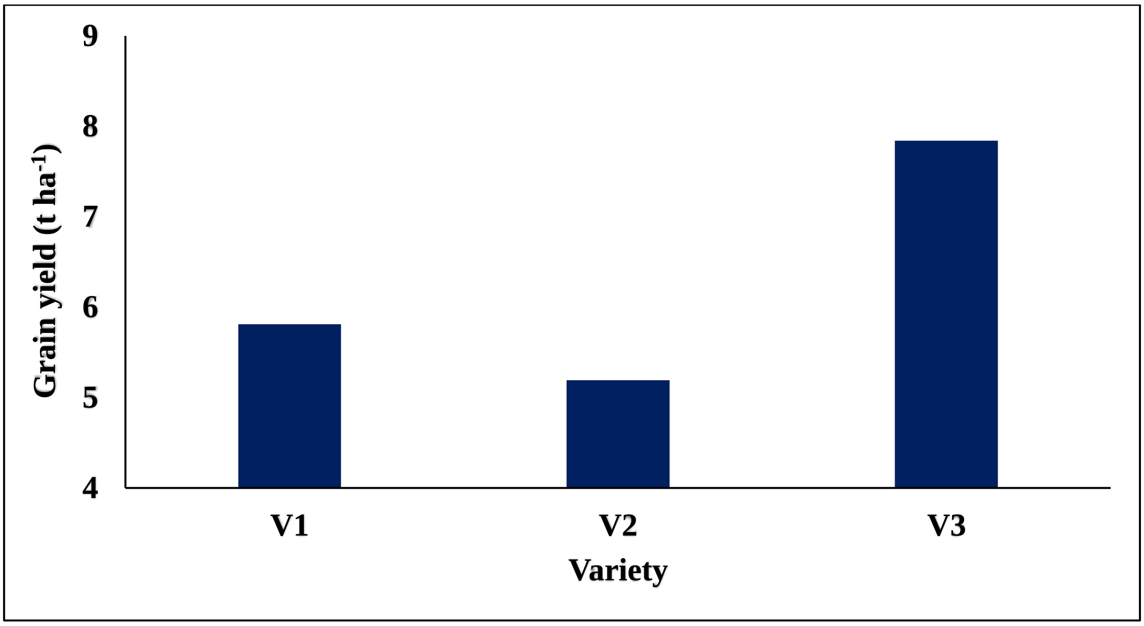
4.2.3.3 Interaction effect of variety and different nutrient combination

Statistically significant variation was recorded on weight of 1000 grain of boro rice due to the interaction effect of rice varieties and different levels of integrated fertilizer management (Table 7). The highest weight of 1000 grain (29.79g) was recorded from V_3F_4 (BRRI hybrid5 and Rice straw decomposition + RDCF) that was followed (29.31g and 29.07g) by V_3F_3 (BRRI hybrid5 and vermicompost + RDCF) and V_3F_2 (BRRI hybrid5 and cow dung + RDCF), respectively and the lowest number (18.63g) was found from V_2F_0 (BRRI dhan81 and Control (no fertilizer)) that was statistically similar to V_1F_0.

4.2.4 Grain yield

4.2.4.1 Effect of variety

Different rice varieties varied significantly in terms of grain yield of boro rice (Figure 17). The highest grain yield (7.84 t ha^{-1}) was observed from V_3. While the lowest grain yield (5.19 t ha^{-1}) was recorded from V_2 which was followed (5.81 t ha^{-1}) by V_1. The grain yield result revealed that the variety V_3 (BRRI hybrid5) out yielded over V_1 (BRRI dhan63) and V_2 (BRRI dhan81) by producing 2.03 t ha^{-1} and 2.65 t ha^{-1} higher yield, repectively.

