EFFECT OF ORGANIC AND INORGANIC FERTILIZER APPLICATION ON RICE PRODUCTION (BRRI dhan29)

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CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF ORGANIC AND INORGANIC FERTILIZER APPLICATION ON RICE PRODUCTION (BRRI dhan29)"** submitted to the Department of Soil Science, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTERS OF SCIENCE (M.S.)** in **SOIL SCIENCE**, embodies the result of a piece of bonafide research work carried out by **JAHID HASAN**, Registration No. 19-10321 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

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Dedicated to
My
Beloved Parents

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EFFECT OF ORGANIC AND INORGANIC FERTILIZER APPLICATION ON RICE PRODUCTION (BRRI dhan29)

ABSTRACT

The experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from December 2020 to May 2021 to examine the effect of organic and inorganic fertilizer application on rice production (BRRI dhan29). The experiment consisted of eight treatments *viz*. T_0 (control; no nutrient application), T_1 (100% RDCF: $N_{120}P_{20}K_{40}S_{20}Zn_{2.5}$ kg ha^{-1}), T_2 (100% cowdung - 10 t ha^{-1}), T_3 (100% poultry manure - 5 t ha^{-1}), T_4 (50% RDCF + 50% cowdung), T_5 (50% RDCF + 50% poultry manure), T_6 (25% RDCF + 75% cowdung) and T_7 (25% RDCF + 75% poultry manure). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Results showed that a significant variation among the treatments was found while different nutrient levels (organic and inorganic) applied in different combinations. The treatment T_1 (100% RDCF: $N_{120}P_{20}K_{40}S_{20}Zn_{2.5}$ kg ha^{-1}) exhibited the highest plant height at 60, 90 DAT and at harvest (83.73, 95.87 and 94.37 cm, respectively) while the treatment T_4 (50% RDCF + 50% cowdung) showed the highest number of tillers hill^{-1} (13.13, 15.33 and 17.73, respectively) whereas control treatment T_0 (no nutrient application) showed the minimum results. Again, the treatment T_4 (50% RDCF + 50% cowdung) showed the highest number of effective tillers hill^{-1} (16.33), flag leaf length (24.28 cm), number of filled grains panicle^{-1} (165.40), panicle length (25.94 cm), 1000 seed weight (21.90 g), grain yield (7.66 t ha^{-1}), straw yield (8.96 t ha^{-1}) and harvest index (46.09%) followed by T_5 (50% RDCF + 50% poultry manure) and T_7 (25% RDCF + 75% poultry manure) whereas the control treatment T_0 (no nutrient application) performed the lowest results on the respected parameters. In case of post harvest soil, different treatments of organic and inorganic fertilizers combinations showed non-significant variation on particle density, pH and organic carbon content but available P and S of post harvest soil affected significantly. The treatment T_4 (50% RDCF + 50% cowdung) showed highest P (23.42 ppm) and S (27.40 ppm) content of post harvest soil whereas the lowest P and S content was obtained from control treatment T_0 (no nutrient application). So, the treatment T_4 (50% RDCF + 50% cowdung) can be considered as very promising treatment for rice production (BRRI dhan29) to obtain higher grain yield.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
CFRR	=	Chemical Fertilizer Recommended Rate
CM	=	Chicken Manure
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DMRT	=	Duncan's Multiple Range Test
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram (s)
i.e.	=	id est (L), that is
Kg	=	Kilogram (s)
LSD	=	Least Significant Difference
m^2	=	Meter squares
ml	=	MiliLitre
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^oC	=	Degree Celceous
%	=	Percentage
NaOH	=	Sodium hydroxide
GM	=	Geometric mean
mg	=	Miligram
P	=	Phosphorus
K	=	Potassium
Ca	=	Calcium
L	=	Litre
RDCF	=	Recommended Doses of Chemical Fertilizers
µg	=	Microgram
USA	=	United States of America
WHO	=	World Health Organization

CHAPTER I

INTRODUCTION

Rice is one of the most important staple cereal foods in human nutrition and a major food grain for about 75% of the world's population (Chaudhary and Tran 2001). Rice is an excellent source of carbohydrates providing up to 50-60% of the daily calories ingested by more than 2.5 billion people across the world (Belder *et al*. 2004; Metwally *et al*. 2011). It is also a main source of zinc intake, providing up to 49% and 69% of dietary zinc for children and women, respectively (Arsenault *et al*. 2010). Rice accounts for 21% of global calorific consumption and 76% of total calorific intake in the South-East Asian area (Fitzgerald *et al*., 2009). Rice grain has influenced the culture and economy of billions of people worldwide (Farooq *et al.*, 2009).

Rice plays absolutely dominant role in Bangladesh agriculture as it covers 77.96% of total cropped area (AIS, 2017). Among the three types of rice, boro rice covers about 54.56% of total rice area, which contributes 41.94% of the total rice production in the country (BBS, 2016). Rice is intensively cultivated in Bangladesh covering about 80% of arable land.

Bangladesh ranks 4^{th} in both area and production and 6^{th} in per hectare production of rice (Sarkar *et al*., 2016). Rice occupied an area of 28,213 thousand acres in 2018-2019, with a yield of 36,603 thousand metric tons (BBS, 2020). According to BBS (2020) *aus, aman* and *boro* produced 2756, 14204 and 19646 metric tons of rice from 2706, 13740 and 11767 thousand acres of land, respectively. Among three growing seasons *Boro* rice occupies the highest area coverage (45% of gross cropping area).

Bangladesh's average rice output is roughly 3.21 t ha^{-1} (BBS, 2020), which is quite low when compared to other rice-growing nations such as China (7.056 t ha^{-1}), Japan (6.82 t ha^{-1}) and Korea (6.87 t ha^{-1}) (FAO, 2021). It is urgently needed to increase average rice production in Bangladesh to feed the large population of this country. Annual food grain deficit could be minimized either by bringing more area under cultivation or by increasing the yield per unit area. Soil fertility deterioration has become a major constraint to higher crop production in Bangladesh (Azim, *et al*., 1999; Haque *et al*., 2001; Farid *et al*., 2011). The increasing land use intensity without adequate and balance use of chemical fertilizers and with little or no use of organic manures have caused severe fertility deterioration of our soils resulting in stagnating or even declining of crop productivity (Farid *et al*., 2011).

The use of inorganic fertilizer in rice cultivation has been progressively increasing since its introduction. However, available reports indicate that the repeated use of chemical fertilizer alone fails to sustain desired yield, impairs soil physical condition and exhausts organic matter content (Mohammad, 2010) leads to environmental degradation and soil health especially due to their continuous use. Application of excess inorganic fertilizer leads to higher pest and disease attacks and also destroys the soil microorganisms. Hence, sustainable farming looks for making the best use of natural resources without damaging the environment and indigenous agricultural knowledge is a vital part of the process of making agriculture sustainable (Ramprasad *et al*., 2009).

In Bangladesh, most of the cultivated soils have less than 1.5% organic matter, where as good agricultural soil should contain of least 2% organic matter. Miah *et al*., 2006; Nambiar (1991) reviewed that integrated use of organic manure and chemical NPK fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining higher soil fertility status. Organic matter takes an important role in maintaining soil fertility and productivity (Islam, 2002; Rahman and Parkinson, 2007). The problem of nutrient deficiencies as well as nutrient mining caused by intensive cropping with HYV of rice and nutrient imbalance can be minimized by judicious application of nutrients through organic manures (Sohel *et al*., 2016). Losses of soil organic matter can only be replenished in the short term by application of organic matter such as manures (Mahajan *et al*., 2008). Cow dung and poultry manure are the most popular and promising bulky organic manures produced from liquid excreta of farm animals, which contain considerable amounts of essential nutrient elements required for plant growth. These are one kind of store house of nutrients of plants. Hence an improvement and addition of a good amount of cowdung and poultry manure to the crop field is essential for fertility and productivity and maintenance of this soil (Singh *et al*., 1999).

