INFLUENCE OF MANURE AND N P FERTILIZER ON YIELD AND SEED QUALITY OF BORO RICE

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DHAKA-1207

JUNE, 2022

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A Thesis
Submitted to the Institute of Seed Technology,
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfilment of the requirements
for the degree of

MASTER OF SCIENCE (MS)

IN

SEED TECHNOLOGY

SEMESTER: JANUARY-JUNE, 2022

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CERTIFICATE

This is to certify that the thesis entitled, **"Influence of manure and N P fertilizer on yield and seed quality 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** in **Seed Technology,** embodies the result of a piece of Bonafede research work carried out by **Md. Ashanuzzaman,** Registration **No. 15-06830,** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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DEDICATED TO

MY

BELOVED PARENTS

ACKNOWLEDGEMENT

All praises are due to the "Almighty Allah," Who kindly enabled the author to complete the research work and the thesis leading to Master of Science.

*The author would like to express his heartiest respect, a deep sense of gratitude, and sincere, profound appreciation to his supervisor, **Dr. A. K. M. Ruhul Amin**, Professor, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for his sincere guidance, scholastic supervision, constructive criticism, and constant inspiration throughout the course and in preparation of the manuscript of the thesis.*

*The author would like to express his heartiest respect and profound appreciation to his Co-supervisor, **Sheikh Muhammad Masum**, Ph.D., Professor, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for his utmost cooperation and constructive suggestions to conduct the research work as well as preparation of the thesis.*

The author expresses his sincere respect to the honorable Director and all the teachers of the Institute of Seed Technology, Sher-e-Bangla Agricultural University, Dhaka, for providing the facilities to experiment and for their valuable advice and sympathetic consideration in connection with the study.

Mere diction is not enough to express his profound gratitude and deepest appreciation to his father, mother, brothers, sisters, and relatives for their ever-ending prayer, encouragement, sacrifice, and dedicated efforts to educate him to this level.

June, 2022

SAU, Dhaka **The Author**

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ABSTRACT

An experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, from October 2021 to April 2022 to study the effect of organic manure and N P fertilizer on *boro* rice's yield and seed quality of boro rice. The BRRI dhan28 was used as the test crop in this experiment. The experiment consists of 2 factors i.e., four level of organic manure. OM_0: Without organic fertilizer (control), OM_1: Cowdung @ 10 tha^{-1}, OM_2: Vermicompost @ 3 tha^{-1} and OM_3: Poultry manure @ 5 tha^{-1}; and four different N P fertilizer level F_0: Without N P fertilizer, F_1: 25% less than the recommended dose of N P fertilizer, F_2: Recommended dose of N P fertilizer and F_3: 25% Higher than the recommended dose of N P fertilizer. The experimental design was RCBD and treatments were replicated three times. The result revealed that among the organic manures, poultry manure was found best in respect of growth, yield, and seed quality parameters, this treatment produced the highest yield (4.90 tha^{-1}), tallest plant (32.66, 50.95, 78.33, 94.75 and 99.30 cm) at 30, 50 70 90 DAT and at harvest, respectively; maximum tillers per plant for all sampling dates (8.90, 12.33, 13.10, 14.33 and 15.09) at 30, 50 70 90 DAT and at harvest, respectively and gave highest yield contributing parameters like effective tiller $hill^{-1}$ (12.67), panicle length (21.90 cm), grain $panicle^{-1}$ (104.15) and 1000 grain weight (21.66 g). On the other hand, 25% Higher than recommended N P fertilizer dose gave the highest yield (4.50 tha^{-1}). This dose also produced maximum plant height and tillers $plant^{-1}$ for all growth stages, the highest number of grains $panicle^{-1}$ (104.75), 1000 grain weight (21.67 g), and straw yield (5.33 tha^{-1}). Considering the interactions, Poultry manure @ 5 tha^{-1} (Om_3), 25% higher than the recommended dose of N P fertilizer (F_3), gave the highest grain yield (5.83 tha^{-1}). This interaction also gave the highest effective tiller $hill^{-1}$ (14.70), panicle length (22.33 cm), and grain $panicle^{-1}$ (6.26 tha^{-1}). Regarding seed quality parameters, Poultry manure @ 5 tha^{-1} (Om_3) and 25% higher than the recommended dose of N P fertilizer (F_3) gave better performance. The study concluded that, poultry manure @ 5 tha^{-1} (Om_3) and 25% Higher than the recommended N P fertilizer (F_3) could be recommended for better yield and seed quality of BRRI dhan28.

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LIST OF ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
FAO	=	Food and Agriculture Organization
et al.	=	And others
DAS	=	Days after Sowing
Mg	=	Milligram
kg	=	Kilogram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources Development Institute
g	=	Gram
cm	=	Centimeter
wt	=	Weight
LSD	=	Least Significant Difference
^{0}C	=	Degree Celsius
NS	=	Not significant
Max	=	Maximum
Min	=	Minimum
%	=	Percent
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of Coefficient of Variance

CHAPTER I

INTRODUCTION

Bangladesh is an agro-based country. Most of her economic activities mainly depend on agriculture. Geographical and climatic conditions of Bangladesh are favourable for rice (*Oryza sativa* L.) cultivation. In Bangladesh, rice covers an area of 114.15 lac hectares with a production of 347.10 lac ton, while the average rice yield is around 3.04 t ha^{-1}. Boro rice covers the largest area of 48.40 lac hectares (42.40%) with a production of 191.92 lac ton /rice grain (55.29%) BRRI has developed 102 rice varieties, of which 42 are boro varieties (BRRI, 2021). As agricultural land is decreasing daily, increasing per hectare yield of boro rice is necessary to satisfy our growing need for food. Using different organic and inorganic fertilizers, we can increase the production of boro rice and quality seeds for a fast-growing population. Organic fertilizer modifies the soil's physical properties and increases the use efficiency of the applied nutrients. Inorganic fertilizer has an established role in the production of rice. The study will be carried out to determine the response of rice to varying organic and inorganic fertilizers. Adding organic fertilizer combined with chemical fertilizers could be a promising technique to increase rice's yield and seed quality. Therefore, adequate and balanced application of organic and inorganic fertilizers is necessary to increase productivity and soil fertility.

Nitrogen and phosphorus nutrition is important due to the considerable impact on growth parameters and rice's physiological traits. The amount of nitrogen affects the percentage of light penetration, photosynthesis active radiation, light use efficiency, and dry matter partitioning to different parts. Dry matter partitioning to the reproductive organs depends on physiological sinks' number, capacity, and activity (Fageria, 2007). The cultivar of rice with higher physiological indices has better growth and higher yield (Esfahani *et al.,* 2006; Katsura, 2007). It can be concluded from the above studies that nitrogen is one of the important agronomic factors which has a significant impact on the growth indices, and by selecting the appropriate amount of nitrogen, a balanced complex of growth indices will be created in the canopy, which lead to yield improvement since the most indicators of growth are related to (LAI) in some way. In every region, (LAI) produces a different maximum yield, and the location-specific research should obtain it. LAI changing through alteration in nitrogen fertilizer levels is one of the most practical ways.

Cropping intensity of 190% (BBS, 2021) is increasing in Bangladesh without adequate and balanced use of fertilizer management and with little or no use of organic manures. The higher the crop yield, the higher the nutrient removal from soil. Nutrient deficiency in this country's soils has arisen chronologically N, P, K, S, Zn, and B (Jahiruddin and Satter, 2010). As a result, soil fertility is causing deterioration, and crop productivity is declining. Soil organic matter supplies a substantial quantity of macro and micronutrients for growing plants and improves soil health. Sarkar (2004) showed that the effect of residual cowdung and fertilizer management was significantly positive on the availability of nitrogen, phosphorus, potassium, sulphur, copper, zinc, manganese, and nutrient content of the soil. It also contributes to soil fertility and productivity through its positive effect on the soil's chemical, physical and biological properties. But, the organic matter content in most of the soils of Bangladesh is below 1.5%. About 45% of net cultivable areas of Bangladesh contain less than 1% OM (FRG, 2017). In spite of that, the farmers are using lesser quantities of animal manure and crop residues because most of these materials are used for cooking, building houses, and cattle feed. Hence, managing soil organic three matter has become a major issue in dealing with the problem of soil fertility and crop productivity in Bangladesh. The combined use of organic and inorganic manures helps maintain soil fertility and crop productivity for the long term. The residual effects of manure or compost application on crop production and soil properties can last several years (Eghball *et al.,* 2005). Rice (*Oryza sativa* L.) is intensively cultivated in Bangladesh, covering about 75% of arable land. By applying integrated use of organic and inorganic manures, farmers may cultivate rice crops without any harmful impact on the soil environment. Using various organic manure and inorganic fertilizers for rice production can reduce the application of fertilizer management, ultimately reducing the cost of production.

Intensive rice cultivation has caused considerable damage to the environment and natural resources, including the build-up of salinity or alkalinity, water logging, water pollution, depletion of groundwater, and health hazards due to excessive use of agro chemicals and pesticides and release of higher methane gas to the environment. For these reasons, farmers, scientists, and policymakers are now looking at the integrated approach to nutrient management for crops, including rice, to some extent. Moreover, adding organic fertilizer to soil may also increase fertilizer-use efficiency. Cowdung and vermicompost are the most commonly used organic fertilizer in most countries. Organic fertilizer supplies a variety of macro and micronutrients to the soil and improves the soil's physiochemical and biological properties. Inorganic fertilizers such as N and P have a significant role in increasing rice yield. Thus, the experiment was done in combination with organic and inorganic fertilizers and using them separately to see the comparative production with the following objectives:

1. To observe the impact of organic manure on the yield and seed quality of rice,
2. To evaluate the different levels of N and P fertilizer on yield and seed quality of rice, and
3. Select the best combination of organic manure and N and P fertilizer levels for higher rice yield and seed quality.

CHAPTER II

REVIEW OF LITERATURE

Organic manure and inorganic fertilizer are essential for sustainable fertility and crop productivity because organic matter stores plant nutrients. Using cowdung, vermicompost, and inorganic fertilizer is a source of essential plant nutrients. Experimental evidence in the use of cow dung, compost, poultry manure, and nitrogen + phosphorus showed an intimate effect on rice yield and yield attributes. Yield and yield contributing characters of rice are considerably influenced by different doses of N+P fertilizer, cowdung, and vermicompost and their combined application. Some literature related to the "Influence of organic manure and N P fertilizer level on yield and seed quality of boro rice (BRRI dhan-28)" is reviewed below.

2.1 Effect of nitrogen management

Haque and Haque (2016) experimented at Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh, during the rainy season in 2014 to assess the growth, yield, and nitrogen use efficiency of a new rice variety. The new rice variety (BU dhan-1) was treated with six levels of nitrogenous fertilizer in a randomized complete block design replicated three times. The treatment variables were the nitrogen levels 0, 20, 40, 60, 80 and 100 N kg ha^{-1}. Results revealed that growth of the new rice variety favoured higher levels of applied nitrogen, although it flattened at 80 and 100 N kg ha^{-1}. Preanthesis assimilates reserves contributed to sustaining the variety's yield, indicating that current photosynthesis was insufficient to support the present yield level. The assimilate remobilization varied from 109.21 to 232.93 g/m^2 between the nitrogen levels, where the maximum amount of remobilization was observed at 60 N kg ha^{-1}. The highest grain yield (5.36 tha^{-1}) was found when BU dhan-1 was fertilized with 60 N kg ha^{-1}. The 60 N kg ha^{-1} application also showed the highest nitrogen use efficiency (344.50 kg grain kg^{-1} N applied).

Azarpour *et al.* (2014) studied the effects of the level of nitrogen fertilizer on yield and physiological traits of rice cultivars (*Oryza sativa* L.). An experiment was conducted in 2009 at the Rice Research Institute, Iran, Rasht, central of Guilan, and

Rudsar, East of Guilan. Factors were cultivar (Khazar, Ali Kazemi, and Hashemi) and nitrogen fertilizer levels (0, 30, 60, and 90 Kg N/ha). Characters measured were: leaf area index (LAI), the total dry weight (TDW), leaf dry weight (LDW), Crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR), leaf area duration (LAD), leaf area ratio (LAR), leaf weight rate (LWR), specific leaf area (SLA), grain yield. Growth parameters were calculated during six growth stages by harvesting samples from leaf area index, leaf dry, and total weight dry weight in all treatments. Results of growth analysis indicated that nitrogen-increasing rates of fertilizer caused the increment of growth indexes. Khazar and Ali Kazemi Hashemi showed higher growth indices rather than Hashemi. Results indicated that cultivar and nitrogen fertilizer significantly contributed to grain yield. Khazar and Ali Kazemi gave the highest grain yield among the cultivars. Also, results indicated that grain yield increased significantly with increasing nitrogen fertilizer application (17,13, and 57 %).