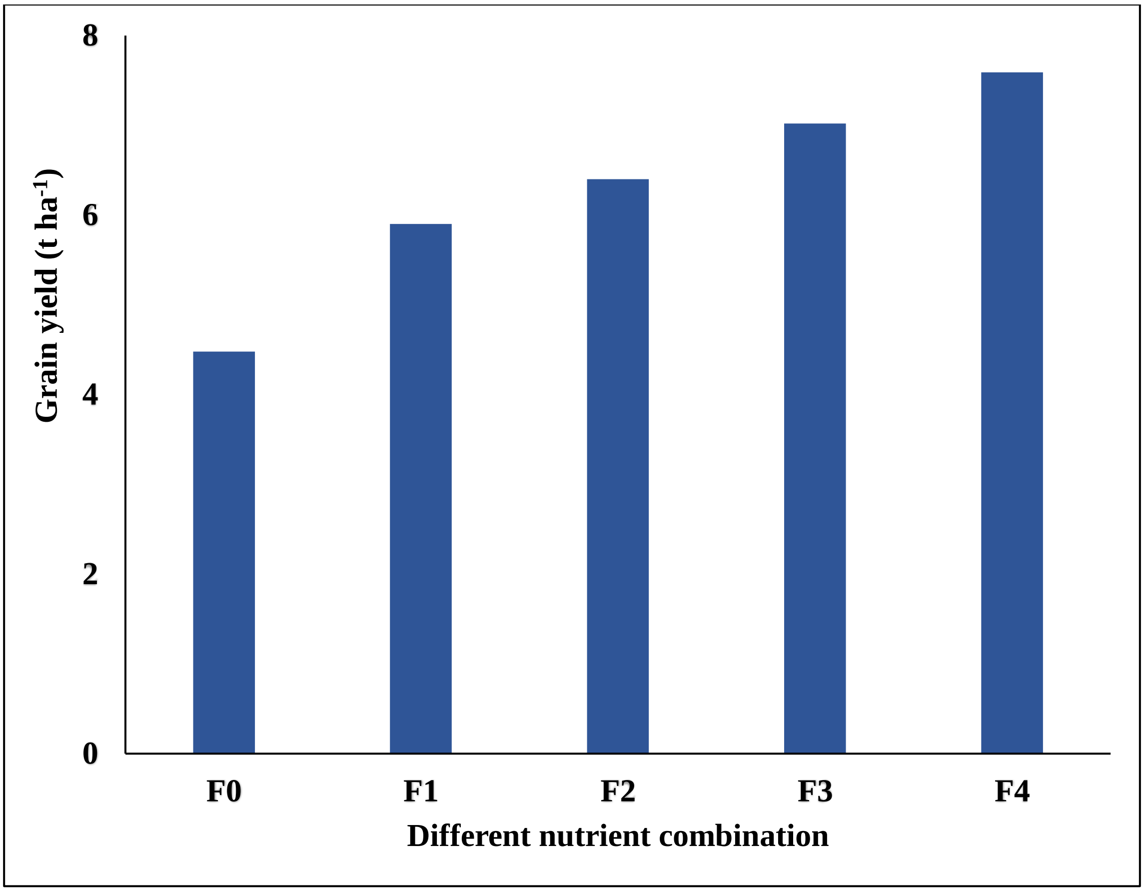


Here, V_1 = BRRIdhan63, V_2 = BRRI dhan81and V_3 = BRRI hybrid5

Figure 17. Effect of rice varieties on grain yield at harvest of rice (LSD $_{0.05}$ = 0.49)

4.2.4.2 Effect of different nutrient combination

Statistically significant variation was recorded in terms of grain yield of boro rice due to different levels of fertilizer management (Figure 18). The highest grain yield (7.59 t ha^{-1}) was found from F_4 which was statistically similar to F_3 (7.02 t ha^{-1}), while the lowest grain yield (4.48 t ha^{-1}) was observed from F_0 which was statistically similar (5.90 t ha^{-1}) to F_1. Choudhary *et al.,* (2011) also observed similar result in case of integrated fertilizer management in rice.



Here, F_0 = Control (no fertilizer), F_1=Recommended dose of chemical fertilizers (RDCF), F_2 = Cow dung + RDCF, F_3 = Vermicompost + RDCF and F_4 = Rice straw decomposition + RDCF

Figure 18. Effect of different nutrient combination on grain yield at harvest of rice (LSD $_{0.05}$ = 0.26)

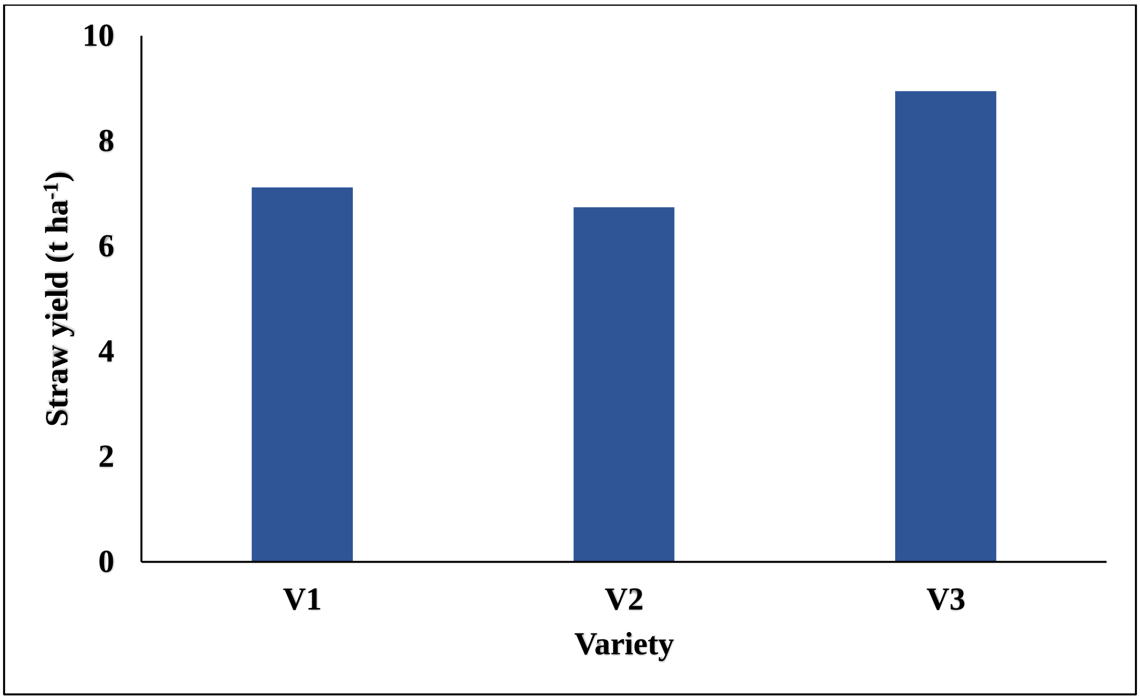
4.2.4.3 Interaction effect of variety and different nutrient combination