Application of organic fertilizer with chemical fertilizer stimulates microbial activity, promotes efficiency in the use of nutrients (Moharana *et al*. 2012) and increases accessibility of the surrounding nutrients, resulting in adequate nutrient uptake by plants. Therefore, in order to increase the soil productivity by supplying all the plant nutrients in readily available form and to maintain good soil health, it is necessary to use organic fertilizer in combination with inorganic fertilizers to obtain optimum yields (Rama *et al*. 2012). Organic fertilizers such as cow dung, poultry manure, organic waste, crop residues and compost will not only increase grain yields but also increase the efficiency of applied nutrients due to their favourable effect on the physical, chemical and biological properties of soil (Hussainy 2019). However, extensive application of nitrogen fertilizer, whether in the form of organic matter or chemicals, can negatively affect the soil because excess nitrogen is converted to nitrates which are detrimental to the soil and human health (Mukherjee 2013).

Keeping these above fact in mind, the present study was designed to study the comparative effectiveness of organic and inorganic fertilizer application on rice production (BRRI dhan29) with the following objectives:

1. To find out the effectiveness of combined application of organic manure and inorganic fertilizer on rice production
2. To create the value of organic manure as a substitute of chemical fertilizer

CHAPTER II

REVIEW OF LITERATURE

Rice is staple food crop in Bangladesh which can be considered as the main driving force in the national economy. Investigations on the comparative effectiveness of organic and inorganic fertilizer application on rice production (BRRI dhan29) have been progressed in many countries of the world. The proper agronomic practices accelerate its growth and influenced its yield. Therefore, available findings of the effect of organic and inorganic fertilizer application on rice production relevant to the present study have been briefly reviewed under the following heads.

2.1 Effect of organic and inorganic fertilizer application on rice production

Alam *et al.* (2021) carried out a study to evaluate the efficacy of different organic and inorganic fertilizers on the growth and yield of boro rice (BRRI dhan29). The experiment had eight treatments with three replications as follows; T_0 : Control, T_1 : 100% $N_{75}P_{12}K_{45}S_9$ kg/ha (Recommended dose), T_2 : 50% NPKS + 6 t cowdung ha^{-1}, T_3 : 75% NPKS + 3 t cowdung ha^{-1}, T_4 : 50% NPKS + 6 t poultry manure ha^{-1}, T_5 : 75% NPKS + 3 t poultry manure ha^{-1}, T_6 : 50% NPKS + 6 t vermicompost ha^{-1} and T_7 : 75% NPKS + 3 t vermicompost ha^{-1}. At harvest stage, the tallest plant (94.37 cm) and the highest number of total tiller per hill (22.10) was recorded from T_4. The longest panicle (26.48 cm), maximum number of total grain per plant (178.3), the highest weight of 1000 seeds (21.96 g), the maximum grain yield (10.33 t ha^{-1}) and straw yield (15.67 t ha^{-1}) was also recorded in T_4 treatment. Although the highest biological yield was recorded from T_4 treatment but statistically similar result was found from T_5 treatment. The findings of the study showed that the performance of the treatment T_4 was the best among all treatments in terms of growth and yields. So, the recommendation of this study is amendment of soil with 50% NPKS + 6 t poultry manure ha^{-1} might be an efficient practice for achieving sustainable higher boro rice (BRRI dhan29) production.

Anisuzzaman *et al*. (2021) conducted a pot experiment aimed to test the effect of organic and inorganic fertilizers on the growth and yield components of 65 rice genotypes during the period of February to June 2019 and August to December 2019 in a randomized complete block design (RCBD) with three replications. There were three treatment combinations *viz*. T_1 : 5 t ha^{-1} chicken manure (CM), T_2 : 2.5 t ha^{-1} CM + 50% CFRR, T_3 : 100% (150 N: 60 P_2O_5 : 60 K_2O kg ha^{-1}) and chemical fertilizer recommended rate (CFRR). Grain and straw samples were collected for chemical analysis, and physical parameters were measured at the harvest stage. Results showed that most of the growth and yield components were significantly influenced due to the application of organic manure with chemical fertilizer. The application of chemical fertilizer alone or in combination with organic manure resulted in a significant increase in growth, yield component traits, and nutrient content (N, P and K) of all rice genotypes. Treatment of 2.5 t ha^{-1} CM + 50% CFRR as well as 100% CFRR showed a better performance than the other treatments. It was observed that the yield of rice genotypes can be increased substantially with the judicious application of organic manure with chemical fertilizer. The benefits of the mixed fertilization (organic + inorganic) were not only the crop yields but also the promotion of soil health, the reduction of chemical fertilizer input, etc.

Sunarpi *et al*. (2021) carried out a study to determine the effect of a combination of organic and inorganic fertilizers on the growth and yield of rice. The three treatments used in this study were P_0N_0 with no organic and inorganic fertilizers; P_0N_{100} with a dose of 100% inorganic fertilizer and $P_{50}N_{50}$ with a dose of 50% organic fertilizer and 50% inorganic fertilizer. The results showed that the combination of organic fertilizers (50%) and inorganic fertilizers (50%) can increase the growth and yield of rice in the screen house compared to control plants and plants which given only 100% inorganic fertilizers. In summary, the combination of organic and inorganic fertilizers can reduce the use of inorganic fertilizers.

Chakraborty *et al*. (2020) conducted an experiment during the boro season of December 2016 to May 2017 to evaluate the effect of integrated nutrient management on two boro rice cultivars. The varieties were BRRI dhan28 and BRRI dhan29 and eight kinds of nutrient management viz., control (no fertilizers), recommended dose of inorganic fertilizers (120-60-40 N, P_2O_5, K_2O kg ha^{-1} + gypsum 60 kg ha^{-1} and $ZnSO_4$ @ 10 kg ha^{-1}), full dose of poultry manure @ 5 t ha^{-1}, cowdung @ 10 t ha^{-1}, poultry manure @ 2.5 t ha^{-1} + 50% prilled urea and full dose of other inorganic fertilizers, cowdung @ 5 t ha^{-1} + 50% prilled urea and full dose of inorganic fertilizers, poultry manure @ 2.5 t ha^{-1} + 75% prilled urea and full dose of inorganic fertilizers, and cowdung @ 5 t ha^{-1} + 75% prilled urea and full dose of other inorganic fertilizers. The experiment was laid out in a split plot design with three replications. Result showed that, yield and yield components of boro rice were significantly influenced by variety, nutrient management and interaction of variety and nutrient management. In respect of grain yield, BRRI dhan29 produced the maximum yield (5.46 t ha^{-1}). BRRI dhan28 showed poor performance with all characters and gave the minimum yield (4.07 t ha^{-1}). In case of nutrient managements, the highest yield and yield component were obtained from poultry manure @ 2.5 t ha^{-1} + 50% prilled urea and full dose of inorganic fertilizers and produced the maximum grain yield (5.70 t ha^{-1}). In the interaction of variety and integrated nutrient management, the highest grain yield (6.83 t ha^{-1}) and straw yield (7.61 t ha^{-1}) was obtained from poultry manure @ 2.5 t ha^{-1} + 50% prilled urea and full dose of inorganic fertilizers with BRRI dhan29 variety. So, BRRI dhan29 with 2.5 t ha^{-1} poultry manure + 50% prilled urea and full dose of the recommended inorganic fertilizers might be a promising practice for boro rice cultivation.

Kakar *et al*. (2020) carried out a research to elucidate the efficacy of different fertilizers' application on growth attributes, yield potential, and grain quality of rice. The treatments included the traditional application rate of nitrogen and phosphorus (RD), animal manure (AM), animal manure with 50% nitrogen and phosphorus of the traditional application rate (AMRD), sawdust (SD), and sawdust with 50% nitrogen and phosphorus of the traditional application rate (SDRD). Growth parameters, grain yield and its components, physicochemical properties, and morphological observation using scanning electron microscopy were recorded. The results revealed that the greatest panicle number, spikelet number, and grain yield were recorded in AMRD and SDRD treatments.