Rao *et al.* (2014) experimented during three consecutive kharif seasons of 2009-10, 2010-11, and 2011-12 at Agricultural Research Station, Seethampeta, Andhra Pradesh, on sandy clay loam soil with three varieties (RGL 2537, RGL 2332 and MTU 7029) and four nitrogen levels (60, 80,100 and 120 kg ha^{-1}) to find out suitable variety with optimum nitrogen level for high altitude areas of Andhra Pradesh. Tiller production, days to 50 percent flowering, dry matter production at harvest, yield attributes, yields and harvest index, gross returns, net returns and rupee per rupee invested, the protein content of 7 grains, soil organic carbon, and available nitrogen were progressively augmented by incremental levels of N. Nutrient response in terms of partial factor productivity was decreased gradually with total levels of N from 60 kg to the highest dose tried. Post-soil fertility status revealed that the status was progressively increased with incremental levels of N up to the highest amount that increased significantly by elevated levels of N.

Pramanik and Bera (2013) conducted during the Kharif season of 2010 and 2011 to investigate the optimization of nitrogen levels under different ages of seedlings transplanted on growth, chlorophyll content, yield, and economics of hybrid rice. Fifteen treatment combinations consisted of three levels of seedlings age (10, 20, and

30 days) and five levels of nitrogen, viz. 0, 50, 100, 150, and 200 kg ha^{-1}. Seedling's age markedly affected all the growth, chlorophyll content, and yield attributing traits. Transplanting of 10 days, seedlings showed significantly the highest grain yield of 5575 and 5946 kg ha^{-1} in 2010 and 2011, respectively. The percentage of grain yields an increase of 10.7 and 21.3 percent in the first year and 10.6 and 21 percent in the second year over 20 and 30-day seedlings, respectively. Among the nitrogen levels, 200 kg ha^{-1} gave significantly higher plant height, panicle initiation, number of tillers $hill^{-1}$, total chlorophyll content, panicle length, and straw yield, and nitrogen levels 150 kg ha^{-1} gave a significantly higher Number of effective $tillers^{-1}$, effective tiller index, panicle weight, filled grain $panicle^{-1}$, 1000 grain weight, grain yield, and harvest index as compared to 0, 50, 100 during both years. 150 kg ha^{-1} produced significantly highest grain yield of 6286 and 6652 kg ha^{-1} in 2010 and 2011, respectively. The percentage of grain yields an increase of 72.5, 44.4, 23.8, and 5.1 percent in the first year and 69.9, 44.1, 22.1, and 3.5 percent in the second year over 0, 50, 100, and 200 kg $ha^{-1,}$ respectively.

The effects of different nitrogen application levels on nutrient uptake and ammonia volatilization were studied with the rice cultivar Zheyou as a material by YU Qiao-gang *et al.* (2013). The accumulative amounts of nitrogen, 8 phosphorus, and potassium in rice plants across all growth stages showed a trend to increase with increasing nitrogen application levels from 0 to 2.70 kg m^2. Still, they decreased at nitrogen application levels exceeding 2.70 kg m^2. Moreover, the rice plants' accumulative uptake of nitrogen, phosphorus, and potassium was increased by applying organic manure in combination with 1.50 kg m^2 of nitrogen. The nitrogen uptake was high during the jointing to heading stages. Correlation analysis showed that rice yield was positively correlated with the accumulative uptake of nitrogen, phosphorus, and potassium by the rice plants. The highest correlation coefficient observed was between the amount of nitrogen uptake and rice yield. The rate and accumulative amounts of ammonia volatilization increased with increasing nitrogen fertilizer application levels. Compared with other stages, the rate and accumulative amount of ammonia volatilization were higher after base fertilizer application. The ammonia volatilization rates in response to the nitrogen application levels of 2.70 kg ha^{-1} and 3.30 kg m^2 were much higher than those in the other treatments. The loss of nitrogen through ammonia volatilization accounted for 23.9% of the total applied nitrogen at the nitrogen application level of 3.30 kg m^2.

Tayefe *et al.* (2011) studied the effects of nitrogen fertilizer on nitrogen use efficiency, yield, and characteristics of nitrogen uptake during two years (2008- 2009) in paddy soil in Guilan province, Iran. In this experiment, four treatments, including N_1-control (no N fertilizer); N_2- 30 kg ha^{-1} N (at transplanting time); N_3- 60 kg ha^{-1} N (at transplanting, and tillering times); N_4- 90 kg ha^{-1} N were compared. Results showed that total N uptake, physiological nitrogen use efficiency (PNUE), apparent nitrogen recovery efficiency (ANRE), and agronomic nitrogen use efficiency (ANUE) varied in different cultivars significantly, and the Khazar variety had the highest contents. Total N uptake, physiological N use efficiency (PNUE), and agronomic nitrogen use efficiency (ANUE) varied significantly with the increasing amount of nitrogen applied. As total N uptake increased with increasing N fertilizing contents but physiological N use efficiency (PNUE), agronomic nitrogen use efficiency 9 (ANUE) decreased. There were significant differences in the effects of applying nitrogen fertilizer on nitrogen use efficiency and characteristics of nitrogen uptake. Xie *et al.* (2007) reported that increased split application of nitrogen from control to 140 kg ha^{-1} increased dry matter accumulation (DMA) of different growth stages of Jinzao-22 and Shanyou-63 rice varieties. After that dose, the DMA was reduced due to the losses of nitrogen by volatilization.

Singh and Modgal (2005) noted that dry-matter accumulation (DMA) and concentration and uptake of nitrogen increased with increasing nitrogen levels at all crop growth stages. Split application of nitrogen with its heavier fractions (1/3+1/3+1/3) at tillering and panicle initiation stages resulted in higher dry-matter accumulation and higher nitrogen concentration of rice. They also noted that the rice plants accumulated nearly 15% of the total absorbed nitrogen up to tillering, 50% to panicle initiation, and 85–90% to heading. Bowen *et al.* (2005) conducted 531 on-farm trials during the Boro and aman seasons in 7 districts of Bangladesh from 2000-2004. The results showed that UDP (Deep placement of urea super granule) increased grain yield by 1120 kg ha^{-1} and 890 kg ha^{-1} during the Boro and aman seasons, respectively.

Subhendu *et al.* (2003) conducted a field experiment during the Kharif season at Hyderabad, India. They found that applying nitrogen (120 kg N ha^{-1}) as urea in equal splits during transplanting, tillering, panicle initiation, and 50% flowering resulted in the highest 1000-grain weight (22.57 g). Mondal and Swamy (2003) found that application of N (120 kg ha^{-1}) as urea in an equal split during transplanting, tillering, panicle initiation, and flowering resulted in the highest number of panicles, number of filled grain $panicle^{-1}$,1000-grain weight, straw yield, and harvest index. Ikeda *et al.* (2003) stated the efficiency of the non-split fertilizer application to the rice variety 'Koshihikari' was evaluated to dispense with top dressing and improve the recovery rate of fertilizer in pneumatic direct sowing culture of rice on a submerged paddy field in Aichi Prefecture, Japan. The fertilizer used in this study, a combination of linear-type coated urea and a sigmoidal-type coated urea, was effective in this cultivation system. Results also showed that nitrogen recovery rate, yield rate, and quality were improved with this system. The accumulative nitrogen release rates of the combined fertilizer were 40% at the panicle formation stage, 80% at the heading stage, and 95% at the maturity stage. Furthermore, the nitrogen release pattern was adapted for the growth phase of this cultivation system.

Bayan and Kandasamy (2002) noticed the application of recommended rates of N in four splits at ten days after sowing, active tillering, and panicle initiation and at heading stages effective tillers/m^2. Islam *et al.* (1996) reported that the number of effective tillers $hill^{-1}$ increased with increasing nitrogen level, and split application was more effective compared to basal application during transplanting. Jaiswal and Singh (2001) experimented with USG and PU at 60 and 120 kg ha^{-1} under different planting methods. They found that the transplanting method with super urea granules was the best for maximum grain yield (4.53 t ha^{-1}). Ehsanullah *et al.* (2001), when working with a split application of nitrogenous fertilizer, reported that nitrogen as a split application at different growth stages significantly influenced grain yield and straw yield.

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

Geethadevi *et al.* (2000) showed that four split applications of 150 kg N ha^{-1} in KRH-1 recorded the maximum yield and increased growth and yield components. The higher number of tillers, filled grains $panicle^{-1}$, and higher grain weight $hill^{-1}$ for split application of nitrogenous fertilizer at 120 N kg ha^{-1}. Ahmed *et al.* (2000) revealed that USG was more efficient than PU at all respective nitrogen levels in producing all yield components and, in turn, grain and straw yields. Placement of USG @ 160 N kg ha^{-1} produced the highest grain yield (4.32 t/ha^{-1}), which was statistically identical to that obtained from 120 N kg ha^{-1} as USG and significantly superior to that obtained from any other level and source of nitrogen. Mishra *et al.* (2000) carried out a field experiment in 1994-95 in Bhubaneswar, Orissa, India, and reported that rice cv. Lalate was given 76 N kg ha^{-1} as USG at 0, 7, 14 for 21 days after transplanting (DAT), and this treated control. N increased plant height, panicle length, N up take and consequently lowland rice grain and straw yields.

2.2 Effect of phosphorus management

Wu-YuQiu (2013) experimented on Fuyou 33, a new rice variety derived from the cross Yanfeng 47xH1024. A field trial was conducted in 2012 in Liaoning with 5 treatments [N application 135 (E_1), 187.5 (E_2), 240 (E_3), 242.5 (E_4), and 345 kg/ha (E_5)] replicated 3 times to investigate the effect of nitrogen application on growth characters and yield of Fuyou. It was found that increasing nitrogen amounts could increase harvested panicles, leaf area index in the full heading stage, photosynthetic rates of flag leaf, and dry weight accumulation in the maturity stage but had a negative effect on productive panicle rates, high-efficiency leaf area rates, and effective leaf area rates in the full heading stage, the rate of dry matter accumulation in the grain yield after heading, and harvest index. The highest yield was marked in E_3 at 9.22 t ha^{-1}.

Ndaeyo *et al.* (2008) experimented Nigeria with five rice varieties (WAB340-8- 8-2HI, WAB881-10-37-18-8-2-HI, WAB99-1-1, WAB224-8-HB, WAB189-B-B-B-8-HB) and four rates of NPK (15:15:15) fertilizer (0, 200, 400 and 600 kg ha^{-1}). The results showed that 600 kg ha^{-1} NPK (15:15:15) fertilizer rate significantly ($P < 0.05$) increased plant height, number of leaves, and tillers $plant^{-1}$ in both years. The 400 kg/ha^{-1} rate increased the number of panicles per plant, the length of central panicle per plant, and the overall grain yield, and straw yield over other rates by 4-32% and 2-21% in 2005 and 2006, respectively. Islam *et al.* (2008) experimented in 2001-2002, 2002-2003, and 2003-2004 to determine the response and the optimum rate of nutrients (NPK) for Chilli- Fallow-T. aman cropping pattern. They found that grain yield was influenced significantly due to the application of different rates of nutrients, and 60-19-36 kg ha^{-1} NPK maximized the yield of *T. Aman* rice varieties in respect of yield and economics.

Rahman *et al.* (2007) conducted a field experiment using rice (cv. BRRI dhan 29) as a test crop. They found that applying S significantly positively affected tillers ha^{-1}, plant height, panicle length, and grains $panicle^{-1}$. They also indicated that applying S fertilizer at a recommended rate (20 kg S/ha) might be necessary for obtaining higher grain yield and straw yield of Boro rice (cv BRRI dhan 29).

Saha *et al.* (2004) experimented in 2002-2003 to create and compare a suitable fertilizer recommendation model for lowland rice. Five different fertilizer recommendation models were tested and compared with one check plot. Results showed that the application of different packages estimated by different fertilizer models significantly influenced panicle length, panicle numbers, spikelet number per panicle, total grains per panicle, number of filled grains, and unfilled grain $panicle^{-1}$. The combination of NPK gave the highest result (120-13- 70-20 kg ha^{-1} NPKS). Saleque *et al.* (2005) found a linear relationship between P uptake and total system productivity, which supports the concept that TSP depends to some extent on P availability. Phosphorus application increased rice yield in different seasons, where the highest response in P was in Aus and Boro than T. Aman.

Rasheed *et al.* (2003) reported the effect of different NP levels, i.e., 0-0, 25-0, 50-25, 75-50, 100-75, and 125-100 kg ha^{-1} on yield and yield attributes of rice Bas-385. Yield attributes (No. of effective tillers $hill^{-1}$, spikelet $panicle^{-1}$, normal kernels $panicle^{-1}$, 1000-grain weight) were improved linearly with increasing NP levels up to 100-75 kg ha^{-1}. The N P level of 100-75 kg ha^{-1} resulted in the highest grain yield of

4.53 tha^{-1} with minimum kernel abnormalities (sterility, abortive kernels, and opaque kernels) as against the minimum of 2.356 t ha^{-1} in control (0-0) followed by 25-0 kg NP ha^{-1} with maximum kernel abnormalities. Singh *et al.* (2003) reported that crop growth rate and relative growth rate, such as total dry matter production, was significantly influenced by NPK fertilizers. The tiller number and total dry matter production are closely correlated with yield depending on the rice cultivar, which can be greatly enhanced by applying proper nutrients. Phaev, *et al.* (2003) concluded that freshly applied P increased rice grain yield by 95%. In the first and second crops using residual P fertilizer, yields increased by 62% and 33% relative to the P-control plot. Cumulative removal of P in four successive rice crops accounted for 30 and 55% of the 16.5 kg ha^{-1} in the form of harvested grain and whole plants. Amin *et al.* (2004) experimented with evaluating the effect of increased plant density and fertilizer dose on the yield of rice variety IR-6. They found that an increased fertilizer dose of NPK increased plant height.