Grain yield of rice showed statistically significant differences due to the combined effect of boro rice varieties and different levels of fertilizer management (Table 7). The highest grain yield (9.38 t ha^{-1}) was found from V_3F_4 which was followed by V_3F_3 and V_3F_2 (8.77 t ha^{-1} and 8.02 t ha^{-1} respectively), whereas the lowest grain yield (3.62 t ha^{-1}) was recorded from V_2F_0 treatment combination which was statistically similar (4.11 t ha^{-1}) to V_1F_0. Kumar *et al.*, (2019) observed significant variation in grain yield for different fertilizer management in rice.

4.2.5 Straw yield

4.2.5.1 Effect of variety

Different rice varieties varied significantly in terms of straw yield of boro rice (Figure 19). The highest straw yield (8.95 t ha^{-1}) was recorded from V_3. While the lowest straw yield (6.74 t ha^{-1}) was observed from V_1 which was statistically similar (7.12 t ha^{-1}) to V_2. Similar findings were also reported by Hassan *et al.,* (2010).

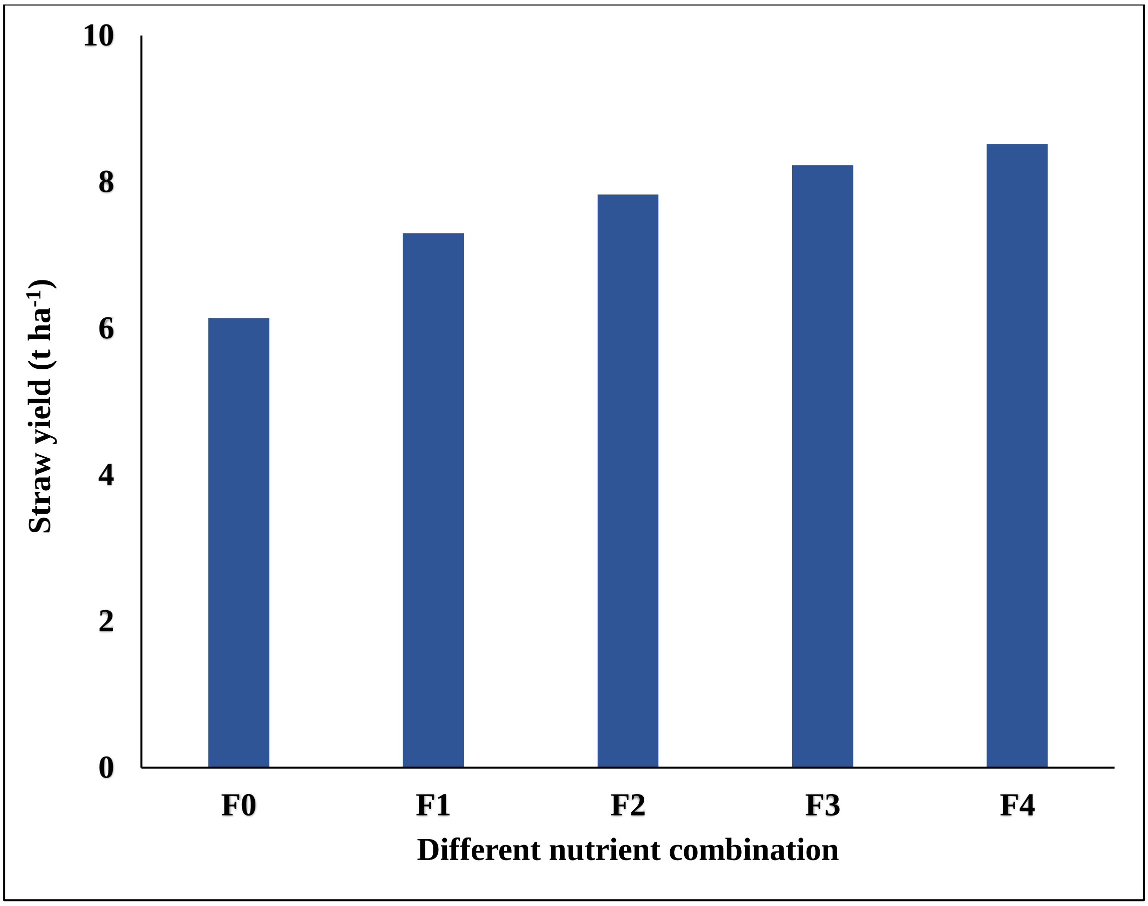


Here, V_1 = BRRIdhan63, V_2 = BRRI dhan81and V_3 = BRRI hybrid5

Figure 19. Effect of rice varieties on straw yield at harvest of rice (LSD $_{0.05}$ = 0.44)

4.2.5.2 Effect of different nutrient combination

Statistically significant variation was recorded in terms of straw yield of boro rice due to different levels of fertilizer management (Figure 20). The highest straw yield (8.52 t ha^{-1}) was found from F_4 which was statistically similar to F_3 and F_2 (8.23 t ha^{-1} and 7.83 t ha^{-1} respectively), while the lowest straw yield (6.14 t ha^{-1}) was observed from F_0 which was statistically similar (7.30 t ha^{-1}) to F_1.