Abdul-Rahman (2019) conducted a pot experiment to evaluate the effect of compost as an organic fertilizer and NPK as an inorganic fertilizer on the growth of rice varieties. The experiment was laid out in a 3 × 4 factorial design with the levels of fertilizers at the full rate of inorganic fertilizer (NPK 90 60 60 kg/ha), compost 12 t/ha, ½ (compost 12 t/ha) + ½ (inorganic fertilizer) and control. The three rice varieties were APO, IR 55419 and UPL R17. The full rate of inorganic fertilizer NPK 90 60 60 kg/ha, respectively was used as a check for comparison. Results recorded at 7 and 9 weeks after planting showed that varieties and fertilizer levels had a positive influence on plant height. The leaf chlorophyll at 9 weeks after planting also responded positively to fertilizer level and varieties, whereas root length was influenced only by varieties. Plant dry biomass did not respond to the fertilizer treatments. A significant difference was obtained between the control, inorganic and organic fertilizers as well as between the APO and IR 55419 varieties. It can be concluded from the findings that use of a quality rice variety and the application of compost, sole or as a complement to chemical fertilizer, has the potential of producing a high yield compared to a full rate of inorganic fertilizer.

Yadav *et al*. (2019) reviewed that nutrient supply is the most limiting factor next to the water for crop production. From a study, the author reported that the treatment 75% RDF + 25%FYM increased the net photosynthesis rate, total biomass, grain yield, and amylose content by 23%, 90%, 95%, and 10%, respectively, compared with control. This increment in growth was the result of 14%, 19%, and 20% higher total root length, root surface area, root volume, and root diameter, respectively. Improvements in these attributes further enhanced the grain yield and nitrogen use efficiency of rice.

Moe *et al*. (2019) investigated the effects of integrated organic and inorganic fertilizers on the growth and yield of indica rice variety Manawthukha and japonica rice variety Genkitsukushi. In a split-plot design, the two rice varieties were assigned as main plot factors, and the integrated treatments were the subplot factors, including no-N fertilizer (N_0), 50% chemical fertilizer (CF) (CF_{50}), 100% CF (CF_{100}), 50% CF + 50% poultry manure (PM) ($CF_{50}PM_{50}$), 50% CF + 50% cow manure (CM) ($CF_{50}CM_{50}$), and 50% CF + 50% compost (CP) ($CF_{50}CP_{50}$). CF_{100} was equivalent to N at 85 kg/hm^2. Manure was applied based on the estimated mineralizable nitrogen (EMN) level, which is dependent on total N (%) of each manure type. Manawthukha rice plants were taller with higher tiller number and dry matter content. However, higher soil-plant analysis development (SPAD) values were measured in Genkitsukushi throughout the crop growth period, resulting in higher seed-setting rate (%) and greater yield. At the same N level, $CF_{50}PM_{50}$ application in both rice varieties resulted in higher SPAD values, plant height and tiller number than CF_{100}. $CF_{50}PM_{50}$ containing total N more than 4% supplied synchronized N for the demands of the rice plants, resulting in maximum dry matter, yield and yield components. $CF_{50}CM_{50}$ and $CF_{50}CP_{50}$ treatments containing total N less than 4% resulted in lower yields which were similar to CF_{100}. These results indicated that integrating organic and inorganic fertilizers enhanced growth parameters and yields of Manawthukha and Genkitsukushi, while reducing the dose of chemical fertilizer.

Singh *et al*. (2018) conducted an investigation entitled “effect of integrated nutrient management on growth and yield of rice (*Oryza sativa* L.)” to evaluate the impact of continuous use of inorganic fertilizers and organic nutrients on productivity, economics and soil fertility status. Growth attributes such as plant height (96.8 cm), number of tiller m^{-2} (332), LAI (4.22) and dry matter accumulation (1285.7 gm^{-2}) were found highest with the treatment T_5 (50% RDF + 50% N through FYM) but remained at par with all the treatment where either 25 or 50% N was substituted through organic sources (T_6 to T_{10}). The differences in growth attributes were statistically alike between 100% RDF and treatments supplimented either 25 or 50% N through organic sources (T_6 to T_{10}). Maximum number of days taken to 50% flowering (98.7 days) and maturity (136.5 days) were recorded with T_5 (50 % RDF+50% N as FYM) but remained at par with all the treatment where either 25 or 50% N was substituted through organic sources (T_6 to T_{10}) and also with 100% inorganic source only.

Moe *et al*. (2017) conducted two field experiments to investigate combined effects of organic and inorganic fertilizers on nitrogen use and recovery efficiencies of hybrid rice (Palethwe-1) during dry and wet seasons, 2015. Four levels of inorganic fertilizer (0%, 50%, 75%, and 100% NPK), based on recommended rates of 150 kg N ha^{-1}, 70 kg P_2O_5 ha^{-1}, and 120 kg K_2O ha^{-1}, were used with cow manure, poultry manure, and vermicompost (5 t ha^{-1} each) in a split-plot design with three replicates. In both seasons, with 50% NPK, the N uptake level achieved with poultry manure was similar to that obtained with 75% and 100% NPK. The greatest N use, internal, agronomic N use, and recovery efficiencies were obtained with 50% NPK + poultry manure, but were similar to those obtained from cow manure and vermicompost subplots. As the amount of applied N from organic and inorganic fertilizer increased, the N use efficiency and related parameters decreased, due to similar yields among plots with different NPK application levels. Poultry manure resulted in the highest significant correlations between applied N and N accumulation, followed by cow manure and vermicompost, in both seasons. Neither chemical fertilizer nor organic manure alone led to optimum N use and N recovery efficiencies. The combination of 50% inorganic fertilizer (75 kg N ha^{-1}) and poultry manure (5 t ha^{-1}) enhanced the N uptake, the N use and recovery efficiencies of hybrid rice. Cow manure (5 t· ha^{-1}) in combination with 75% inorganic fertilizer (112.5 kg N ha^{-1}) was an adequate substitute for reduced chemical fertilizer usage. Therefore, this study highlighted combined application of inorganic fertilizers and organic manures had the benefits not only in reducing the need for chemical fertilizers but also in improving N uptake by hybrid rice (Palethwe-1) leading to the better environment.

Islam *et al*. (2016) conducted a field experiment in combination with chemical fertilizers and manure. The treatments were T_0 (control), T_1 ($N_{100}P_{15}K_{45}S_{20}$ (Recommended dose), T_2 (50% NPKS+5 t ha^{-1} CD), T_3 (70% NPKS+3 t ha^{-1} CD), T_4(50% NPKS+4t ha^{-1} PM), T_5 (70% NPKS+2.4 t ha^{-1} PM), T_6 (50% NPKS+10 t ha^{-1} DH) and T_7 (70% NPKS+6 t ha^{-1} DH). The result demonstrated that the grain and straw yields were significantly influenced by the added fertilizers and manure. Application of 50% of NPKS fertilizers plus 10 t ha^{-1} dhaincha produced maximum grain yield (5085 kg ha^{-1}) which was identical to that obtained with 70% of NPKS with 6 t ha^{-1} dhaincha. In case of straw yield, the treatment T_7 (70% NPKS+6 t ha^{-1} DH) produced the highest yield (5470 kg ha^{-1}) and then (5250 kg ha^{-1}) yield obtained from T_6 (50% NPKS+10 t ha^{-1} DH) treatment. The grain yield increases over control ranges between 115 to 176%. The overall findings of this study indicate that the integrated use of fertilizer and manure should be encouraged to address the deteriorating soil fertility and increased crop yield.