Asif *et al.* (2000) reported that NPK levels significantly increased the panicle length, and number of primary and secondary branches $panicle^{-1}$ when NPK fertilizer was applied in 180-90-90 kg ha^{-1}. This might be attributed to the adequate supply of NPK. Sarker *et al.* (2001) obtained the nitrogen responses of a *Japonica* (Yumelvitachi) and an *Indica* (Takanari) rice variety with different nitrogen levels viz. 0, 40, 80, and 120 N kg ha^{-1}. They observed that applying nitrogen increased grain and straw yields significantly, but the harvest index did not increase significantly.

Singh and Singh (2002) carried out a field experiment to see the effect of different S levels (0, 20, and 40 kg ha^{-1}) on rice cv. Swarna and PR-108 in Varanasi, Uttar Pradesh, India. They reported that plant height, tillers m^2, dry matter production, panicle length, and grains $panicle^{-1}$ were significantly increased with increasing levels of S up to 40 kg ha^{-1}.

Haq *et al.* (2002) experimented with twelve treatments combination of N, P, K, S, Zn, and Diazinon. They found that all the treatments significantly increased the grain and straw yields of BRRI dhan30 rice over control. 90 kg N + 50 kg P_2O_5 + 40 kg K_2O + 10 kg S + 4 kg Zn ha^{-1} + diazinon gave the highest grain and straw yields.

2.3 Combined effect of organic and chemical fertilizer management

2.3.1 Effect of nitrogen + phosphorus and cowdung on the growth and yield of rice

Rahman *et al.* (2009) conducted a field experiment to study the effect of urea N in combination with poultry manure and cowdung in rice. They found the application of manures and different doses of urea fertilizer significantly increased the yield components and grain and straw yields.

Tripathy *et al.* (2004) found significantly higher seed yield under the blended cowdung and NPK fertilizer's residual effects than the control. Saleque *et al.* (2004) conducted a field experiment to determine the effect of different doses of chemical fertilizers alone or in combination with cowdung and rice husk ash on the yield of lowland rice-rice cropping sequence. Cowdung and ash were applied on dry season rice only, and found the application of cowdung and ash increased rice yield by about 1 t ha^{-1} per year over that obtained with chemical fertilizer alone. The treatments, which showed a positive yield trend, also showed a positive total P uptake trend, and positive yield trends were attributed to the increasing P supplying power of the soil.

Saleque *et al.* (2004) showed that applying one third of recommended inorganic fertilizers with 5 t cowdung increased the low land rice yield than other treatments and yielded 8.87 t ha^{-1}.

Dao and Cavegelli (2003) reported that animal manure had long been used as an organic source of plant nutrients and organic matter to improve agricultural lands' physical and fertility conditions.

Mannan *et al.* (2000) reported that manuring with cowdung up to 10 t ha^{-1} in addition to recommended inorganic fertilizers with late N application improved grain and straw yields and the quality of transplant aman rice over inorganic fertilizer alone.

Saitoh *et al.* (2001) experimented to evaluate the effect of organic fertilizers (cowdung and poultry manure) and pesticides on the growth and yield of rice. They revealed that the yield of organic manure-treated and pesticide-free plots was 10%

lower than that of chemical fertilizer and pesticide-treated plots due to decreased panicles. A yearly application of manure increases the soil's total carbon and nitrogen content.

2.3.2 Effect of N P fertilizer and vermicompost on the growth and yield of rice

Mahmud *et al.* (2016) studied the combined effect of vermicompost and chemical fertilizers on the nutrient content in grain, straw, and post-harvest soil of boro rice cv. BRRI dhan-29, a field experiment, was conducted from December, 2013 to June 2014 at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. Sixteen combinations of 4 vermicompost levels @ 0, 1, 2, 4 t ha$^{-1,}$ and 4 NPKS levels, i.e., 0-0-0-0, 50-8-33-6, 100-16-66-12, 150-24-99-18 kg/ha^{-1}, respectively were applied in a Randomized Complete Block Design (RCBD) with three replications. Results showed that the highest dose of vermicompost and chemical fertilizer significantly increased the concentration of P, K and S by rice grain and straw at the harvesting stage. The combination of vermicompost and chemical fertilizers also significantly increased post-harvest soil's organic matter, P, K and S status. Combined application of vermicompost and chemical fertilizer failed to increase the total N content of post-harvest soil.

Sudhakar (2016) conducted at Annamalai University, Experimental Farm, Annamalainagar, Chidambaram, Tamil Nadu, India, during two seasons to identify and evaluate different sources of vermicompost on productivity enhancement, nutrient uptake, and nitrogen use efficiency in low-land rice under SRI method of cultivation The experiment comprised of eight treatments which include recommending dose of fertilizer alone and in combination with vermicompost prepared from various organic wastes namely Paddy straw, Coirpith, sewage sludge, Sugarcane trash, Pressmud and Crop residues @ 5 tha^{-1}. These were laid out in randomized block design and replicated thrice. The rice variety ADT 36 was used as the test variety. The results revealed that crops raised with pressmud-based vermicompost registered higher grain, straw yield, and harvest index. The vermicompost treatments significantly influenced the nutrient uptake, Nitrogen use efficiency (NUE), and Economic nitrogen use efficiency (ENUE) over control and recommended dose of fertilizer by the crop at harvest. Among the different organic sources of vermicompost, pressmud-based vermicompost registered the highest N, P, K uptake, nitrogen use efficiency (NUE), and economical nitrogen use efficiency (ENUE) values at harvest. From the above experimental results, it could be concluded that the application of pressmud-based vermicompost @ 5.0 t ha^{-1} not only resulted in higher yields but was also superior regarding nutrient uptake and nitrogen economy under the SRI method of rice cultivation.

Sultana *et al.* (2015) experimented Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh, from December 2011 to April 2012 to assess the effect of integrated use of vermicompost, pressmud, and urea on the nutrient status of grain and straw of rice (Hybrid Dhan Hira 2). Ten treatments coded from T_1 to T_{10} were used in this experiment. The highest amount of nitrogen (1.092%), phosphorus (0.297 %), and potassium (0.374 %) in grain, and the highest amount of potassium (1.213%), sulphur (0.091%) in straw were observed in T_3 treatment receiving 90 N kg ha^{-1} from urea along with 30 N kg ha^{-1} from vermicompost. The 23 highest sulphur (0.124 %) content in grain and, the highest nitrogen (0.742%), the highest phosphorus (0.182 %) in straw were recorded in treatment T_2 receiving 120 N kg ha^{-1} from urea. The highest amount of nitrogen (93.81 kg ha^{-1}), phosphorus (26.07 kg/ha), potassium (32.82 kg ha^{-1}), and sulphur (10.79 kg ha^{-1}) uptake by grains and the highest amount of nitrogen (55.70 kg ha^{-1}), phosphorus (13.79 kg ha^{-1}), potassium (92.43 kg ha^{-1}) and sulphur (6.91 kg ha^{-1}) uptake by the straw of rice were observed in T_3 treatment. On the other hand, the lowest values of these parameters were obtained from control treatment T_1.

The importance of composts as a source of humus and nutrients to increase soil fertility and plant growth has been well recognized in the present study. Vermicompost and chemical fertilizer 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 vermicompost was rich in nutrients like Potassium, Nitrate, Sodium, Calcium, Magnesium, and Chloride and had the potential to improve plant growth more than Fertilizer. The optimal growth of SRI Rice in our study was conducted for a period of four months. The study also showed distinct differences between vermicompost and chemical fertilizers regarding their nutrient content and effect on SRI Rice plant growth (Kandan and Subbulakshmi, 2015).

Dekhane *et al.* (2014) conducted a trial with three replications, and six treatments in a Randomized Block Design to assess the performance of different organic and inorganic fertilizer on the growth and yield of paddy crop (Variety GR 11) during the Kharif season. The data clearly revealed that the yield obtained with treatment T5 (50% RDF + 50% N through vermicompost) was recorded significantly higher growth as well as yield attributes than all other treatments. 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.

Kumar *et al.* (2014) carried out an experiment during the Kharif season of 2011 to study the effect of organic and inorganic sources of nutrients on yield, yield attributes, and nutrient uptake of rice cv. PRH-10. Applying organic and inorganic sources of nutrients 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 compared to other treatments, followed by 100% RDF + 5 t ha^{-1} vermicompost. 125% RDF + 5 t/ha vermicompost increased the number of panicles (20.50%), panicle length (23.12%), and 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 lowest yield, yield attributes, gross return, and nutrient uptake were recorded in the control.

Veerendra *et al.* (2012) conducted an experiment to study the impact of integrated nutrient management on yield, economics, and nutrient uptake of hybrid rice was conducted in sandy loam Dystrochrepts soil at Fertilizer Research Station, Pura of C.S. Azad University of Agriculture and Technology, Kanpur during Kharif 2007 and 2008. Results revealed that integrated biofertilizers or organic manure treatments registered significantly higher seed yield, the net return, and nutrient uptake over RDF alone.

Tharmaraj *et al.* (2011) studied the effect of vermicompost on soil chemical, and physical properties was evaluated during samba rice cultivation studies. The experiments were arranged in a completely randomized block design manner with three replications. The soil sampling and plant growth measurements were carried out for two months, i.e., during the initial and final stages. The study was carried out to know the impact of various vermiproduct such as vemicompost, vermiwash, and a mixture of vermicompost and vermiwash on soil physicochemical properties during the pot culture studies with samba rice. The physical properties such as electrical conductivity (EC), porosity, moisture content, water holding capacity, and chemical properties like nitrogen, phosphorous, potassium, calcium, and magnesium were found distinctly enhanced in vermicompost treated soil. In contrast, the corresponding physicochemical values in the control were minimum. The soil treated with vermicompost had significantly more electrical conductivity than unamended pots. The addition of vermicompost in soil resulted in a decrease in soil pH. The physical properties such as water holding capacity, moisture content and porosity in soil amended with vermicompost were improved. The vermiproduct treated plants exhibit faster and higher growth rates and productivity than the control plants. Among the treated group, the growth rate was high in the mixture of vermicompost and vermiwash treated plants, then in the vermicompost and vermiwash un-treated plants. The maximum range of some plant parameter's like the number of leaves, leaf length, 17 height of the plants, and root length of the plant, were recorded in the mixture of vermicompost and vermiwash. This experiment's results revealed that adding vemicompost had significant positive effects on the soil's physical, chemical properties and plant growth parameters.

Conjunctive use of vermicompost @ 2 t ha^{-1} along with 50 percent N h^{-1} enabled hybrid rice to produce grain yield at par that obtained by application of a recommended dose of fertilizer (Upendrarao and Srinivasulureddy, 2004). A field experiment was carried out during the wet season 1997 to study the response of scented rice (cv. Pusa basmati1) to levels of NPK, vermicompost, and growth regulator at ARS, Siraguppa. The results revealed that the application of 150:75:75 NPK kg ha^{-1} had recorded significantly higher growth, yield attributes, and yield (5261 kg ha^{-1}) than lower NPK levels. Scented rice Pusa Basmati-1 responded significantly to the organic manure. Application of vermicompost @ 5 tha^{-1} resulted in a significantly higher yield (4889 kg ha^{-1}) than no vermicompost application. Significant 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 (Murali and Setty, 2004). Vermicomposting is the bioconversion of organic waste materials into nutritious compost by earthworm activity and is an important component of the organic farming package. Meena (2003) reported multifarious effects of vermicompost on the growth and yield of crops.

In a recent field experiment conducted at Kerala Agricultural University, vermicompost @ 6 t/ha was tried as an organic manure for short-duration rice variety in Kanchana. It was found that vermicompost addition had a positive influence on the growth and yield attributes of rice, resulting in a better grain yield of 4.54 tha^{-1} and straw yield of 5.15 tha^{-1} along with the NPK dose of 105: 52.5: 52.5 kg/ha supplied through inorganic sources. Apart from the improvement in fertilizer use efficiency, vermicompost ensured a steady supply of secondary nutrients like Mg and micronutrients throughout the growth period, which improved the chlorophyll content of leaves and reduced the chaff percentage. Unlike other organic manures, vermicompost addition has the advantage of quick nutrient absorption by plants, resulting in better dry matter accumulation. The increase in panicle number per m 2 noted in the study was due to the promotion of tiller production with the supply of vermicompost (Sudha and Chandini, 2003). The application of vermicompost improved the chemical and physical structures of the soil. (Anitha and Prema, 2003).

Earthworms can live in decaying organic wastes and degrade them into fine particulate materials rich in nutrients. Earthworm make the soil porous and help in better aeration and water infiltration. Vermicomposting is the application of earthworms in producing vermin-fertilizer, which helps in the maintenance of a better environment and results in sustainable agriculture. Vermicompost can be prepared from different organic materials like sugarcane trash, coir pith, pressmud, weeds, cattle dung, bio-digested slurry, etc. Increased availability of nutrients in vermicompost compared to non-ingested soil resulted in significantly better growth and yield of rice has been reported by several workers (Sudhakar *et al.*, 2002). The application of vermicompost with fertilizer N and bio-fertilizer increased the rice yield by 16% over the application of fertilizer N alone. Vermicompost applied with FYM recorded higher rice grain and straw yield (Jeyabal and Kuppuswamy, 2001).