Here, F_0 = Control (no fertilizer), F_1=Recommended dose of chemical fertilizers (RDCF), F_2 = Cow dung + RDCF, F_3 = Vermicompost + RDCF and F_4 = Rice straw decomposition + RDCF

Figure 20. Effect of different nutrient combination on straw yield at harvest of rice ($LSD_{0.05}$ = 0.42)

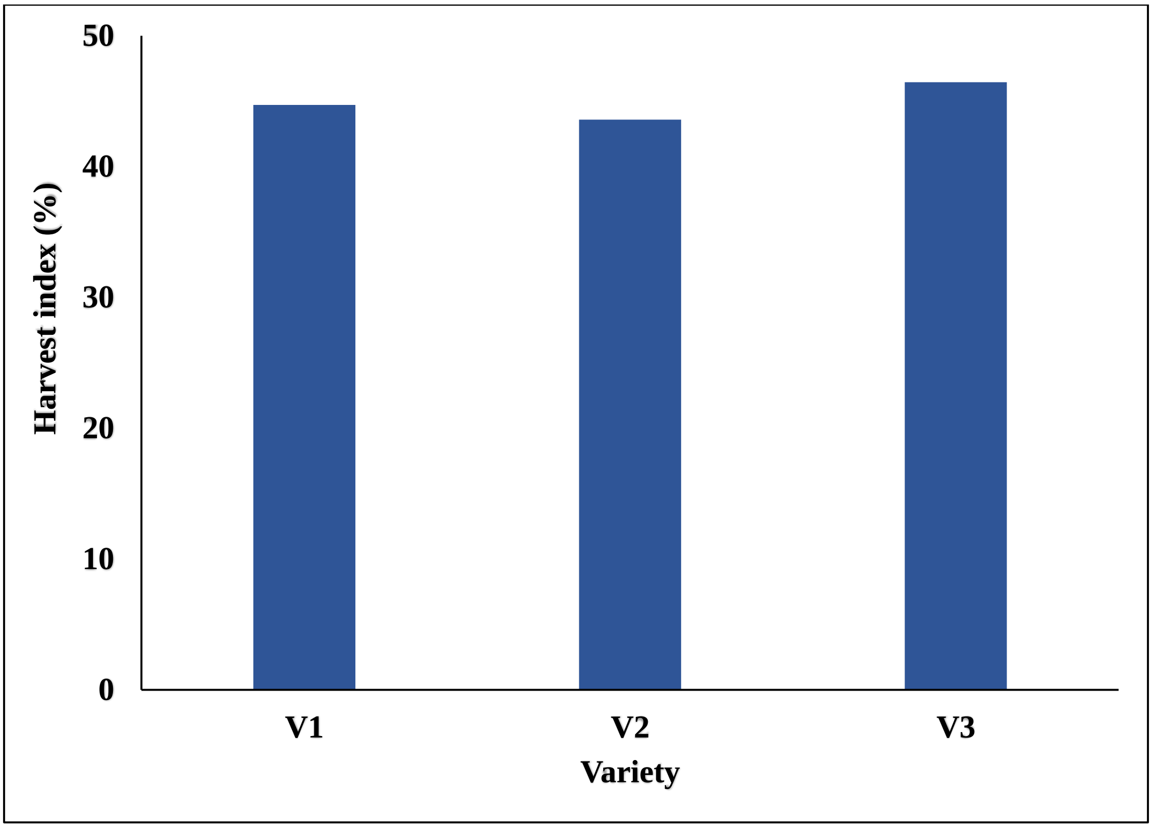
4.2.5.3 Interaction effect of variety and different nutrient combination

Straw yield of boro rice showed statistically significant differences due to the combined effect of boro rice varieties and different levels of fertilizer management (Table 7). The highest straw yield (9.82 t ha^{-1}) was found from V_3F_4 which was statistically similar to V_3F_3 and V_3F_2 (9.56 t ha^{-1} and 9.10 t ha^{-1} respectively), whereas the lowest straw yield (4.95 t ha^{-1}) was recorded from V_2F_0 treatment combination which was statistically similar (5.62 t ha^{-1}) to V_1F_0.

4.2.6 Harvest index

4.2.6.1 Effect of variety

Different rice varieties varied significantly in terms of harvest index of boro rice (Figure 21). The highest harvest index (46.44%) was recorded from V_3 which was followed (44.71%) by V_1, whereas the lowest harvest index (43.59%) was found from V_2.