Biswas *et al*. (2016) conducted an experiment during the period from December 2013 to May 2014 to evaluate the integrated use of poultry manure with prilled urea and USG for improving the growth, yield and protein content of aromatic Boro rice (cv. BRRI dhan50). The experiment comprised 14 treatments *viz*. control (no manure and no fertilizer), recommended dose of prilled urea (115 kg N ha^{-1}), urea super granules (USG) 1.8 g (55 kg N ha^{-1}), USG 2.7 g (80 kg N ha^{-1}), poultry manure (PM) 2.5 t ha^{-1}, PM 5 t ha^{-1}, recommended dose of prilled urea + PM 2.5 t ha^{-1}, recommended dose of prilled urea + PM 5 t ha^{-1}, 50% of recommended dose of prilled urea + PM 2.5 t ha^{-1}, 50% of recommended dose of prilled urea + PM 5 t ha^{-1}, USG 1.8 g + PM 2.5 t ha^{-1}, USG 1.8 g + PM 5 t ha^{-1}, USG 2.7 g + PM 2.5 t ha^{-1} and USG 2.7 g + PM 5 t ha^{-1}. The experiment was laid out in a randomized complete block design with three replications. Morphological characteristics, yield contributing characters and yield of aromatic Boro rice (cv. BRRI dhan50) were significantly influenced by integrated use of poultry manure with prilled urea and USG. USG 2.7 g + PM 5 t ha^{-1} gave the highest plant height, number of tillers hill^{-1} and total dry matter production at all sampling dates while their corresponding lowest values were recorded in control. The highest yield contributing characters viz. number of effective tillers hill^{-1} (13.08), grains panicle^{-1} (124.26g) and 1000- grain weight (21.41g) were recorded in USG 2.7 g + PM 5 t ha^{-1} and the lowest values were recorded in control. The highest grain yield (5.33 t ha^{-1}) and protein content (7.49%) were obtained at USG 2.7 g + PM 5 t ha^{-1} which was as good as recommended dose of prilled urea (115 kg N ha^{-1}) + PM 5 t ha^{-1}, USG 2.7 g + PM 2.5 t ha^{-1}, USG 1.8 g + PM 5 t ha^{-1}, recommended dose of prilled urea (115 kg N ha^{-1}) + PM 2.5 t ha^{-1} while the lowest one (2.00 t ha^{-1}) was obtained in control plots. The integrated use of poultry manure (5 t ha^{-1}) with USG 1.8 g (55 kg N ha^{-1}) appeared as the promising practice because of reducing considerable amount of prilled urea or USG in aromatic Boro rice (cv. BRRI dhan50) cultivation in terms of grain yield and grain protein content.

Mahmud *et al*. (2016) carried out an experiment to study the effect of vermicompost and chemical fertilizers on the growth and yield components in rice (BRRI dhan29) and reported that combination of organic and inorganic sources of nutrients is necessary for sustainable agriculture that can ensure food production with high quality. The treatments of vermicompost were given in 4 levels (0.0, 1.0, 2.0 and 4.0 t ha^{-1}) and 4 levels of chemical fertilizers (0-0-0-0, 50-8-33-6, 100-16-66-12 and 150-24-99-18 kg N, P, K and S ha^{-1}, respectively). Different levels of vermicompost and NPKS fertilizers showed significant effect on growth, yield and yield contributing characters of BRRI dhan29. Results showed that application of medium level of chemical fertilizer with 4 t ha^{-1} vermicompost gave the maximum yield. It was observed that over dose of NPKS fertilizers from chemical source decreased rice yield. Results also revealed that the highest plant height, effective tillers hill^{-1}, flag leaf length, panicle length, filled grains panicle^{-1}, 1000-grain weight, grain yield, straw yield and biological yield were obtained from the combination of 4 t ha^{-1} vermicompost with 100 kg ha^{-1} N, 16 kg ha^{-1} P, 66 kg ha^{-1} K, 12 kg ha^{-1} S. It was observed that yield of rice can be increased substantially with the judicious application of organic fertilizer with chemical fertilizer.

Puli *et al*. (2016) conducted an experiment to study the effect of organic and inorganic sources of nutrients on rice crop for two consecutive years (2011-2012 and 2012-2013). The experiment was laid out in a randomized block design in wet season with four treatments and five replications. The treatments consisted of M_1 (recommended dose of fertilizers (RDF) - Control), M_2 (10 t farmyard yard manure (FYM) ha^{-1} + RDF), M_3 (1.5 t vermicompost ha^{-1} + RDF), M_4 (Green manuring + RDF). Data collected on biometric observations (plant height, number of tillers, dry matter accumulation) and yield. The yield of crop was significantly increased with the application of 100% NPK in combination with FYM @10t ha^{-1}. However, it was at par with green manuring along with the application of 100% RDF (NPK).Thus, green manure in situ with Dhaincha may be used as an alternative organic source of nutrients to the FYM.

Sohel *et al*. (2016) conducted a field experiment to evaluate the integrated effect of cow dung, poultry manure and water hyacinth with chemical fertilizers on the growth and yield of Boro rice (cv. BRRI dhan29). The effect of different levels of organic fertilizers in combination with recommended doses of inorganic fertilizers were tested over growth parameters and yield of rice. Among the yield contributing characters studied plant height, effective tillers hill^{-1}, panicle length and filled grains panicle^{-1} were varied significantly by the different treatments. Most of the yield contributing characters influenced positively in treatment having quarter doses of cow dung, poultry manure and water hyacinth over recommended dose. The highest grain yield (5.58 t/ha) and straw yield (7.28 t/ha) were observed in that same treatment T_6 (1/3 Cow dung + 1/3 Poultry Manure + 1/3 water hyacinth + Fertilizers) over other treatments. Thus, the application of cow dung, poultry manure and water hyacinth with chemical fertilizers had significant and positive effect on N, P, K and S contents of rice.

Redda and Abay (2015) reported that organic manure such as farmyard manure improves the physicochemical conditions of soils due to its residual effect in the soil's fertility status. Integrated Nutrient Management (INM) which implies combined application of organic and inorganic fertilizers and helps to overcome the problems associated with single application of either source for enhanced crop productivity. Based on this fact, an experiment was conducted to evaluate the effect of integrated application of inorganic fertilizers and FYM on yield and yield components of upland rice. A 4×3 factorial experiment consisting of four levels of inorganic fertilizers (0, 25, 50 and 75 kg/ha) and three levels of FYM (0, 6 and 9 t/ha) was laid out in RCB Design with three replications. Rice (variety: NERICA-3) was used as an indicator crop and planted in rows. The results revealed that application of 9 t/ha FYM with 75 kg/ha of IF (inorganic fertilizer) resulted in grain yield of 44.4 q/ha and delayed flowering and maturity by about 14.67 days and 20.33 days respectively.