From the above reviews it was evident that, Judicial use of N P fertilizer improved boro rice productivity and the addition of organic manure in soil resulted in a decrease in soil pH, water holding capacity, moisture content and porosity in soil.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, during the period from October 2021 to April 2022 to study the effect of organic manure and different level of N P fertilizer on the yield and yield contributing parameters and seed quality of boro rice. The details of the materials and methods have been presented below:

3.1 Description of the experimental site

3.1.1 Location

The present piece of research work was conducted at the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The site's location is 237°4'N latitude and 90°35'E longitude with an elevation of 8.4 m from sea level (Appendix-I).

3.1.2 Soil

The selected plot was medium high land. The soil belongs to "The Modhupur Tract", AEZ-28. The top soil was silty clay loam in texture, olive-gray with common fine to medium distinct dark yellowish-brown mottles. Soil pH was 5.9, and organic carbon content was 0.84%. The experimental area was flat, having available irrigation and drainage system. The details of experimental plots of soil have been presented in Appendix-II.

3.1.3 Climate

The geographical location of the experimental site was under the subtropical climate, characterized by three distinct seasons: the winter season from November to February, the pre-monsoon period or hot season from March to April, and the monsoon period from May to October. Details of the meteorological data of temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e Bangla Nagar, Dhaka, and have been presented in Appendix III.

3.2 Test crop

BRRI dhan28 was used as the test crop in this experiment. The grains are medium fine, and white.

3.3 Experimental details

3.3.1 Treatments

Factor A: Organic manure (4)

i. OM_0: Without organic manure (control)
ii. OM_1: Cowdung @ 10 t ha^{-1}
iii. OM_2: Vermicompost @ 3 t ha^{-1}
iv. OM_3: Poultry manure @ 5 t ha^{-1}

Factor B: N P fertilizer level (4)

i. F_0: Without N P fertilizer
ii. F_1: 25% less than recommended dose of N P fertilizer
iii. F_2: Recommended dose of N P fertilizer
iv. F_3: 25% Higher than recommended dose of N P fertilizer

3.3.2 Experimental design and layout

The experiment was laid out in a two factor Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the combination of a different combination of nutrient levels. Thus, there were 48 unit plots, each of 2.75 m × 1.5 m in size (4.13m^2). The treatments of the experiment were assigned in the unit plot at random as per the design of the experiment.

3.4 Growing of crops

3.4.1 Raising seedlings

3.4.1.1 Seed collection

The seeds of the test crop, i.e., BRRI dhan28 were collected from Bangladesh Rice Research Institute (BRRI), Joydevpur, Gazipur.

3.4.1.2 Seed sprouting

Healthy seeds were selected by a specific gravity method, immersed in a water bucket for 24 hours, and then kept tightly in gunny bags. After taking the bucket, seeds started sprouting after 48 hours and were sown after 72 hours.

3.4.1.3 Nursery

The land selected for the nursery was thoroughly ploughed. Spreader seeds were sown uniformly in the nursery bed on 25th November 2021. Weeding and plant protection measures were taken per the crop's requirements.

3.4.2 Preparation of the main field

The plot selected for the experiment was opened on 15th December 2021 with a power tiller and was exposed to the sun for a week. After that, the land was harrowed, ploughed, and cross-ploughed several times, followed by laddering to obtain a good tilth. Weeds and stubble were removed and finally obtained a desirable soil tilth for seedlings transplanting.

3.4.3 Fertilizers and manure application

Nitrogen + phosphorus was applied in the form of urea and TSP. The recommended dose of urea, TSP, MoP, and gypsum was applied @ 180, 164, 180, and 90 kg ha^{-1}, respectively. All the fertilizers were applied as basal doses except urea. Urea was applied in three instalments at 30 and 60 DAT. The amount of urea and TSP was maintained per the required treatments mentioned in section 3.3.1. The whole amount of cowdung, vermicompost and poultry litter were applied during final land preparation.

3.4.4 Uprooting of seedlings

The nursery bed was made wet by applying water one day before uprooting the seedlings. The seedlings, 40 days old, were uprooted on January 4th, 2022, for transplanting without causing much mechanical injury to the roots.

3.4.5 Transplanting of seedlings in the field

On January 4th, 2022, the rice seedlings were transplanted in lines, each having a line-to-line distance of 25 cm and a plant-to-plant distance of 15 cm in the well-prepared plots.

3.4.6 After care

After the establishment of seedlings, various intercultural operations were accomplished for better growth and development of the rice seedlings.

3.4.6.1 Irrigation and drainage

Flood irrigation was provided to maintain a constant level of standing water up to 5-6 cm in the early stages to enhance tillering and 10-12 cm in the later stage to discourage late tillering and weed growth. The field was finally dried out 15 days before harvesting.

3.4.6.2 Gap filling

First, gap filling was done for all plots 10 days after transplanting (DAT) by planting same-aged seedlings.

3.4.6.3 Weeding

Weeding was done to keep the plots from weeds, ultimately ensuring better growth and development. The newly emerged weeds were uprooted carefully at the tillering stage and at the panicle initiation stage by hand pulling.

3.4.6.5 Plant protection

No major incidence of pests was found except a minor incidence of leaf folder, observed at 38 DAT, which was controlled by spraying Carbofuran 3G@1.5 kg ha^{-1}.

3.5 Harvesting, threshing and cleaning

The rice was harvested depending on the maturity of the plant, and harvesting was done manually from each plot on 25th April 2022. For taking yield attributes data, 5 randomly selected plants from each plot except border rows. Each plot's harvested plants of the control $1m^2$ area were bundled separately, properly tagged, and brought to the threshing floor. Enough care was taken during harvesting, threshing, and cleaning rice seeds. The grains were cleaned, and finally, the weight was adjusted to a moisture content of 14%. The straw was sun-dried, and the grain and straw $plot^{-1}$ yields were recorded and converted to t ha^{-1}.

3.6 Data recording

Crop Growth contributing characters

i. Plant height at 20 days interval starting from 30 DAS upto harvest
ii. Total tiller/plant at 20 days interval starting from 45 DAS upto harvest

Yield contributing characters

i. Panicle length(cm)
ii. Filled grain panicle (number)
iii. Unfilled grain panicle (number)
iv. Weight of 1000 grains (gm)

Yield and harvest index

i. Grain yield (t ha^{-1})
ii. Straw yield (t ha^{-1})
iii. Biological yield (t ha^{-1})
iv. Harvest index (%)

Seed quality characters

Seeds collected from each plot were dried properly and kept separately, followed by proper tagging. These seeds were used for taking seed quality attributes data as follows:

i. Germination percentage
ii. Root length (cm)
iii. Shoot length (cm)
iv. Dry weight seedlings^{-1} (g)

3.6.1 Plant height

The height of the plant was recorded in centimeter (cm) at harvest. Data were 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 tiller.

3.6.2 Total tillers plant^{-1}

The total tillers plant^{-1} was calculated by adding effective and non-effective tillers plant$^{-1,}$ and the average value was recorded. It was taken from the 5 randomly pre-selected plants from each plot.

3.6.3 Length of panicle

The length of the panicle was measured with a meter scale from 10 selected panicles, and the average value was recorded.

3.6.4 Filled grain panicle^{-1}

The total number of filled grains was collected from randomly selected 5 plants of a plot on the basis of grain in the spikelet, and then the average number of filled grains panicle^{-1} was recorded.

3.6.5 Unfilled grains panicle^{-1}

The total number of unfilled grains was collected from randomly selected 5 plants of a plot on the basis of no things inside the grain in the spikelet, and then the average number of unfilled grains in panicle^{-1} was recorded.

3.6.6 Grain yield

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of the central 1 m^2 area from each plot was taken and then converted to t ha^{-1}.

3.6.7 Straw yield

Straw obtained from each unit plot was sun-dried and weighed carefully. The dry weight of straw of a central 1 m^2 area was taken and finally converted to t ha^{-1}.

3.6.8 Biological yield

Grain yield and straw yield together were regarded as biological yield. The biological yield was calculated with the following formula:

Biological yield = Grain yield + Straw yield.

3.6.9 Harvest index (%)

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

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

3.6.10 Germination percentage (%)

50 (fifty) seeds from each plot were taken for the germination test. Seeds were sown in petrisdishes containing soaked sand. After 10 days, the total number of germinated seeds was counted, and the gemination percentage was measured using the following formula:

$$\text{Germination percentage} = \frac{\text{Total no.of germinated seeds}}{\text{Total no.of germinated and non-germinated seeds}} \times 100$$

3.6.11 Root length (cm)

Length of root of 10 randomly selected seedlings were measured 10 days after germination. Values were calculated as average and recorded as the root length (cm) of the seedlings.

3.6.12 Shoot length (cm)

The shoot length of 10 randomly selected seedlings was measured 10 days after germination. Values were calculated as average and recorded as the seedlings' shoot length (cm).

3.6.13 Dry weight of seedlings (g)

The previously selected 10 seedlings used for root and shoot length measurements were oven dried at 65℃ for 72 hours, and dry weight was recorded mean weight of 10 seedlings was considered as the dry weight of seedlings (g).

3.7 Statistical Analysis

The collected data were compiled and analysed statistically using the analysis of variance (ANOVA) technique using the computer package program MSTAT-C to observe the significant difference among the treatment means. All the characters' mean values were calculated, and variance analysis was performed. The mean difference was adjusted by the Least Significance Difference (LSD) test at a 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to investigate the effects of the integrated use of organic manure and different N P fertilizer levels on the growth and yield potential of BRRI Dhan28. Data on different parameters were analysed statistically. The result of the present study has been presented and discussed in this chapter under the following heading.

4.1. Plant height

Effects of organic manure

The effects of organic manure management practices were evident 30, 50, 70, 90 DAT and at harvest, recorded significantly influenced plant height. The tallest plant (32.50, 52.30, 75.50, 94.05 and 98.75 cm) was produced in OM_3 (Poultry manure @ 5 t ha^{-1}). The shortest plant height (18.30, 39.67, 63.33, 80.33, and 84.50 cm) was produced under control treatment OM_0 (Table 1). The increase in plant height due to the application of increased levels of fertilizer and manure might be associated with the stimulating effect of nitrogen on various physiological processes, including cell division and cell elongation of the plant. In general, plant height increases with the increasing nitrogen level of organic matter. The results agree with those of Singh and Singh (2002), who reported a positive effect of USG level on plant height.

Table 1. Effect of organic manure on plant height at different days after transplanting

Treatments	Plant height (cm)				
	30 DAT	50 DAT	70 DAT	90 DAT	At harvest
OM_0	18.30 d	39.67 d	63.33 d	80.33 d	84.50 d
OM_1	20.33 c	41.70 c	65.45 c	84.66 c	89.30 c
OM_2	30.00 b	48.66 b	71.33 b	90.20 b	95.33 b
OM_3	32.50 a	52.30 a	75.50 a	94.05 a	98.75 a
LSD (5%)	2.04	2.89	3.01	3.02	3.14
CV (%)	6.17	5.83	7.02	5.42	5.77

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Least Significance Difference (LSD) test.

OM_0: Without organic manure (control) OM_1: Cowdung @ 10 t ha^{-1}, OM_2: Vermicompost @ 3 t ha^{-1} and OM_3: Poultry manure @ 5 t ha^{-1}]

Effects of different levels of N P fertilizer

The effects of different N P fertilizer levels were observed at 30, 50, 70, 90 DAT, and at harvest, recorded as significantly influencing plant height. The tallest plant (32.66, 50.95, 78.33, 94.75, and 99.30 cm) was produced in F_3 (25% Higher than the recommended dose of N P fertilizer). The shortest plant height (18.33, 37.70, 58.10, 77.66, and 84.03 cm) was produced under control treatment F_0 (Figure 1).