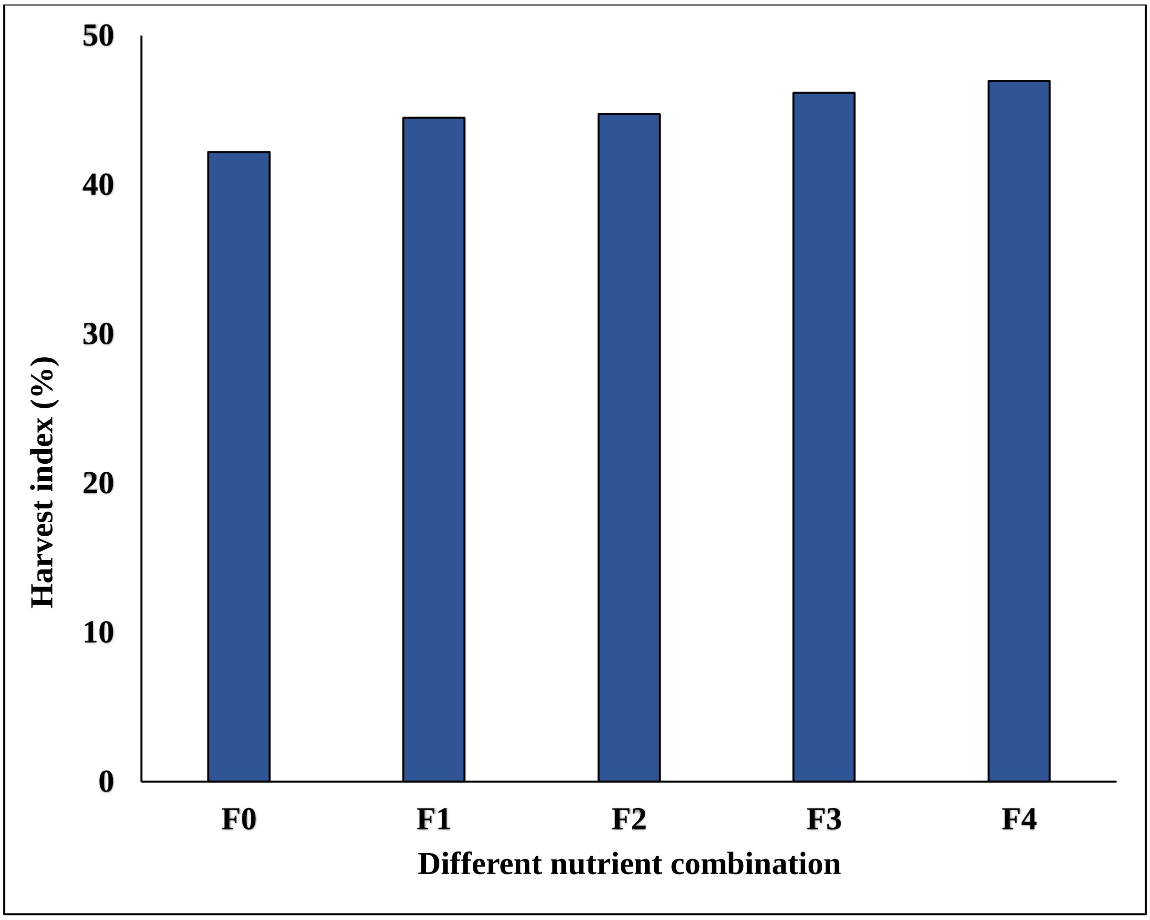


Here, V_1 = BRRIdhan63, V_2 = BRRI dhan81and V_3 = BRRI hybrid5

Figure 21. Effect of rice varieties on harvest index at harvest of rice (LSD $_{0.05}$ = 2.44)

4.2.6.2 Effect of different nutrient combination

Harvest index of boro rice showed statistically significant variations due to different levels of fertilizer management (Figure 22). The highest harvest index (46.95%) was found from F_4 which were followed by F_3 and F_2 (46.17% and 44.75% respectively), whereas the lowest harvest index (42.20%) was recorded from F_0 which was statistically similar (44.49%) to F_1.



Here, F_0 = Control (no fertilizer), F_1=Recommended dose of chemical fertilizers (RDCF), F_2 = Cow dung + RDCF, F_3 = Vermicompost + RDCF and F_4 = Rice straw decomposition + RDCF

Figure 22. Effect of different nutrient combination on harvest index at harvest of rice ($LSD_{0.05}$ = 2.29)

4.2.6.3 Interaction effect of variety and different nutrient combination

Statistically significant variation was recorded on harvest index of boro rice due to the combined effect of rice varieties and different levels of fertilizer management (Table 7). The highest harvest index (48.85%) was observed from V_3F_4 that were followed by V_3F_3 and V_3F_2 (47.85% and 46.85%, respectively), whereas the lowest harvest index (42.11%) was found from V_3F_0 treatment combination.