Sarker *et al*. (2015) conducted an experiment during the period from August to December 2012 to study the effect of various combinations of organic manure and inorganic fertilizer on the growth, yield, chlorophyll and nutrient content of rice var. BRRI dhan33. The treatment consists of T_1: 100% Inorganic fertilizer (Recommended dose) + 5 ton poultry manure (PM)/ha , T_2: 75 % N of recommended dose + 5 ton PM/ha, T_3: 50 % N of recommended dose + 5 ton PM/ha, T_4: 25 % N of recommended dose + 5 ton PM/ha, T_5: 75 % S of recommended dose + 5 ton PM/ha, T_6: 50 % S of recommended dose + 5 ton PM/ha, T_7: 25 % S of recommended dose + 5 ton PM/ha, T_8: 100% Inorganic fertilizer and T_9: 5 ton PM/ha. Significant variation was found in growth and yield parameters as well as in chlorophyll content and nutrient content of aman rice. The most of the growth parameters (plant height, leaf length and diameter, leaf number and total tiller plant^{-1}) results were found better in 100% Inorganic fertilizer + 5 ton PM ha^{-1} which was statistically similar with 75 % of recommended dose of S + 5 ton PM ha^{-1}, 75 % of recommended dose of N + 5 ton PM ha^{-1} and followed by 50 % of recommended dose of S + 5 ton PM ha^{-1}, respectively while the lowest from 5 ton/ha PM treatment. Number of effective tillers plant^{-1}, panicle length, number of rachis plant^{-1}, filled grain plant^{-1} and fresh weight of plant were highest in 100% Inorganic fertilizer + 5 ton PM/ha and it was either statistically similar or closely followed by 75 % of recommended dose of S + 5 ton PM ha^{-1}. Higher grain yield (4.18 t ha^{-1}) was recorded in T_1 which was statistically similar with T_5 (4.13 t ha^{-1}) whereas lowest grain yield (3.67 t ha^{-1}) was from sole PM. Similarly, N content in grain and N, K content in straw were also showed similar trend. S content in grain and P, S content in straw were higher in 75 % of recommended dose of S + 5 ton PM/ha compared to other fertilizer treatments. Lowest N and S content in grain and N, P, K, S content in straw were found from the treatment using poultry manure only.

Arif *et al*. (2014) conducted an experiment to evaluate the integrated use of organic and inorganic manures on the yield of rice (BRRI dhan28). The organic sources used were farmyard manure, poultry manure, rice straw, sesbania, compost and mungbean residues alone and in combinations with 50% of recommended dose of fertilizer (RDF). Recommended dose of fertilizer (150-90-60 kg NPK/ha) and control treatments were also included in the experiment. The results showed that organic and inorganic manures in combination increased the plant height, fertile tillers per hill, number of grains per panicle, panicle length, number of panicles per hill, 1000-grain weight, biological yield, grain yield and harvest index. Maximum number of fertile tillers per plant (16.79), number of panicles per hill (8.41), 1000- grain weight (21.12 g), biological yield (10.19 t/ha), grain yield (4.47 t/ha) and harvest index (43.76%) were recorded from the plots receiving poultry manure @ 10 t/ha in combination with 50% of RDF. This was followed by 100% RDF. It is evident that yield of rice can be increase significantly with the combined use of organic manure with chemical fertilizers.

Sarkar *et al*. (2014) conducted an experiment to study the yield and quality of aromatic fine rice as affected by variety and nutrient management during the period from June to December 2013. The experiment comprised three aromatic fine rice varieties *viz*. BRRI dhan34, BRRI dhan37 and BRRI dhan38, and eight nutrient managements *viz*. control (no manures and fertilizers), recommended dose of inorganic fertilizers, cowdung at 10 t ha^{-1}, poultry manure at 5 t ha^{-1}, 50% of recommended dose of inorganic fertilizers + 50% cowdung, 50% of recommended dose of inorganic fertilizers + 50% poultry manure, 75% of recommended dose of inorganic fertilizers + 50% cowdung and 75% of recommended dose of inorganic fertilizers + 50% poultry manure. The experiment was laid out in a randomized complete block design with three replications. The tallest plant (142.7 cm), the highest number of effective tillers $hill^{-1}$ (10.02), number of grains $panicle^{-1}$ (152.3), panicle length (22.71cm), 1000-grain weight (15.55g) and grain yield (3.71 t ha^{-1}) were recorded in BRRI dhan34. The highest grain protein content (8.17%) was found in BRRI dhan34 whereas the highest aroma was found in BRRI dhan37 and BRRI dhan38. The highest number of effective tillers $hill^{-1}$ (11.59), number of grains $panicle^{-1}$ (157.6), panicle length (24.31 cm) and grain yield (3.97 t ha^{-1}) were recorded in the nutrient management of 75% recommended dose of inorganic fertilizers + 50% cowdung (5 t ha^{-1}). The treatment control (no manures and fertilizers) gave the lowest values for these parameters. The highest grain yield (4.18 t ha^{-1}) was found in BRRI dhan34 combined with 75% recommended dose of inorganic fertilizers + 50% cowdung, which was statistically identical to BRRI dhan34 combined with 75% of recommended dose of inorganic fertilizers + 50% poultry manure and the lowest grain yield (2.7 t ha^{-1}) was found in BRRI dhan37 in control (no manures and fertilizers). The highest grain protein content (10.9 %) was obtained in the interaction of BRRI dhan34 with recommended dose of inorganic fertilizers which was as good as that of BRRI dhan38 and 75% of recommended dose of inorganic fertilizers + 50% poultry manure. The highest aroma was found in BRRI dhan38 combined with 75% recommended dose of inorganic fertilizers + 50% cowdung.

Islam *et al*. (2013) conducted an experiment to study the effect of fertilizer and manure with different water management on the growth, yield and nutrient concentration of BRRI dhan28. The experiment consisted of 2 factors i.e. irrigation and fertilizer plus manure. There were 2 irrigation levels (I_0= Alternate wetting and drying, I_1= Continuous flooding) and 8 fertilizer treatment (T_0: control, T_1: 100% RDCF, ($N_{100}P_{15}K_{45}S_{20}Zn_2$ kg/ha), T_2: 10 ton cowdung/ha, T_3: 50% RDCF + 5 ton cowdung/ha, T_4: 8 ton poultry manure/ha, T_5: 50% RDCF + 4 ton poultry manure/ha, T_6: 10 ton vermicompost/ha, T_7: 50% RDCF + 5 ton vermicompost/ha). There were 16 treatment combinations and 3 replications. Irrigation had no significant effect on the yield and yield parameters of BRRI dhan 28. The yield contributing characters and yields were significantly influenced by applied fertilizer and manure. The T_5 (50% RDCF + 4 ton poultry manure/ha) showed the highest effective tillers/hill, plant height, panicle length, 1000 grain wt., grain yield (5.92 kg/plot) and straw yield (5.91 kg/plot). The higher grain and straw yields were obtained organic manure plus inorganic fertilizers than full dose of chemical fertilizer and manure. The highest grain (5.93 kg/plot) and straw yields (6.42 kg/plot) were recorded from

I_0T_5 (Alternate wetting and drying + 50% RDCF plus 4 ton poultry manure/ha) and the lowest was found in I_1T_0 (Continuous flooding + control treatment) treatment combination. The highest concentrations of grain and straw N, P, K, S were recorded in T_5 treatment. The levels of organic matter and nutrient concentration were increased in the post harvest soils due to added manure plus inorganic fertilizer.

Farid *et al*. (2011) carried out a field experiment was during the T. Aman season to study the combined effect of cowdung, poultry manure, dhaincha and chemical fertilizers on the yield and nutrient uptake of BRRI dhan 41. The treatments were T_0: control, T_1: 100% NPKS, T_2: 70% NPKS + Dhaincha @ 10 t ha^{-1}, T_3: 70% NPKS + Dhaincha @ 8 t ha^{-1}, T_4: 70% NPKS + Poultry manure @ t ha^{-1}, T_5 : 70% NPKS + Poultry manure @ 3 t ha^{-1}, T_6: 70% NPKS + Cowdung @ 8 t ha^{-1} and T_7: 70% NPKS + Cowdung @ 5 t ha^{-1}. It was observed that the grain and straw yields as well as the yield attributing parameters like plant height, number of effective tillers $hill^{-1}$, panicle length, and number of field grains per panicle were significantly influenced due to different treatments except 1000 grain weight. The maximum grain yield was 4.49 t ha^{-1} recorded in T_4 treatment and minimum grain yield of 2.69 t ha^{-1} in T_0 (control). The dhaincha or cowdung along with 70% NPKS increase the grain yield significantly over 70% NPKS application. The relative performances of organic manures were in the order of PM>DH>CD.

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out at the experimental field of Sher-e-Bangla Agricultural University, Dhaka under the Department of Soil Science during the period December 2020 to May 2021 to study the effect of organic and inorganic fertilizer application on rice production (BRRI dhan29). Details of different materials used and methodologies followed to conduct the studies are presented in this chapter.