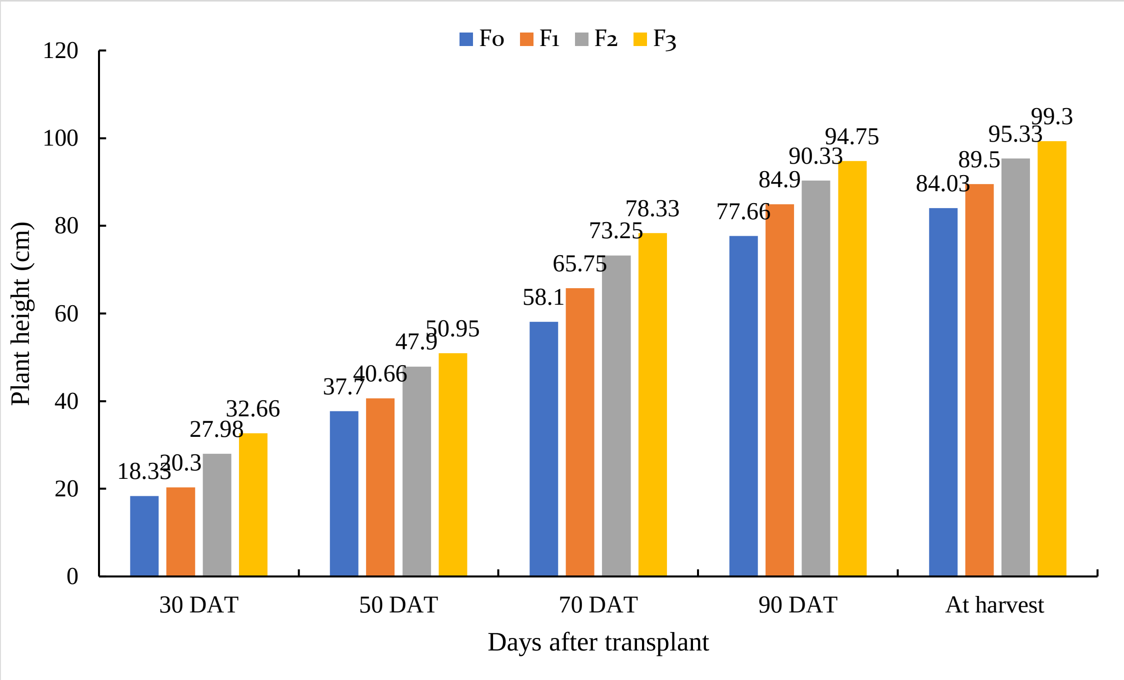

Figure 1. Effect of different levels of N P fertilizer on plant height at different days after transplanting [F_0: Without N P fertilizer, F_1: 25% less than recommended dose of N P fertilizer, F_2: Recommended dose of N P fertilizer and F_3: 25% Higher than recommended dose of N P fertilizer]

Effect of combined use of organic manure and N P fertilizer

The effects of integrated use of organic manure and different level of nitrogen + phosphorus management practices were evident at 30, 50, 70, 90 DAT, and at harvest recorded significantly influenced on plant height. The tallest plant (34.53, 62.15, 85.15, 101.15, and 105.90 cm) was produced in OM_3F_3 (Poultry manure @ 5 t ha^{-1} with 25% Higher than the recommended dose of N P fertilizer) treatment combination. The shortest plant height (16.28, 30.15, 52.85, 72.33, and 78.60 cm) was produced under control treatment OM_0F_0 (Table 2).

Table 2. Effect of combined use of organic manure and N P fertilizer on plant height at different days after transplanting

Treatments		Plant height (cm)				
		30 DAT	50 DAT	70 DAT	90 DAT	At harvest
OM_0	F_0	16.28 j	30.15 j	52.85 l	72.33 h	78.60 gh
	F_1	19.33 hi	36.67 hi	59.83 j	78.67 fg	82.66 fg
	F_2	29.67 e	44.20 fg	68.53 g	84.70 ef	89.66 d
	F_3	31.70 cd	47.15 e	72.20 ef	88.67 d	92.35 cd
OM_1	F_0	18.32 i	32.33 i	55.27 k	76.40 gh	81.75 g
	F_1	20.13 gh	37.67 h	62.82 hi	83.80 ef	86.50 e
	F_2	30.05 de	46.15 ef	71.50 f	87.67 de	92.70 cd
	F_3	32.45 bc	51.30 cd	75.64 d	90.50 cd	96.65 b
OM_2	F_0	19.33 hi	39.25 gh	60.75 i	81.75 f	89.40 de
	F_1	21.33 g	44.27 f	67.32 gh	86.33 ef	93.85 bc
	F_2	31.85 c	52.30 c	76.70 c	95.15 bc	99.53 ab
	F_3	33.90 b	58.66 b	80.50 b	98.60 ab	102.67 ab
OM_3	F_0	20.12 gh	41.85 g	63.33 h	86.53 ef	91.50 cd
	F_1	22.90 f	46.75 d	72.85 e	90.67 c	95.15 bc
	F_2	32.90 bc	58.33 bc	80.33 bc	99.67 ab	102.50 ab
	F_3	34.53 a	62.15 a	85.15 a	101.15 a	105.90 a
LSD (5%)		1.93	2.04	2.71	4.05	3.66
CV (%)		7.10	3.89	7.14	5.38	5.41

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Least Significance Difference (LSD) test.

OM_0: Without organic manure (control) OM_1: Cowdung @ 10 t ha^{-1}, OM_2: Vermicompost @ 3 t ha^{-1} and OM_3: Poultry manure @ 5 t ha^{-1};

F_0: Without N P fertilizer, F_1: 25% less than recommended dose of N P fertilizer, F_2: Recommended dose of N P fertilizer and F_3: 25% Higher than recommended dose of N P fertilizer]

4.2 Number of tillers $hill^{-1}$

Effect of organic manure

The effects of organic manure management practices were evident 30, 50, 70, 90 DAT, and at harvest recorded significantly influenced on the number of tillers $hill^{-1}$. The highest tiller (8.90, 12.33, 13.10, 14.33, and 15.09) was produced in OM_3 (Poultry manure @ 5 t ha^{-1}). The lowest tiller (4.10, 8.75, 9.80, 10.95, and 13.08) was produced under control treatment OM_0 (Table 3).

Table 3. Effect of organic manure on the number of tillers hill^{-1} at different days after transplanting

Treatments	Tiller hill^{-1} (No.)				
	30 DAT	50 DAT	70 DAT	90 DAT	At harvest
OM_0	4.10 d	8.75 d	9.80 d	10.95 d	13.08 cd
OM_1	6.25 c	10.09 c	10.98 c	12.85 c	13.66 c
OM_2	7.40 b	11.66 b	12.33 b	13.90 b	14.25 b
OM_3	8.90 a	12.33 a	13.10 a	14.33 a	15.09 a
LSD (5%)	1.03	1.02	1.02	1.04	1.01
CV (%)	8.31	7.94	7.56	7.50	7.18

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Least Significance Difference (LSD) test.

OM_0: Without organic manure (control) OM_1: Cowdung @ 10 t ha^{-1}, OM_2: Vermicompost @ 3 t ha^{-1} and OM_3: Poultry manure @ 5 t ha^{-1}]

Effect of different levels of N P fertilizer

The effects of different N P fertilizer levels were observed at 30, 50, 70, 90 DAT, and at harvest recorded significantly influenced on the number of tillers hill^{-1}. The highest tiller (8.90, 12.30, 14.01, 14.80, and 16.15) was produced in F_3 (25% Higher than the recommended dose of N P fertilizer). The lowest tiller hill^{-1} (4.73, 8.25, 9.75, 10.50, and 11.20) was produced under control treatment F_0. (Figure 2)

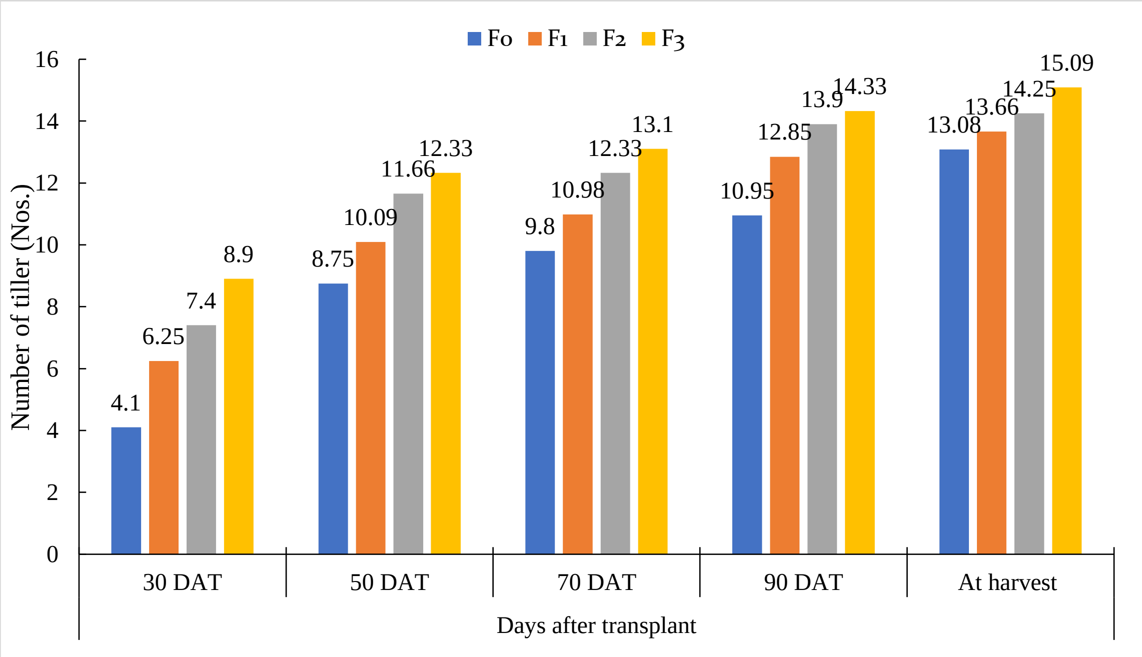

Figure 2. Effect of different levels of N P fertilizer on the number of tiller hill^{-1} at different days after transplanting [F_0: Without N P fertilizer, F_1: 25% less than recommended dose of N P fertilizer, F_2: Recommended dose of N P fertilizer and F_3: 25% Higher than recommended dose of N P fertilizer]

Effect of combined use of organic manure and N P fertilizer

The number of tiller hill^{-1} varied significantly due to interaction treatments of different organic manure and N P fertilizer doses at 30, 50, 70, 90 DAT, and at harvest (Table 4). The highest value of the number of tiller hill^{-1} (9.80, 14.15, 14.75, 15.95, and 16.85) was found with the interaction treatment of OM_3F_3 (Poultry manure @ 5 t ha^{-1} with 25% Higher than the recommended dose of N P fertilizer) treatment combination which is statistically similar with OM_3F_2 interaction for all sampling dates except 50 DAT. However, the lowest tiller (3.08, 6.42, 8.85, 9.90, and 10.25) was produced under control treatment OM_0F_0 (Table 4). The progressive improvement in the formation of tillers might be due to the effect of fertilizer and manure. Mirzeo and Reddy (1989) and Singh and Singh (1986) also reported similar results.

Table 4. Effect of integrated use of organic manure and N P fertilizer on the number of tiller hill^{-1} at different days after transplanting

Treatments		Tiller hill^{-1} (No.)				
		30 DAT	50 DAT	70 DAT	90 DAT	At harvest
OM_0	F_0	3.08 h	6.42 j	8.85 h	9.90 f	10.25 e
	F_1	4.66 f	7.85 i	10.93 e	11.03 de	12.27 cd
	F_2	5.86 e	10.23 ef	11.50 de	12.75 c	13.33 c
	F_3	6.03 de	11.05 e	12.33 cd	13.15 bc	14.33 bc
OM_1	F_0	3.33 g	7.95 hi	9.63 g	10.25 e	11.67 d
	F_1	5.50 ef	8.78 g	10.76 ef	11.95 d	13.33 c
	F_2	6.45 de	11.45 d	12.40 cd	13.67 bc	14.33 bc
	F_3	7.47 cd	12.15 cd	13.16 bc	14.33 bc	15.35 ab
OM_2	F_0	5.25 ef	8.60 gh	10.67 ef	11.85 de	12.35 cd
	F_1	6.90 cd	10.45 ef	12.33 cd	13.52 bc	14.40 bc
	F_2	8.08 bc	12.68 c	13.75 bc	14.80 b	15.15 ab
	F_3	8.72 bc	13.25 bc	14.50 ab	15.08 ab	16.51 ab
OM_3	F_0	7.53 cd	10.23 ef	11.05 de	12.15 cd	12.85 cd
	F_1	8.05 bc	11.05 de	12.33 cd	13.50 bc	14.67 b
	F_2	9.33 ab	13.65 b	14.25 ab	15.45 ab	15.93 ab
	F_3	9.80 a	14.15 a	14.75 a	15.95 a	16.85 a
LSD (5%)		0.98	0.97	1.01	1.107	1.02
CV (%)		4.97	5.13	5.04	5.73	4.18

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Least Significance Difference (LSD) test.

OM_0: Without organic manure (control) OM_1: Cowdung @ 10 t ha^{-1}, OM_2: Vermicompost @ 3 t ha^{-1} and OM_3: Poultry manure @ 5 t ha^{-1};

F_0: Without N P fertilizer, F_1: 25% less than recommended dose of N P fertilizer, F_2: Recommended dose of N P fertilizer and F_3: 25% Higher than recommended dose of N P fertilizer]

4.3 Number of effective tillers hill^{-1}

Effects of organic manure

The effects of different organic manure on the number of tiller hill^{-1} of rice are presented in Table 5. The use of different organic manure significantly influenced the number of effective tiller hill^{-1}. Between the applied manure, OM_3 (Poultry manure @ 5 t ha^{-1}) showed a higher (12.66) number of effective tiller hill$^{-1,}$ and OM_0 (Without organic manure, Control) treatment showed a lower (9.78) number of effective tiller hill^{-1}.