Table 7. Interaction effect of variety and different nutrient combination on yield attributes, yield and harvest index of rice

Treatment combinations	Effective tillers hill^{-1} (no.)	Grains panicle^{-1} (no.)	Weight of 1000 grains (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
$V_1 \times F_0$	7.96 g	76.70 -e-g	19.45 ef	4.11 i	5.62 g	42.24 de
$V_1 \times F_1$	9.53 ef	79.27 b-f	21.55 cd	5.57 g	7.05 ef	44.14 b-e
$V_1 \times F_2$	10.03 d-f	81.13 b-e	21.63 cd	5.84 fg	7.36 de	44.24 b-e
$V_1 \times F_3$	10.60 c-e	86.37 a-c	21.80 cd	6.48 e	7.57 de	46.12 a-e
$V_1 \times F_4$	11.17 cd	88.88 a	22.23 c	7.06 d	8.02 cd	46.82 a-c
$V_2 \times F_0$	7.91 g	71.72 fg	18.63 f	3.62 i	4.95 g	42.24 e
$V_2 \times F_1$	9.47 ef	74.19 e-g	19.55 d-f	4.81 h	6.42 f	42.83 c-e
$V_2 \times F_2$	9.56 ef	79.23 c-f	20.03 c-f	5.34 g	7.03 ef	43.17 c-e
$V_2 \times F_3$	9.90 ef	84.83 a-d	20.53 c-e	5.82 g	7.57 de	44.55 b-e
$V_2 \times F_4$	10.63 c-e	86.60 ab	21.27 c-e	6.35 ef	7.71 c-e	45.16 a-e
$V_3 \times F_0$	9.03 fg	69.86 g	27.10 b	5.71 g	7.85 cd	42.11 e
$V_3 \times F_1$	10.55 c-e	72.18 fg	28.63 ab	7.32 d	8.42 bc	46.51 a-d
$V_3 \times F_2$	11.27 bc	73.44 e-g	29.07 a	8.02 c	9.10 ab	46.85 a-c
$V_3 \times F_3$	12.43 ab	77.84 d-f	29.31 a	8.77 b	9.56 a	47.85 ab
$V_3 \times F_4$	12.93 a	80.09 b-e	29.79 a	9.38 a	9.82 a	48.85 a
$LSD_{(0.05)}$	**1.1736**	**7.2801**	**1.7492**	**0.4574**	**0.7218**	**3.9694**
CV (%)	**6.83**	**5.48**	**4.44**	**4.32**	**5.63**	**5.24**

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of significance

Here, V_1 = BRRIdhan63, V_2 = BRRI dhan81and V_3 = BRRI hybrid5; F_0 = Control (no fertilizer), F_1 = Recommended dose of chemical fertilizers (RDCF), F_2 = Cow dung + RDCF, F_3 = Vermicompost + RDCF and F_4 = Rice straw decomposition + RDCF

CHAPTER V

SUMMARY AND CONCLUSION

5.1 Summary

The present study was conducted at Sher-e-Bangla Agricultural University, Dhaka during the boro season of 2020-21 to evaluate the growth, yield and yield attributes of three boro rice as affected by different nutrient combinations. Three rice varieties namely BRRI dhan63 (V_1) BRRI dhan81 (V_2) and BRRI hybrid5 (V_3) and five fertilizer managements viz. F_0 = Control (no fertilizer), F_1 = Recommended dose of chemical fertilizers (RDCF), F_2 = Cow dung + RDCF, F_3 = Vermicompost + RDCF and F_4 = Rice straw decomposition + RDCF were considered as treatment variables.

The two factors experiment (Factor A: Variety and Factor B: Fertilizer Management) was laid out in Split Plot Design (SPD) method with three replications. In case of the effect of variety, plant height, tillers no. hill^{-1}, dry weight plant^{-1}, SPAD value, leaf area leaf^{-1}, number of effective tillers hill^{-1}, grains panicle^{-1}, 1000-grain weight, grain yield, straw yield and harvest index were significantly affected due to the main effect of variety. Between the varieties, BRRI hybrid5 variety showed superior performance than BRRI dhan63 and BRRI dhan81 among the whole characters of the study except plant height and grain panicle^{-1}. At harvest, the tallest plant (97.36 cm) obtained from V_1 (BRRI dhan63) that was followed (91.61 cm) by V_3 (BRRI hybrid5) and the shortest plant (86.94 cm) obtained from V_2 (BRRI dhan81). Again, more tillers no. hill^{-1} (12.05), highest dry weight plant^{-1}(31.24g), highest SPAD value (36.51), leaf area leaf^{-1} (3254 mm^2), more effective tillers hill^{-1} (11.24), more filled grains panicle^{-1} (74.68), highest weight of 1000-grain (28.78 g), highest yield of grain and straw (7.84 t ha^{-1} and 8.95 t ha^{-1} respectively), highest harvest index 46.44% were obtained from the variety V_3 that was followed by V_1 and the lowest tillers no. hill^{-1}, dry weight plant^{-1}, lowest spade value, lowest leaf area leaf^{-1}, effective tillers hill^{-1}, filled grains panicle^{-1}, 1000-grain weight, grain yield, straw yield and harvest index (10.55, 25.49g, 34.01, 2638.6 mm^2, 9.49, 74.68, 20.0 g, 5.19 t ha^{-1}, 6.74 t ha^{-1}, 43.59%, respectively) were obtained from V_2.