3.1 Site description

The experiment was conducted at the Sher-e-Bangla Agricultural University research field, Dhaka, under the Agro-ecological zone of Modhupur Tract, AEZ-28. The land area is situated at 23°41´ N latitude and 90°22´ E longitude at an altitude of 8.6 meter above sea level. The experimental site is shown in the AEZ Map of Bangladesh in Appendix I.

3.2 Climate

The experimental area is under the sub-tropical climate that is characterized by high temperature, high humidity and heavy rainfall with occasional gusty winds in kharif season (April-September) and less rainfall associated with moderately low temperature during the Rabi season (October-March). The weather data during the study period of the experimental site is shown in Appendix II.

3.3 Soil

The farm belongs to the general soil type, shallow red brown terrace soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. The experimental area was flat having available irrigation and drainage system. The land was above flood level and sufficient sunshine was available during the experimental period. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done by Soil Resources and Development Institute (SRDI), Dhaka. The physicochemical properties of the soil are presented in Appendix III.

3.4 Treatments

Single factor experiment consisting seven treatments of organic and inorganic fertilizer including control was considered for the present study which is as follows:

1. T_0 = control (no nutrient application)
2. T_1 = RDCF ($N_{120}P_{20}K_{40}S_{20}Zn_{2.5}$ kg/ha- 100% chemical fertilizer) [Urea = 260 kg ha^{-1}, TSP = 42 kg ha^{-1}, MoP = 67 kg ha^{-1}, Gypsum = 111 kg ha^{-1} and $ZnSO_4$ = 7 kg ha^{-1}]
3. T_2 = 100% cowdung - 10 t ha^{-1}
4. T_3 = 100% poultry manure - 5 t ha^{-1}
5. T_4 = 50% RDCF + 50% cowdung
6. T_5 = 50% RDCF + 50% poultry manure
7. T_6 = 25% RDCF + 75% cowdung
8. T_7 = 25% RDCF + 75% poultry manure

3.5 Plant materials and collection of seeds

The rice variety BRRI dhan29 was used as plant materials for the present study. The seeds of this variety was collected from BRRI, Joydebpur, Gazipur, Bangladesh.

3.6 Seed sprouting

Healthy seeds were stored in water bucket for 24 hours and then it was kept tightly in gunny bags. The seeds started sprouting after 48 hours and were sown after 72 hours.

3.7 Preparation of nursery bed and seed sowing

As per BRRI recommendation, seedbed was prepared with 1 m wide adding nutrients as per requirements of soil. Seeds were sown in the seed bed on 1st December, 2020 in order to transplant the seedlings in the main field.

3.8 Preparation of experimental land

The plot selected for the experiment was opened in the first week of January 2021 with a power tiller, and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed, and finally obtained a desirable field for transplanting of the seedlings. The land was fully prepared for transplanting of seedlings on 8 January 2021.

3.9 Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications (block). At first the experiment plot was divided into three equal blocks. Each block was then divided into 8 sub plots where different treatments were assigned. Thus the total number of unit plots was 8×3=24. The size of the unit plot was 5m × 2m. The distance maintained between the row was 0.5m and between column was 0.5m. The treatments were randomly assigned to the plots within each block. The layout of the experimental design is shown in Figure 1.

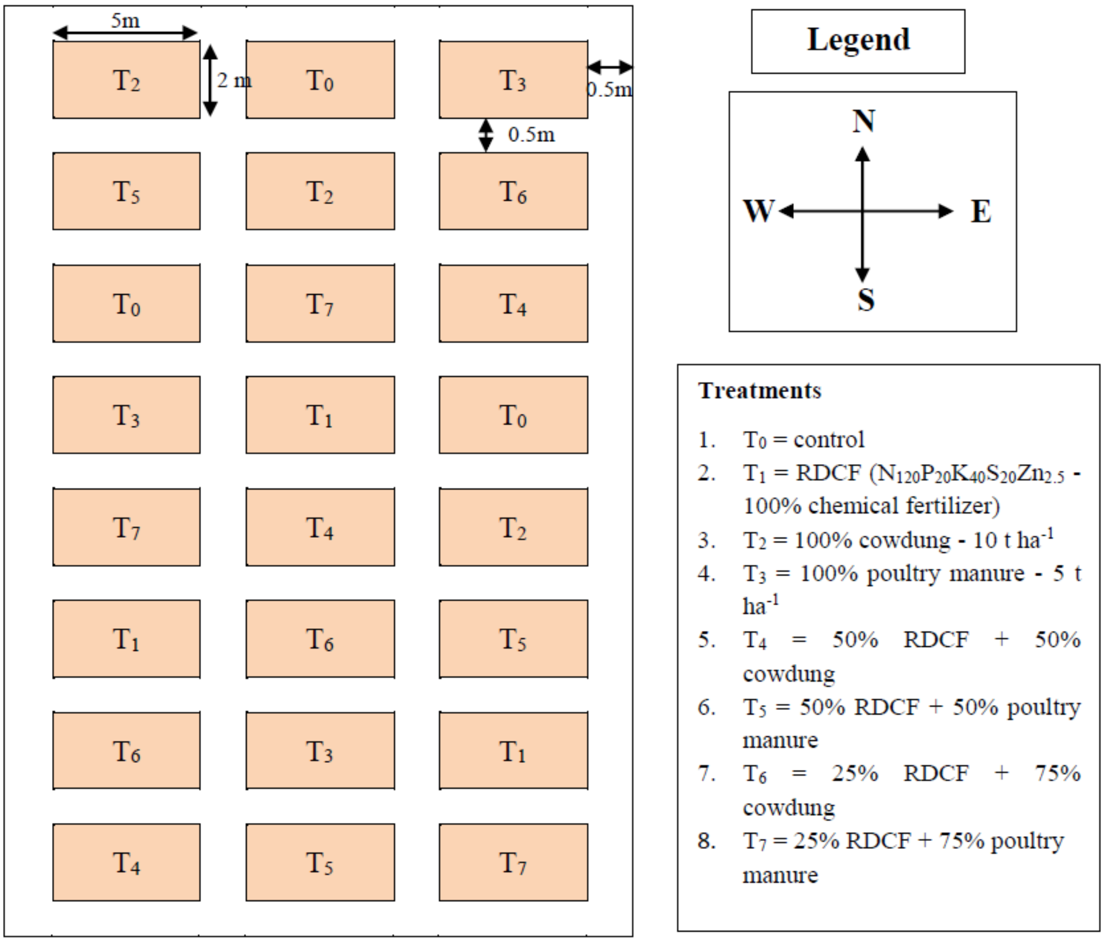

Figure 1. Layout of the experimental plot

3.10 Fertilizer application

The following doses of fertilizer were applied for cultivation of crop as recommended by BRRI, 2016.

Fertilizer	**Recommended doses ha^{-1}**	**Experimental treatments**
Cowdung	10 t	As per treatment
Poultry manure	5 t	As per treatment
N-120	260 kg	As per treatment
P-20	88 kg	As per treatment
K-40	112 kg	As per treatment
S-20	7 kg	As per treatment
Zn-2.5	111 kg	As per treatment

The fertilizers N, P, K, S and Zn in the form of urea, TSP, MP, gypsum and zinc sulphate, respectively were applied. The entire amount of TSP, MoP, gypsum and zinc sulphate was applied during the final preparation of land. Mixture of cowdung or poultry manure was applied at the rate of 10 or 5 ton ha^{-1}, respectively during 15 days before transplanting. Urea was applied in three equal installments at seedling establishment, tillering and before panicle initiation.

3.11 Uprooting of seedlings

The nursery bed was made wet by application of water one day before uprooting the seedlings. The seedlings were uprooted on 7 January, 2021 without causing much mechanical injury to the roots.