Effects of different levels of N P fertilizer

Rice plants showed significant variation in the number of effective tiller hill^{-1} when different N P fertilizer levels were applied (Table 6). Among the different fertilizer doses, F_3 (25% Higher than the recommended N P fertilizer dose) gave the most effective tiller hill^{-1} (13.66). On the other hand, the lowest (9.95) number of effective tiller hill^{-1} was observed in the F_0 treatment, where that received no fertilizer (control).

Effect of integrated use of organic manure and N P fertilizer

Combined application of different organic manure and N P fertilizer significantly varied the number of effective tiller hill^{-1} of rice (Table 7). The highest (14.70 number of effective tiller hill^{-1} was recorded with OM_3F_3 (Poultry manure @ 5 tha^{-1} with 25% Higher than the recommended dose of N P fertilizer) treatment combination, which was statistically similar to OM_3F_2 OM_2F_3 and OM_1F_3 On the other hand, the lowest (8.90) number of effective tiller hill^{-1} was observed in the treatment combination OM_0F_0 (control).

4.4 Panicle length (cm)

Effects of organic manure

The effects of organic manure on the panicle length of rice are presented in Table 5. The use of organic manure significantly influenced panicle length. Between the applied manure, OM_3 (Poultry manure @ 5 t ha^{-1}) showed the highest (21.90 cm) panicle length, and OM_0 (Without organic manure, Control) showed the lowest (17.23 cm) panicle length.

Effects of different levels of N P fertilizer

Rice plants showed significant variation in panicle length when different N P fertilizer levels were applied (Table 6). Among the different fertilizer doses, F_3 (25% higher than the recommended N P fertilizer) gave the highest panicle length (21.83 cm), which was statistically similar to F_2. On the other hand, the lowest (18.15 cm) panicle length was observed in the F_0 treatment, where that received no fertilizer (control).

Effect of combined use of organic manure and N P fertilizer

Combined application of different doses of organic manure and N P fertilizer expressed significant variation in the panicle length of rice (Table 7). The highest (22.33 cm) panicle length was recorded with OM_3F_3 (Poultry manure @ 5 t ha^{-1} with 25% Higher than the recommended dose of N P fertilizer) treatment combination. On the other hand, the lowest (18.40 cm) panicle length was observed in the treatment combination OM_0F_0 (control).

4.5 Number of grain $panicle^{-1}$

Effects of organic manure

Grain per panicle of rice exhibited significant variation due to the application of different organic manure (Table 5). The use of organic manure significantly influenced grain per panicle. Between the applied manure, OM_3 (Poultry manure @ 5 t ha^{-1}) showed the highest (104.15) grain per panicle, and OM_0 (Without organic manure, Control) showed the lowest (81.20) grain per panicle.

Effects of different levels of N P fertilizer

Rice plants showed significant variation in grain per panicle when different N P fertilizer levels were applied (Table 6). Among the different fertilizer doses, F_3 (25% Higher than recommended N P fertilizer) gave the highest grain per panicle (104.75).

On the other hand, the lowest (75.05) grain per panicle was observed in F_0 (control) treatment, where that received no fertilizer.

Effect of combined use of organic manure and N P fertilizer

The combined effect of different doses of organic manure and N P fertilizer significantly varied grain panicle^{-1} of rice (Table 7). The highest (123.67) grain panicle^{-1} was recorded with OM_3F_3 (Poultry manure @ 5 t ha^{-1} with 25% Higher than the recommended dose of N P fertilizer) treatment combination. On the other hand, the lowest (68.90) grain per panicle was observed in the treatment combination OM_0F_0 (control). An adequate gradual supply of nitrogen from organic manure contributed to grain formation, which probably increased the number of grain panicle^{-1} with increasing nitrogen levels. Rama *et al.* (1989) found significantly higher filled grains panicle^{-1} with 40, 80, or 120 kg N ha^{-1}, which support the present results.

4.6 1000-grain weight (g)

Effects of organic manure

The weight of 1000-grain rice exerted significant variation due to applying different organic manure. Between the applied manure, OM_3 (Poultry manure @ 5 t ha^{-1}) showed the highest (21.67 g) grain weight, and OM_0 (Without organic manure, Control) showed the lowest (18.67 g) 1000 grain weight.

Effects of different levels of N P fertilizer

Rice plants showed significant variation in respect of 1000-grain weight due to the application of different levels of N P fertilizer (Table 6). Among the different fertilizer doses, F_3 (25% Higher than recommended N P fertilizer) gave the highest seed weight (21.67 g). On the other hand, the lowest (18.90 g) grain weight was observed in the F_0 treatment where that received no fertilizer applied treatment (control).

Effect of combined use of organic manure and N P fertilizer

The combined application of different doses of organic manure and N P fertilizer significantly varied the 1000-grain weight of rice (Table 7). The highest (22.05 g) grain weight was recorded with OM_3F_3 (Poultry manure @ 5 t ha^{-1} with 25% Higher than the recommended dose of N P fertilizer) treatment combination. On the other hand, the lowest (19.33 g) 1000-grain weight was observed in the treatment combination OM_0F_0 (control).

4.7 Grain yield (t ha^{-1})

Effects of organic manure

The use of organic manure significantly influenced grain yield. Among the applied organic manure, OM_3 (Poultry manure @ 5 t ha^{-1}) showed the highest (4.90 t ha^{-1}) grain yield, and OM_0 (Without organic manure, Control) treatment showed the lowest (2.75 t ha^{-1}) grain yield. It indicates that poultry manure out yielded over control by producing 78.18% higher grain yield.

Effects of different levels of N P fertilizer

Rice plants showed significant variation in grain yield when different N P fertilizer levels were applied (Table 6). Among the different fertilizer doses, F_3 (Poultry manure @ 5 t ha^{-1} with 25% higher than recommended N P fertilizer) gave the highest grain yield (5.13 t ha^{-1}). On the other hand, the lowest (3.14 t ha^{-1}) grain yield was observed in the F_0 treatment, where no fertilizer (control) was applied treatment.

Effect of combined use of organic manure and N P fertilizer

The combined application of different doses of organic manure and N P fertilizer significantly varied rice grain yield (Table 7). The highest grain yield (5.83 t ha^{-1}) was recorded with OM_3F_3 (Poultry manure @ 5 t ha^{-1} with 25% Higher than the recommended dose of N P fertilizer) treatment combination. On the other hand, the lowest grain yield (2.75 t ha^{-1}) was observed in the treatment combination $OM0F_0$ (control). Similar results were reported by Mishra *et al.* (2000) and Raju *et al.* (1987), who observed that among all the levels of N recorded the highest grain yield and proved significantly superior to other sources. An adequate amount of nitrogen application is probably favored to yield components, i.e., number of tillers hill^{-1}, panicle length, and number of grains which ultimately gave higher grain yield.

4.8 Straw yield (t ha^{-1})

Effects of organic manure

The straw yield was significantly influenced by using organic manure in boro rice (Table 5). Between the applied manure, OM_3 (Poultry manure @ 5 t ha^{-1}) showed the highest straw yield (5.25 t ha^{-1}), and OM_0 (Without organic manure, Control) showed the lowest straw yield (3.50 t ha^{-1}).

Effects of different levels of N P fertilizer

Rice plants showed significant variation in straw yield when different N P fertilizer levels were applied (Table 6). The result shows that the different fertilizer doses, F_3 (25% Higher than the recommended N P fertilizer), gave the highest straw yield (5.33 t ha^{-1}). On the other hand, the lowest straw yield (3.67 t ha^{-1}) was observed in the F_0 treatment, where no fertilizer (control) was applied condition.

Effect of combined use of organic manure and N P fertilizer

The combined application of different doses of organic manure and N P fertilizer significantly varied the straw yield of rice (Table 7). The highest straw yield (6.26 t ha^{-1}) was recorded with OM_3F_3 (Poultry manure @ 5 t ha^{-1} with 25% Higher than the recommended dose of N P fertilizer) treatment combination. On the other hand, the lowest straw yield (2.90 t ha^{-1}) was observed in the treatment combination OM_0F_0 (control).

4.9 Harvest index (%)

Effects of organic manure

The harvest index was significantly influenced by using organic manure in boro rice (Table 5). The result revealed that among the applied organic manure, OM_3 (Poultry manure @ 5 t ha^{-1}) showed the highest (48.27 %) harvest index, and OM_0 (Without organic manure, Control) showed the lowest (44.00 %) harvest index.

Effects of different levels of N P fertilizer

Significant variation was observed in respect of the harvest index of rice when different levels of N P fertilizer were applied (Table 6). The result revealed that the different fertilizer doses, F_3 (25% Higher than the recommended N P fertilizer), gave the highest harvest index (49.04 %). On the other hand, the lowest harvest index (46.10 %) was observed in the F_0 treatment, where no fertilizer (control) was received.

Effect of combined use of organic manure and N P fertilizer

Combined application of different doses of organic manure and N P fertilizer exhibited significant variation in the harvest index of rice (Table 7). The highest harvest index (48.33 %) was recorded with OM_3F_3 (Poultry manure @ 5 t ha^{-1} with 25% Higher than the recommended dose of N P fertilizer) treatment combination. On the other hand, the lowest harvest index (43.80 %) was observed in the treatment combination OM_0F_0 (control). Ali (2005) reported that the nitrogen management strategy did not influence the harvest index. On the other hand, Miah *et al.* (2004) also reported that levels of nitrogen fertilizer had exerted minimal variation on the harvest index.

Table 5. Effect of organic manure on yield and yield contributing characteristics of rice

Treatments	Effective tillers $hill^{-1}$ (no.)	Panicle length (cm)	Grains $panicle^{-1}$ (no.)	1000 grain wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
OM_0	9.78 d	17.23 d	81.20 d	18.67 d	2.75 c	3.50 bc	44.00 bc
OM_1	10.75 c	18.66 c	84.05 c	19.05 c	3.05 bc	3.85 b	44.20 bc
OM_2	11.98 b	20.75 b	97.66 b	20.33 b	3.93 b	4.90 ab	45.30 b
OM_3	12.66 a	21.90 a	104.15 a	21.67 a	4.90 a	5.25 a	48.27 a
LSD (5%)	0.97	0.95	0.94	0.84	0.98	0.53	0.03
CV (%)	8.15	7.31	8.14	8.05	9.30	10.31	10.18

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Least Significance Difference (LSD) test.

OM_0: Without organic manure (control) OM_1: Cowdung @ 10 t ha^{-1}, OM_2: Vermicompost @ 3 t ha^{-1} and OM_3: Poultry manure @ 5 t ha^{-1}]

Table 6. Effect of N P fertilizer on yield and yield contributing characteristics of rice

Treatments	Effective tillers $hill^{-1}$ (no.)	Panicle length (cm)	Grains $panicle^{-1}$ (no.)	1000 grain wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
F_0	9.95 cd	18.15	75.05 d	18.90 cd	3.14 d	3.67 d	46.10 d
F_1	11.30 c	20.30	85.20 c	19.15 c	3.33 c	3.89 c	46.12 c
F_2	12.25 b	21.70 ab	98.08 b	20.50 b	4.50 b	4.95 b	47.62 b
F_3	13.66 a	21.83 a	104.75 a	21.67 a	5.13 a	5.33 a	49.04 a
LSD (5%)	0.95	0.94	0.94	0.71	0.11	0.14	1.02
CV (%)	7.92	7.10	8.15	12.07	11.23	10.21	10.05

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Least Significance Difference (LSD) test.

F_0: Without N P fertilizer, F_1: 25% less than recommended dose of N P fertilizer, F_2: Recommended dose of N P fertilizer and F_3: 25% Higher than recommended dose of N P fertilizer]

Table 7. Effect of combined use of organic manure and different level of N P fertilizer on yield and yield contributing characteristics of rice

Treatments		Effective tillers hill^{-1} (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	1000 grain wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
OM_0	F_0	8.90 f	18.40 d	68.90 m	19.33 f	2.75 h	2.90 l	43.80 h
	F_1	10.08 de	19.90 cd	76.93 k	20.50 de	3.28 f	3.90 j	45.53 f
	F_2	11.33 cd	20.95 b	87.78 h	21.05 cd	4.25 d	4.99 f	46.01 def
	F_3	12.67 bc	21.33 ab	92.25 gh	21.20 cd	4.67 cd	5.33 e	46.50 d
OM_1	F_0	9.85 ef	19.95 c	70.20 l	19.93 e	3.05 g	3.67 k	45.43 fg
	F_1	11.50 c	20.33 bc	78.53 j	20.85 de	3.67 ef	4.28 ij	46.03 def
	F_2	12.50 bc	20.25 bc	92.33 gh	21.25 cd	4.83 c	5.67 d	46.50 d
	F_3	13.15 ab	21.75 ab	98.67 e	21.50 cd	5.15 bc	5.80 cd	47.05 cd
OM_2	F_0	10.15 de	20.50 bc	78.35 jk	20.17 de	3.25 fg	3.80 jk	46.15 de
	F_1	11.25 cd	20.89 bc	83.67 i	20.33 de	3.85 e	4.33 h	47.02 cd
	F_2	12.83 b	21.70 ab	96.75 f	21.85 cd	5.10 bc	5.67 cd	47.20 c
	F_3	13.75 ab	22.15 ab	105.27 c	21.67 cd	5.33 bc	5.83 c	47.75 bc
OM_3	F_0	10.75 d	20.15 bc	93.20 g	20.90 d	3.78 ef	4.33 h	46.53 d
	F_1	12.25 bc	20.90 bc	101.33 d	21.74 cd	4.20 de	4.60 g	47.75 bc
	F_2	13.75 ab	21.95 ab	117.33 b	21.95 b	5.50 b	6.05 b	47.98 b
	F_3	14.70 a	22.33 a	123.67 a	22.05 a	5.83 a	6.26 a	48.33 a
LSD (5%)		0.91	0.80	1.05	0.32	0.20	0.21	0.45
CV (%)		7.54	4.13	6.68	10.21	11.27	10.98	8.31

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Least Significance Difference (LSD) test.