Among the growth, yield and yield contributing characters, fertilizer management treatment F_4 (Rice straw decomposition + RDCF) showed the best performance among other treatments that was followed by F_3. At harvest, the tallest plant (97.60 cm), more tillers no. hill^{-1} (12.27), highest dry weight plant^{-1}(31.24g), highest SPAD value (38.24), highest leaf area leaf^{-1} (3340.3 mm^2), more effective tillers hill^{-1} (11.58), more grains panicle^{-1} (85.19), highest weight of 1000-grain (24.43 g), highest yield of grain and straw (7.59 t ha^{-1} and 8.52 t ha^{-1}, respectively) , highest harvest index (46.95%) was recorded from F_4 treatment. the second highest plant height, tillers no. hill^{-1}, dry weight plant^{-1}, SPAD value, leaf area leaf^{-1}, effective tillers hill^{-1}, grains panicle^{-1}, 1000-grain weight, grain yield, straw yield, harvest and index (95.55 cm, 11.89, 31.90g, 36.49, 3253 mm^2, 10.97, 83.01, 23.88g, 7.02 t ha^{-1}, 8.23 t ha^{-1} and 46.17%, respectively) were obtained from F_3 that was statistically similar with F_2, whereas the lowest plant height, tillers no. hill^{-1}, dry weight plant^{-1}, SPAD value, leaf area leaf^{-1}, effective tillers hill^{-1}, grains panicle^{-1}, 1000-grain weight, grain yield, straw yield and harvest index (82.65 cm, 9.78, 18.75g, 32.16, 2107.7 mm^2, 8.30, 72.76, 21.73g, 4.48 t ha^{-1}, 6.14 t ha^{-1} and 42.20%, respectively) were observed in F_0 that was statistically similar to F_1.

In case of the effect of interaction between variety and different nutrient combination plant height, tillers no. hill^{-1}, dry weight plant^{-1}, SPAD value, leaf area leaf^{-1}, effective tillers hill^{-1}, grains panicle^{-1}, 1000-grain weight, grain yield, straw yield, harvest and index were significantly affected. Among the interactions, the variety V_1 receiving of recommended dose of fertilizer (V_1F_4) produced significantly the tallest plant (103.19cm) that was followed (96.87 cm) by V_3F_4. Again, this interaction (V_3F_4) are showed the highest tillers no. hill^{-1} (13.46), highest dry weight plant^{-1}(35.82g), highest spade value (39.82), highest leaf area leaf^{-1} (3791 mm^2), more effective tillers hill^{-1} (12.93), more grains panicle^{-1} (88.88), highest weight of 1000-grain (29.79 g), highest yield of grain and straw (9.38 t ha^{-1} and 9.82 t ha^{-1} respectively) , highest harvest index (48.85%). The second highest tillers no. hill^{-1}, dry weight plant^{-1}, spade value, leaf area leaf^{-1}, effective tillers hill^{-1}, grains panicle^{-1}, 1000-grain weight, grain yield, straw yield, harvest and index (13.08, 34.88g, 37.77, 3663 mm^2, 12.43, 80.09, 29.31g, 8.77 t ha^{-1}, 9.56 t ha^{-1} and 47.85%, respectively) were obtained from V_3F_3 that was statistically similar with V_1F_4.

The lowest plant height, tillers no. hill^{-1}, dry weight plant^{-1}, spade value, leaf area leaf^{-1}, effective tillers hill^{-1}, grains panicle^{-1}, 1000-grain weight, grain yield, straw yield and harvest index (76.40 cm, 9.47, 15.16g, 31.07, 1982 mm^2, 7.91, 71.72, 18.63g, 3.62 t ha^{-}

^{1}, 4.95 t ha^{-1} and 42.24%, respectively) were obtained from V_2F_0 that statistically similar with V_1F_0.

5.2 Conclusion

It could be concluded that

1. Cultivar BRRI hybrid5 proved to be superior to BRRI dhan63 and BRRI dhan81 in all respect of growth and yield.

2. Nutrient combination comprised with rice straw decomposition + RDCF (Recommended dose of chemical fertilizer) seems promising interns of grain yield of rice.

3. Interaction of BRRI hybrid5 with rice straw decomposition + RDCF performed best in producing yield of boro rice.

Recommendation

i. Such study is needed to be repeated in different agro-ecological zones (AEZ) of Bangladesh for the evaluation of regional adaptability,

ii. Other combination of organic manures and chemicals fertilizer may be used for further study to achieve a package management for sustainable boro rice production in Bangladesh.