3.12 Transplanting of seedlings in the field

The seedlings were transplanted in the main field on 9th January, 2021 with a spacing 15 cm from hill to hill and 20 cm from row to row.

3.13 Intercultural operations

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

3.13.1 Irrigation and drainage

Flood irrigation was given to maintain a constant level of standing water upto 3 cm at the early stages to enhance tillering and 4-5 cm in the later stage to discourage late tillering. The field was finally dried out at 15 days before harvesting.

3.13.2 Gap filling

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

3.13.3 Weeding

The crop was infested with some common weeds, which were controlled by uprooting and remove them three times from the field during the period of experiment. Weeding was done after 16, 34 and 54 days of transplanting.

3.13.4 Plant protection

There were some incidence of insects specially stem borer which was controlled by Furadan 5G @ 10 kg ha^{-1} at 30 days after transplanting. Brown spot of rice was controlled by spraying tilth.

3.14 Harvesting, threshing and cleaning

The rice plant was harvested depending upon the maturity of the plant on 11 May 2021 and harvesting was done manually from each plot. The harvested crop of each plot was bundled separately, properly tagged and brought to threshing floor. Enough care was taken for harvesting, threshing and also cleaning of rice seed. Fresh weight of grain and straw were recorded plot wise. The grains were cleaned and finally the weight was adjusted to a moisture content of 12%. The straw was sun dried and the yields of grain and straw plot^{-1} were recorded and converted to ton ha^{-1}.

3.15 General observation of the experimental field

The field was observed time to time to detect visual difference among the treatments and any kind of infestation by weeds, insects and diseases so that considerable losses by pest was minimized.

3.16 Recording of data

The following data were recorded during the study period:

3.16.1 Growth parameters

1. Plant height (cm)
2. Number of tillers hill^{-1}

3.16.2 Yield contributing parameters

1. Total number of effective tillers hill^{-1}
2. Number of non-effective tillers hill^{-1}
3. Flag leaf length (cm)
4. Number of filled grains panicle^{-1}
5. Number of unfilled grains panicle^{-1}
6. Panicle length (cm)
7. 1000 grain weight (g)

3.16.3 Yield parameters

1. Grain yield (t ha^{-1})
2. Straw yield (t ha^{-1})
3. Harvest index (%)

3.16.4 Soil analysis

1. Particle size analysis
2. pH

3. Soil organic carbon content
4. Available phosphorus
5. Available sulphur

3.17 Procedures of recording data

A brief outline of the data recording procedure is given below:

3.17.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 60, 90 DAT and at harvest. Data were recorded as the average of 5 plants pre-selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the plant.

3.17.2 Number of total tillers hill^{-1}

Total tillers which had at least one leaf visible were counted. It includes both productive and unproductive tillers. It was counted from the average of nearly similar 5 plants pre-selected at random from the inner rows of each plot. Number of tillers hill^{-1} was recorded at 60, 90 DAT and at harvest.

3.17.3 Number of effective tillers hill^{-1}

The total number of effective tillers hill^{-1} was counted from 5 selected hills at harvest and average value was recorded.

3.17.4 Number of non-effective tillers hill^{-1}

The total number of non-effective tillers hill^{-1} was counted from 5 selected hills at harvest and average value was recorded.

3.17.5 Flag leaf length (cm)

Flag leaf length was measured with a meter scale from 5 pre-selected plants from the inner rows of each plot.

3.17.6 Number of filled grains panicle^{-1}

The total number of filled grains was collected from panicles of randomly selected 5 hills of a plot and then average number of filled grains panicle^{-1} was recorded.

3.17.7 Number of unfilled grains panicle^{-1}

The total number of unfilled grains was collected from panicles of randomly selected 5 hills of a plot and then average number of unfilled grains panicle^{-1} was recorded.

3.17.8 Panicle length (cm)

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

3.17.9 Weight of 1000 grain (g)

One thousand cleaned dried grains were counted randomly from each plot and weighed by using a digital electric balance when the grains retained 12% moisture and the mean weight was expressed in gram.

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

Grain from each plot area was thoroughly sun dried till constant weight was attained. Then yield per hectare was determined based on net plot area.

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

After separation of grains from plants of each plot the straw was sun dried till a constant weight is obtained then per hectare straw yield was calculated.

3.17.12 Harvest index (%)

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

$$\text{Harvest index (\%)} = \frac{\text{Grain yield}}{\text{Total biological yield}} \times 100$$

Biological yield = Grain yield + Straw yield

3.17.13 Soil analysis

The soil samples were analyzed by the following standard methods as follows:

3.17.13.1 Particle size analysis

Particle size analysis of soil sample was done by hydrometer method as outline by day. The textural classes were ascertained using Marshall's Textural Triangular coordinate as designated by USDA, 1993.

3.17.13.2 pH

Soil pH was measured with the help of a glass electrode pH meter, the soil water ratio being maintained at 1: 2.5 as described by Akul *et al.* (1982)

3.17.13.3 Soil organic carbon content

Organic carbon in the soil sample was determined by the wet oxidation method. The underlying principle was used to oxidize the organic carbon with an excess of 1N $K_2Cr_2O_7$ in presence of conc. H_2SO_4 and conc. H_3PO_3 and titrate the excess $K_2Cr_2O_7$ solution with 1N $FeSO_4$.

3.17.13.4 Available phosphorus

Available P was extracted from the soil with 0.5 M $NaHCO_3$ solutions, pH 8.5 (Olsen *et al.*, 1954). Phosphorus in the extract was then determined by developing blue color with reduction of phosphomolybdate complex and the color intensity was measured calorimetrically at 660 ηm wavelength and readings were calibrated with the standard P curve (Akul *et al.*, 1982)

3.17.13.5 Available sulphur

Available sulphur was extracted from the soil with Ca $(H_2PO_4)_2.H_2O$ (Fox *et al.,* 1964). Sulphur in the extract was determined by the turbidimetric method as described by hunt (1980) using a Spectrophotometer (LKB Novaspce. 4049).

3.17 Statistical analysis

Collected data from the experiment field were statistically analyzed to find out the significant difference among the treatment by using the MSTAT-C computer package program. The mean values of all the characters were calculated and analysis of variance was performed. The significance of the difference among the treatments means was estimated by the Least Significant Difference Test (LSD) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

This study was conducted to explore the comparative effectiveness of organic and inorganic fertilizer application on rice production (BRRI dhan29). Data were collected on different growth, yield and yield contributing parameters and present in this chapter through different Tables and Graph. The results and discussions and also possible interpretations have been given under the following headings:

4.1 Growth parameters

4.1.1 Plant height (cm)

Different doses of organic manure (cowdung or poultry manure) and inorganic fertilizers (NPKZnS) combinations showed significant influence on plant height of rice at different growth stages (Figure 2 and Appendix IV). Results indicated that at 60 DAT, the maximum rice plant height (83.73 cm) was recorded from the treatment T_1 (100% RDCF: $N_{120}P_{20}K_{40}S_{20}Zn_{2.5}$ kg ha^{-1}) which was statistically identical with the treatment T_7 (25% RDCF + 75% poultry manure) (83.02 cm) followed by T_4 (50% RDCF + 50% cowdung) and T_5 (50% RDCF + 50% poultry manure) (79.57 and 76.96 cm, respectively) while the minimum plant height (70.05 cm) was found from the control treatment T_0 (no nutrient application) which was statistically identical with the treatment T_2 (100% cowdung - 10 t ha^{-1}), T_3 (100% poultry manure - 5 t ha^{-1}) and T_6 (25% RDCF + 75% cowdung) (70.52, 70.59 and 73.25 cm, respectively). At 90 DAT, the treatment T_1 (100% RDCF: $N_{120}P_{20}K_{40}S_{20}Zn_{2.5}$ kg ha^{-1}) gave the maximum plant height (95.87 cm) which was statistically similar with the treatment T_4 (50% RDCF + 50% cowdung) and T_7 (25% RDCF + 75% poultry manure) (91.80 and 92.27 cm, respectively). The minimum plant height at 90 DAT (79.73 cm) was observed from the control treatment T_0 (no nutrient application) which was statistically identical with the treatment T_2 (100% cowdung - 10 t ha^{-1}), T_3 (100% poultry manure - 5 t ha^{-1})