OM_0: Without organic manure (control) OM_1: Cowdung @ 10 t ha^{-1}, OM_2: Vermicompost @ 3 t ha^{-1} and OM_3: Poultry manure @ 5 t ha^{-1};

F_0: Without N P fertilizer, F_1: 25% less than recommended dose of N P fertilizer, F_2: Recommended dose of N P fertilizer and F_3: 25% Higher than recommended dose of N P fertilizer]

4.10 Germination percentage

Effects of organic manure

The effects of organic manure on rice germination (%) are presented in Table 8. The result revealed that germination was significantly influenced due to use of organic manure. Between the applied manure, OM_3 (Poultry manure @ 5 t ha^{-1}) showed the highest germination (91.25 %), and OM_0 (Without organic manure, Control) showed the lowest germination (80.75 %) of rice.

Effects of different levels of N P fertilizer

Rice plants showed significant variation in germination percentage when different N P fertilizer levels were applied (Table 9). Among the different fertilizer doses, F_3 (25% Higher than the recommended N P fertilizer) gave the highest germination (90.35 %). On the other hand, the lowest germination (79.75 %) was observed in the F_0 treatment, where that received no fertilizer (control).

Effect of combined use of organic manure and N P fertilizer

The interaction effect of the application of different doses of organic manure and N P fertilizer had a significant variation in the germination percentage of rice (Table 10). The highest germination (95.75 %) was recorded with OM_3F_3 (Poultry manure @ 5 t ha^{-1} with 25% Higher than the recommended dose of N P fertilizer) treatment combination, which was statistically significant with the combination of OM_3F_2. On the other hand, the lowest germination (76.50 %) was observed in the treatment combination OM_0F_0 (control).

4.11 Root length

Effects of organic manure

The effects of organic manure on rice's root length (cm) are presented in Table 8. The use of organic manure significantly influenced root length. Between the applied manure, OM_3 (Poultry manure @ 5 t ha^{-1} with 25% Higher than the recommended dose of N P fertilizer) showed the highest (9.33 cm) root length, and OM_0 (Without organic manure, Control) showed the lowest (7.25 cm) root length.

Effects of different level of N P fertilizer

Rice seedlings showed significant variation in root length when different N P fertilizer levels were applied (Table 9). Among the different fertilizer doses, F_3 (25% Higher than recommended N P fertilizer) gave the highest root length (9.05 cm). On the other hand, the lowest (7.15 cm) root length was observed in the F_0 treatment, where no N P fertilizers were used.

Effect of combined use of organic manure and N P fertilizer

The combined application of different doses of organic manure and N P fertilizer significantly varied the root length of rice (Table 10). The highest (9.90 cm) root length was recorded with OM_3F_3 (Poultry manure @ 5 t ha^{-1} with 25% Higher than the recommended dose of N P fertilizer) treatment combination, which was statistically significant with the combination of OM_3F_2, OM_2F_3, OM_2F_2, OM_2F_1, OM_1F_3, OM_1F_2 and OM_1F_1. On the other hand, the lowest (6.23 cm) root length was observed in the treatment combination OM_0F_0 (control).

4.12 Shoot length

Effects of organic manure

The effects of organic manure on rice's shoot length (cm) are presented in Table 8. The result showed that the use of organic manure significantly influenced shoot length. Organic manure OM_3 (Poultry manure @ 5 t ha^{-1}) showed the highest shoot length (14.85 cm), statistically similar to OM_2 and OM_1. OM_0 (Without organic manure, Control) showed the lowest shoot length (11.15 cm).

Effects of different levels of N P fertilizer

Rice seedlings were affected significantly regarding shoot length when different levels of N P fertilizers were applied (Table 9). Among the different fertilizer doses, F_3 (25% Higher than the recommended N P fertilizer) gave the highest shoot length (14.90 cm), which was statistically significant with F_2. On the other hand, the lowest shoot length (11.67 cm) was observed in the F_0 treatment, where that received no fertilizer (control).

Effect of integrated use of organic manure and N P fertilizer

Integrated application of different doses of organic manure and N P fertilizer significantly varied the shoot length of rice seedlings (Table 10). The highest shoot length (16.13 cm) was recorded with OM_3F_3 (Poultry manure @ 5 t ha^{-1} with 25% Higher than the recommended dose of N P fertilizer) treatment combination. On the other hand, the lowest shoot length (10.40 cm) was observed in the treatment combination OM_0F_0 (control).

4.13 Dry weight of seedlings

Effects of organic manure

The dry weight of rice seedlings was significantly influenced by the use of organic manure. Among the applied manure, OM_3 (Poultry manure @ 5 t ha^{-1}) showed the highest (37.75 g) weight, and OM_0 (Without organic manure, Control) showed the lowest (31.85 g) weight.

Effects of different level of N P fertilizer

Rice seedlings varied significantly in respect to dry-weight seedling when different N P fertilizer levels were applied (Table 9). Among the different fertilizer doses, F_3 (25% Higher than recommended N P fertilizer) gave the highest weight (37.10 g). On the other hand, the lowest (31.25 g) dry weight was observed in the F_0 treatment, where that received no fertilizer (control).

Effect of combined use of organic manure and N P fertilizer

The interaction of different doses of organic manure and N P fertilizer had significant variations on the dry weight of rice seedlings (Table 10). The highest weight (39.45 g) was recorded with OM_3F_3 (Poultry manure @ 5 t ha^{-1} with 25% Higher than the recommended dose of N P fertilizer) treatment combination, which was statistically significant with OM_3F_2 and OM_2F_3. On the other hand, the lowest (25.70 g) weight was observed in the treatment combination OM_0F_0 (control).

Table 8. Effect of organic manure on seed quality parameters of rice

Treatments	Germination (%)	Root length (cm)	Shoot length (cm)	Dry weight of seedling (g)
OM_0	80.75 c	7.25 b	11.15 b	31.85 c
OM_1	86.90 bc	8.33 ab	13.66 ab	35.33 bc
OM_2	88.15 b	8.15 ab	13.91 ab	35.90 b
OM_3	91.25 a	9.33 a	14.85 a	37.75 a
LSD (5%)	3.24	2.01	1.44	2.13
CV (%)	6.13	6.08	7.13	7.41

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Least Significance Difference (LSD) test.

OM_0: Without organic manure (control) OM_1: Cowdung @ 10 t ha^{-1}, OM_2: Vermicompost @ 3 t ha^{-1} and OM_3: Poultry manure @ 5 t ha^{-1}]

Table 9. Effect of different levels of N P fertilizer on seed quality parameters of rice

Treatments	Germination (%)	Root length (cm)	Shoot length (cm)	Dry weight of seedling (g)
F_0	79.75 b	7.15 b	11.67 b	31.25 c
F_1	88.70 ab	8.50 ab	13.50 ab	35.50 b
F_2	89.65 ab	8.75 ab	14.05 ab	36.67 ab
F_3	90.35 a	9.05 a	14.90 a	37.10 a
LSD (5%)	2.08	1.30	1.21	1.44
CV (%)	5.32	6.01	7.05	8.50

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Least Significance Difference (LSD) test.

F_0: Without N P fertilizer, F_1: 25% less than recommended dose of N P fertilizer, F_2: Recommended dose of N P fertilizer and F_3: 25% Higher than recommended dose of N P fertilizer]

Table 10. Effect of combined use of organic manure and different level of N P fertilizer on seed quality parameters of rice

Treatments		Germination (%)	Root length (cm)	Shoot length (cm)	Dry weight of seedling (g)
OM_0	F_0	76.50 h	6.23 c	10.40 e	25.70 f
	F_1	83.35 e	7.25 bc	11.90 de	31.75 de
	F_2	84.05 de	7.50 bc	12.33 cd	33.50 d
	F_3	85.33 d	8.06 b	12.81 c	34.40 cd
OM_1	F_0	78.85 g	7.20 bc	11.67 cd	30.67 e
	F_1	88.25 cd	8.45 ab	13.45 cd	35.95 c
	F_2	88.67 cd	8.75 ab	14.20 bc	36.67 bc
	F_3	88.95 cd	8.99 ab	14.50 bc	37.25 bc
OM_2	F_0	80.50 fg	7.33 bc	11.91 d	32.05 de
	F_1	89.83 cd	8.67 ab	13.67 c	35.20 cd
	F_2	90.90 c	8.93 ab	14.53 bc	37.15 bc
	F_3	91.33 bc	9.15 ab	14.65 bc	38.05 ab
OM_3	F_0	80.83 f	7.45 bc	12.50 cd	34.08 cd
	F_1	92.90 b	7.98 bc	14.95 bc	37.67 b
	F_2	95.15 ab	9.05 ab	15.45 b	38.50 ab
	F_3	95.75 a	9.90 a	16.13 a	39.45 a
LSD (5%)		1.95	1.15	1.21	2.03
CV (%)		5.47	5.58	6.92	8.58

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Least Significance Difference (LSD) test.

OM_0: Without organic manure (control) OM_1: Cowdung @ 10 t ha^{-1}, OM_2: Vermicompost @ 3 t ha^{-1} and OM_3: Poultry manure @ 5 t ha^{-1};

F_0: Without N P fertilizer, F_1: 25% less than recommended dose of N P fertilizer, F_2: Recommended dose of N P fertilizer and F_3: 25% Higher than recommended dose of N P fertilizer]

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, during the period from October 2021 to April 2022 to study the effect of nitrogen + phosphorus and organic (vermicompost) management on the growth and yield potential of boro rice. The BRRI dhan-28 was used as the test crop in this experiment. The experiment consists of 2 factor i.e., organic fertilizer and different manure. OM_0: Without organic manure (control) OM_1: Cowdung @ 10 t ha^{-1}, OM_2: Vermicompost @ 3 t ha^{-1} and OM_3: Poultry manure @ 5 t ha^{-1}; F_0: Without N P fertilizer, F_1: 25% less than recommended dose of N P fertilizer, F_2: Recommended dose of N P fertilizer and F_3: 25% Higher than recommended dose of N P fertilizer. The experimental design was RCBD with 3 replications.

The effects of organic manure management practices were evident 30, 50, 70, 90 DAT and at harvest, recorded significantly influenced on plant height. The tallest plant (32.50, 52.30, 75.50, 94.05, and 98.75 cm) was produced in OM_3 (Poultry manure @ 5 t ha^{-1}). The shortest plant height (18.30, 39.67, 63.33, 80.33, and 84.50 cm) was produced under control treatment OM_0. The effects of different N P fertilizer levels were observed at 30, 50, 70, 90 DAT, and at harvest, recorded as significantly influencing plant height. The tallest plant (32.66, 50.95, 78.33, 94.75, and 99.30 cm) was produced in F_3 (25% higher than the recommended dose of N P fertilizer). The shortest plant height (18.33, 37.70, 58.10, 77.66, and 84.03 cm) was produced under control treatment F_0. The tallest plant (34.53, 62.15, 85.15, 101.15, and 105.90 cm) was produced in OM_3F_3 (Poultry manure @ 5 t ha^{-1} with 25% Higher than the recommended dose of N P fertilizer) treatment combination. The shortest plant height (16.28, 30.15, 52.85, 72.33, and 78.60 cm) was produced under control treatment OM_0F_0

The highest number tiller (8.90, 12.33, 13.10, 14.33, and 15.09) was produced in OM_3 (Poultry manure @ 5 t ha^{-1}). The lowest tiller (4.10, 8.75, 9.80, 10.95, and 13.08) was produced under control treatment OM_0. The highest tiller (8.90, 12.30, 14.01, 14.80, and 16.15) was produced in F_3 (25% higher than the recommended dose of N P fertilizer). The lowest tiller (4.73, 8.25, 9.75, 10.50, and 11.20) was produced under control treatment F_0. The highest value of the number of tiller hill^{-1} (9.80, 14.15, 14.75, 15.95, and 16.85) was found with the interaction treatment of OM_3F_3 (Poultry manure @ 5 t ha^{-1} with 25% higher than the recommended dose of N P fertilizer) treatment combination which is statistically similar with OM_3F_2 interaction for all sampling dates except 50 DAT. However, the lowest tiller (3.08, 6.42, 8.85, 9.90, and 10.25) was produced under control treatment OM_0F_0. The use of different organic manure significantly influenced the number of effective tiller hill-1. Between the applied manure, OM_3 (Poultry manure @ 5 t ha^{-1}) showed a higher (12.66) number of effective tiller hill$^{-1,}$ and OM_0 (Without organic manure, Control) treatment showed a lower (9.78) number of effective tiller hill^{-1}. Among the different fertilizer doses, F_3 (25% higher than the recommended N P fertilizer) gave the highest number of effective tiller hill^{-1} (13.66). On the other hand, the lowest (9.95) number of effective tiller hill^{-1} was observed in the F_0 treatment, where that received no fertilizer (control).