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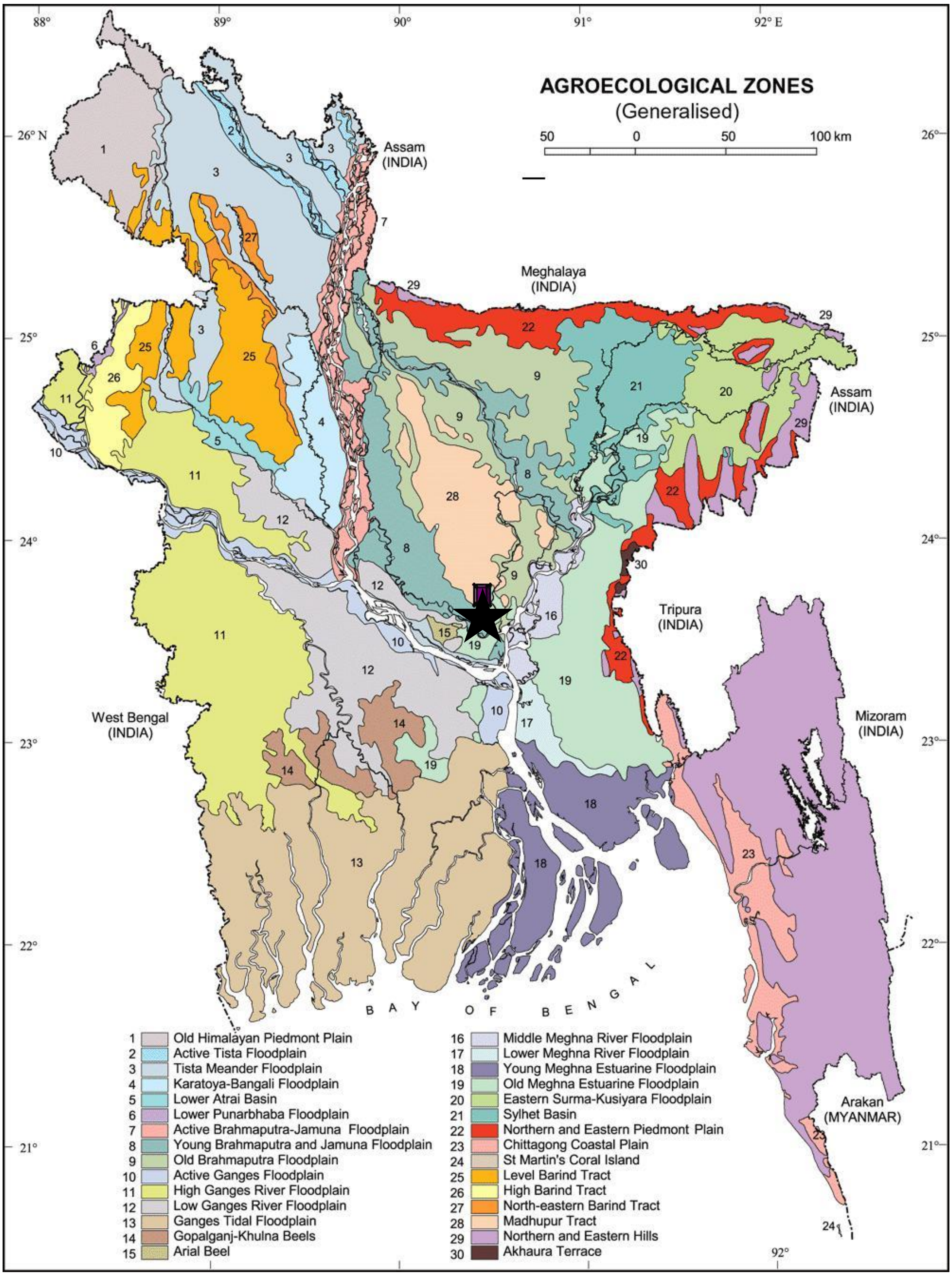
APPENDICES

Appendix I. The map of the experimental site



★ The experimental side under the study

Appendix II. Soil characteristics of experimental field as analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

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

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	26
% Silt	43
% clay	31
Textural class	Silty clay
pH	5.9
Catayon exchange capacity	2.64 meq 100 g/soil
Organic matter (%)	1.15
Total N (%)	0.03
Available P(ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI), Khamarbari, Farmgate, Dhaka-1215

Appendix III: Layout of the experiment

	↓ 0.5 m		
V_2F_0	V_1F_3	V_3F_1	
V_2F_3	V_1F_2	V_3F_4	
V_2F_2	V_1F_0	V_3F_3	R_1
V_2F_1	V_1F_4	V_3F_2	
V_2F_4	V_1F_1	V_3F_0	
	↓ 0.75 m		
V_1F_1	V_3F_0	V_2F_3	
V_1F_4	V_3F_3	V_2F_2	
V_1F_0	V_3F_4	V_2F_1	R_2
V_1F_2	V_3F_1	V_2F_4	
V_1F_3	V_3F_2	V_2F_0	
	↓ 0.75 m		
V_3F_4	V_2F_3	V_1F_1	
V_3F_2	V_2F_4	V_1F_3	
V_3F_1	V_2F_2	V_1F_0	R_3
V_3F_0	V_2F_1	V_1F_2	
V_3F_3	V_2F_0	V_1F_4	
	↓ 0.5 m		

Factore A: Variety (3)

V_1 = BRRI dhan63
V_2 = BRRI dhan81
V_3 =BRRI hybrid5

Factor B: Fertilizer management (5)

F_0 = Control (no fertilizer)
F_1=Recommended dose of chemical fertilizers (RDCF)
F_2 = Cow dung + RDCF
F_3 = Vermicompost + RDCF
F_4 = Rice straw decomposition + RDCF

Appendix IV. Monthly records of air temperature, relative humidity and rainfall during the period from November 2020 to April 2021.

Month	RH (%)	Air temperature (C)			Rainfall (mm)
		Max.	Min.	Mean	
November	65	32	19	26	35
December	74	29	15	22	15
January	68	26	10	18	7
February	57	15	24	25.42	25
March	57	34	16	28	65
April	66	35	20	28	155

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka–1207