The highest (14.70) number of effective tiller hill^{-1} was recorded with OM_3F_3 (Poultry manure @ 5 t ha^{-1} with 25% Higher than the recommended dose of N P fertilizer) treatment combination, which was statistically similar to OM_3F_2 OM_2F_3 and OM_1F_3 On the other hand, the lowest (8.90) number of effective tiller hill^{-1} was observed in the treatment combination OM_0F_0 (control). Panicle length was significantly influenced by the use of organic manure. Between the applied manure, OM_3 (Poultry manure @ 5 t ha^{-1}) showed the highest (21.90 cm) panicle length, and OM_0 (Without organic manure, Control) showed the lowest (17.23 cm) panicle length. Among the different fertilizer doses, F_3 (25% Higher than recommended N P fertilizer) gave highest panicle length (21.83 cm), which was statistically similar to F_2. On the other hand, the lowest (18.15 cm) panicle length was observed in the F_0 treatment, where that received no fertilizer (control). The highest (22.33 cm) panicle length was recorded with OM_3F_3 (Poultry manure @ 5 t ha^{-1} with 25% Higher than the recommended dose of N P fertilizer) treatment combination. On the other hand, the lowest (18.40 cm) panicle length was observed in the treatment combination OM_0F_0 (control).

Number of grain panicle^{-1} was significantly influenced by the use of organic manure. Between the applied manure, OM_3 (Poultry manure @ 5 t ha^{-1}) showed the highest (104.15) grain per panicle, and OM_0 (Without organic manure, Control) showed the lowest (81.20) grain per panicle. Among the different fertilizer doses, F_3 (25% Higher than recommended N P fertilizer) gave the highest grain per panicle (104.75). On the other hand, the lowest (75.05) grain per panicle was observed in F_0 (control) treatment, where that received no fertilizer. The highest (123.67) grain per panicle was recorded with OM_3F_3 (Poultry manure @ 5 t ha^{-1} with 25% Higher than the recommended dose of N P fertilizer) treatment combination. On the other hand, the lowest (68.90) grain per panicle was observed in the treatment combination OM_0F_0 (control).

Among the applied organic manure, OM_3 (Poultry manure @ 5 t ha^{-1}) showed the highest (4.90 tha^{-1}) grain yield, and OM_0 (Without organic manure, Control) treatment showed the lowest (2.75 tha^{-1}) grain yield. It indicates that poultry manure out yielded over control by producing 78.18% higher grain yield. Among the different fertilizer doses, F_3 (Poultry manure @ 5 t ha^{-1} with 25% higher than recommended N P fertilizer) gave the highest grain yield (5.13 tha^{-1}). On the other hand, the lowest (3.14 tha^{-1}) grain yield was observed in the F_0 treatment, where no fertilizer (control) was applied treatment. The highest grain yield (5.83 tha^{-1}) was recorded with OM_3F_3 (Poultry manure @ 5 t ha^{-1} with 25% Higher than the recommended dose of N P fertilizer) treatment combination. On the other hand, the lowest grain yield (2.75 tha^{-1}) was observed in the treatment combination $OM0F_0$ (control).

The result revealed that germination was significantly influenced due to use of organic manure. Between the applied manure, OM_3 (Poultry manure @ 5 t ha^{-1}) showed the highest germination (91.25 %), and OM_0 (Without organic manure, Control) showed the lowest germination (80.75 %) of rice. Among the different fertilizer doses, F_3 (25% Higher than the recommended dose of N P fertilizer) gave the highest germination (90.35 %). On the other hand, the lowest germination (79.75 %) was observed in the F_0 treatment, where that received no fertilizer (control). The highest germination (95.75 %) was recorded with OM_3F_3 (Poultry manure @ 5 t ha^{-1} with 25% Higher than the recommended dose of N P fertilizer) treatment combination, which was statistically significant with the combination of OM_3F_2. On the other hand, the lowest germination (76.50 %) was observed in the treatment combination OM_0F_0 (control).

Among the applied manure, OM_3 (Poultry manure @ 5 t ha^{-1}) showed the highest (37.75 g) weight, and OM_0 (Without organic manure, Control) showed the lowest (31.85 g) weight. Among the different fertilizer doses, F_3 (25% higher than recommended N P fertilizer) gave the highest weight (37.10 g). On the other hand, the lowest (31.25 g) dry weight was observed in the F_0 treatment, where that received no fertilizer (control). The highest weight (39.45 g) was recorded with OM_3F_3 (Poultry manure @ 5 t ha^{-1} with 25% Higher than the recommended dose of N P fertilizer) treatment combination, which was statistically significant with OM_3F_2 and OM_2F_3. On the other hand, the lowest (25.70 g) weight was observed in the treatment combination OM_0F_0 (control).

From the above discussion, it can be concluded that;

- Organic manure applied from poultry manure performed best for the higher yield and best seed quality of BRRI dhan28.
- Among the different nitrogen + phosphorus levels, 25% Higher than recommended N P fertilizer dose gave a higher yield and best seed quality of BRRI dhan28.
- Interaction of Poultry manure @ 5 t ha^{-1} with 25% Higher than the recommended dose of N P fertilizer seems to perform for better yield and best seed quality of BRRI dhan28.

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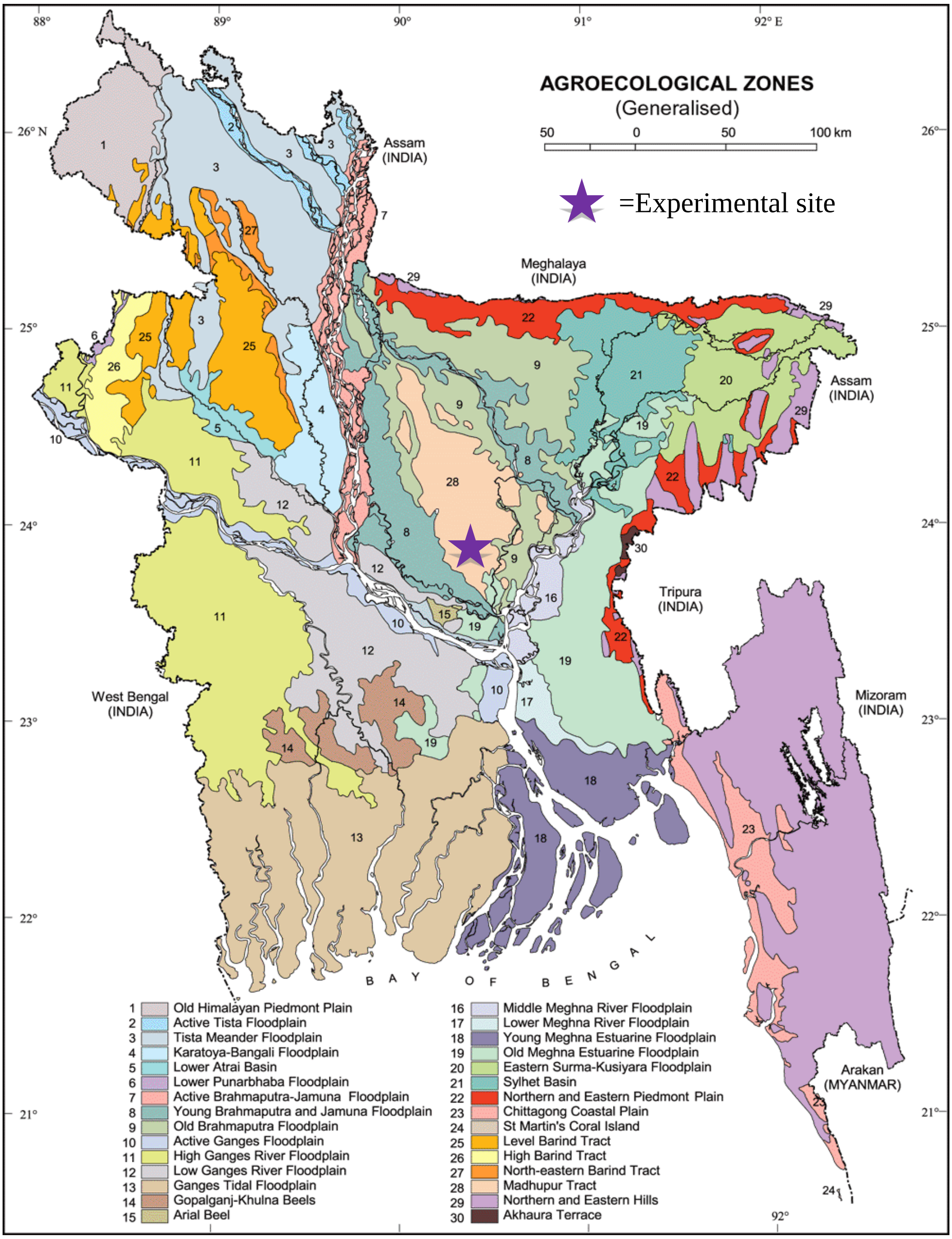
APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II. Characteristics of soil of experimental site.

A. Morphological characteristics of the experimental site

Morphological features	**Characteristics**
Location	Sher-e-Bangla Agricultural University Agronomy research field, Dhaka
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Shallow Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly levelled

B. The initial physical and chemical characteristics of soil of the experimental site (0 - 15 cm depth)

Physical characteristics	
Constituents	Percent
Sand	26
Silt	45
Clay	29
Textural class	Silty clay
Chemical characteristics	
Soil characters	Value
pH	5.9
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.03
Available P (ppm)	20.54
Exchangeable K (me/100 g soil)	0.10

Appendix III. Monthly meteorological information during the period from November, 2021 to April, 2022

Year	Month	Air temperature (^0C)		Relative humidity (%)	Total rainfall (mm)
		Maximum	Minimum		
2021	November	28.10	11.83	58.18	47
	December	25.00	9.46	69.53	00
2022	January	25.20	12.80	69.00	00
	February	27.30	16.90	66.00	39
	March	31.70	19.20	57.00	23
	April	33.50	25.90	64.50	119

Meterological Centre, Agargaon, Dhaka (Climate Division)

Appendix IV. Analysis of variance on plant height (cm) at different DAS

Source of variation	D.F.	Mean square				
		30 DAT	50 DAT	70 DAT	90 DAT	At harvest
Replication	2	3.591	4.348	5.927	3.736	0.789
N P fertilizer(A)	3	69.873**	133.637**	64.247**	105.723**	114.240**
Organic manure (B)	3	35.192**	30.963**	23.911**	1029.541**	1288.293**
A × B	9	26.774**	42.542**	10.770**	21.620**	21.615**
Error	32	3.290	3.024	2.442	2.234	2.417

**: Significant at 0.01 level of significance.

Appendix V. Analysis of variance on tiller hill^{-1} number at different DAS

Source of variation	D.F.	Mean square				
		30 DAT	50 DAT	70 DAT	90 DAT	At harvest
Replication	2	0.020	0.735	0.539	0.003	0.149
N P fertilizer(A)	3	0.098*	1.112*	2.937**	5.298**	8.878**
Organic manure (B)	3	0.091*	3.205*	0.852**	4.808**	5.120**
A × B	9	0.138**	0.991*	0.728**	0.111**	0.219**
Error	32	0.047	1.939	0.116	0.278	0.371

**: Significant at 0.01 level of significance, *: Significant at 0.05 level of significance.

Appendix VI. Analysis of variance on effective tillers hill^{-1}, panicle length and number of grains panicle^{-1} of boro rice

Source of variation	D.F.	Effective tillers hill^{-1} (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)
Replication	2	8.39	3.52	14.41
N P fertilizer(A)	3	1144.621*	928.667**	2559.201**
Organic manure (B)	3	8846.203*	7558.388*	26506.200*
A × B	9	157.734*	145.677*	263.600*
Error	32	9.88	8.92	21.80

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

Appendix VII. Analysis of variance on yield of boro rice

Source of variation	D.F.	1000 grain wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
Replication	2	404.072	19241	40.528	0.14
N P fertilizer(A)	3	841.504**	358484*	111.028**	403.04*
Organic manure (B)	3	20.565*	504235*	50.778**	4467.66*
A × B	9	200.754*	30547*	59.139*	57.27 *
Error	32	124.47	78792	110.04	1.49

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

Appendix VIII. Analysis of variance on seed quality of boro rice

Source of variation	D.F.	Germination (%)	Root length (cm)	Shoot length (cm)	Dry weight of seedling (g)
Replication	2	0.644	0.313	0.00335	0.148
N P fertilizer(A)	3	3.070*	8.917**	5.298**	8.878**
Organic manure (B)	3	0.267*	0.598*	4.808**	5.120**
A × B	9	0.263*	0.428*	0.111*	0.219*
Error	32	0.22	0.30	0.28	0.37

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