and T_6 (25% RDCF + 75% cowdung) (82.80, 83.40 and 83.87 cm, respectively). Similarly, at harvest, the treatment T_1 (100% RDCF: $N_{120}P_{20}K_{40}S_{20}Zn_{2.5}$ kg ha^{-1}) gave the maximum plant height (94.37 cm) which was statistically identical with the treatment T_4 (50% RDCF + 50% cowdung), T_5 (50% RDCF + 50% poultry manure) and T_7 (25% RDCF + 75% poultry manure) (91.79, 93.18 and 94.27 cm, respectively) whereas the control treatment T_0 (no nutrient application) gave the minimum plant height (85.37 cm) which was statistically identical with the treatment T_2 (100% cowdung - 10 t ha^{-1}), T_3 (100% poultry manure - 5 t ha^{-1}) and T_6 (25% RDCF + 75% cowdung) (85.83, 86.88 and 87.67 cm, respectively).

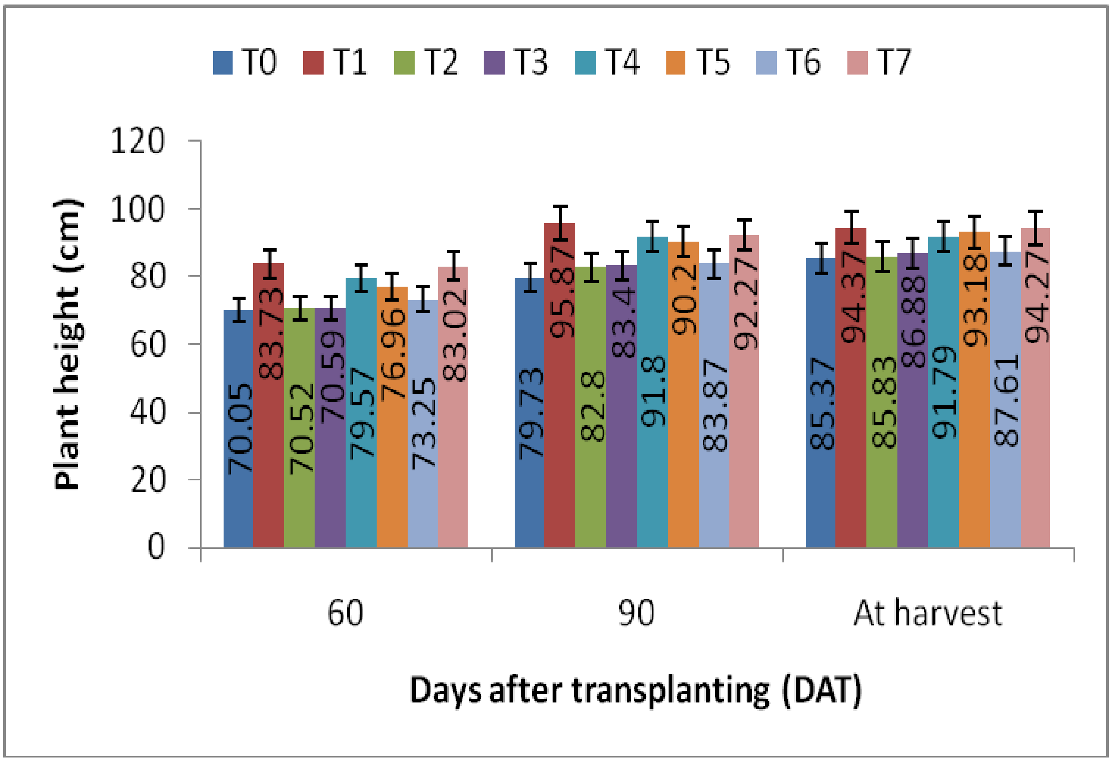

Figure 2. Effect of organic and inorganic fertilizer on plant height of rice (BRRI dhan29) at different growth stages ($LSD_{0.05}$ = 3.424, 4.251 and 4.04 at 60, 90 DAT and at harvest, respectively)

T_0 = control (no fertilizer), T_1 = RDCF ($N_{120}P_{20}K_{40}S_{20}Zn_{2.5}$ -100% chemical fertilizer), T_2 = 100% cowdung - 10 t ha^{-1}, T_3 = 100% poultry manure - 5 t ha^{-1}, T_4 = 50% RDCF + 50% cowdung, T_5 = 50% RDCF + 50% poultry manure, T_6 = 25% RDCF + 75% cowdung, T_7 = 25% RDCF + 75% poultry manure

According to Siavoshi *et al*. (2011) plant height, number of tillers per hill, spikelet number per panicle, grain yield and 1000-grain weight increased with the application of organic and chemical fertilizers and this could be due to the increase in the absorption of available nutrients. They also stated that the difference in plant height was due to the variation of major nutrients in fertilizer sources. A similar result was observed by Ibrahim *et al*. (2008), Abdul-Rahman (2019) and Moe *et al*. (2019) in ascertaining the combined effect of organic manure with compost on rice.

4.1.2 Number of tillers hill^{-1}

Application of different doses of organic and inorganic fertilizers combinations to rice showed significant influence on number of tillers hill^{-1} at different growth stages (Figure 3 and Appendix V). Results revealed that at 60 DAT, the treatment T_4 (50% RDCF + 50% cowdung) showed the highest number of tillers hill^{-1} (13.13) which was statistically identical with the treatment T_5 (50% RDCF + 50% poultry manure) (12.60) followed by T_1 (100% RDCF: $N_{120}P_{20}K_{40}S_{20}Zn_{2.5}$ kg ha^{-1}) (11.80) and T_7 (25% RDCF + 75% poultry manure) (11.60) whereas the lowest number of tillers hill^{-1} (9.87) was found from the control treatment T_0 (no nutrient application) which was significantly different from other treatments. Similarly, at 90 DAT, the treatment T_4 (50% RDCF + 50% cowdung) gave the highest number of tillers hill^{-1} (15.33) which was statistically identical with the treatment T_1 (100% RDCF: $N_{120}P_{20}K_{40}S_{20}Zn_{2.5}$ kg ha^{-1}) (14.80) and T_5 (50% RDCF + 50% poultry manure) (15.00) whereas control treatment T_0 (no nutrient application) gave the the lowest number of tillers hill^{-1} (11.07) which was significantly different from other treatments. Again, at harvest, the highest number of tillers hill^{-1} (7.67, 20.04 and 25.68, respectively) was achieved from the treatment T_4 (50% RDCF + 50% cowdung) (17.73) which was statistically similar to the treatment T_5 (50% RDCF + 50% poultry manure) whereas the lowest number of tillers hill^{-1} (13.00) was found from the control treatment T_0 (no nutrient application) which was statistically identical with the treatment T_2 (100% cowdung - 10 t ha^{-1}). Siavoshi *et al.* (2011) also reported number of tillers per hill increased with the application of organic and chemical fertilizers and this could be due to the increase in the absorption of available nutrients. They also reported that tillering is an essential parameter for panicle number and thereby an important factor in grain yield production. Hasanuzzaman *et al.* (2010) reported an increase in tiller number per unit area under combined application of organic and inorganic fertilizer treatment. According to Belefant (2007), Alam *et al.* (2021), Moe *et al.* (2019) and Singh *et al.* (2018), the application of manure or chemical fertilizer alone to soil increases the tiller number but combined application of manure and chemical fertilizer resulted in higher number of tillers.

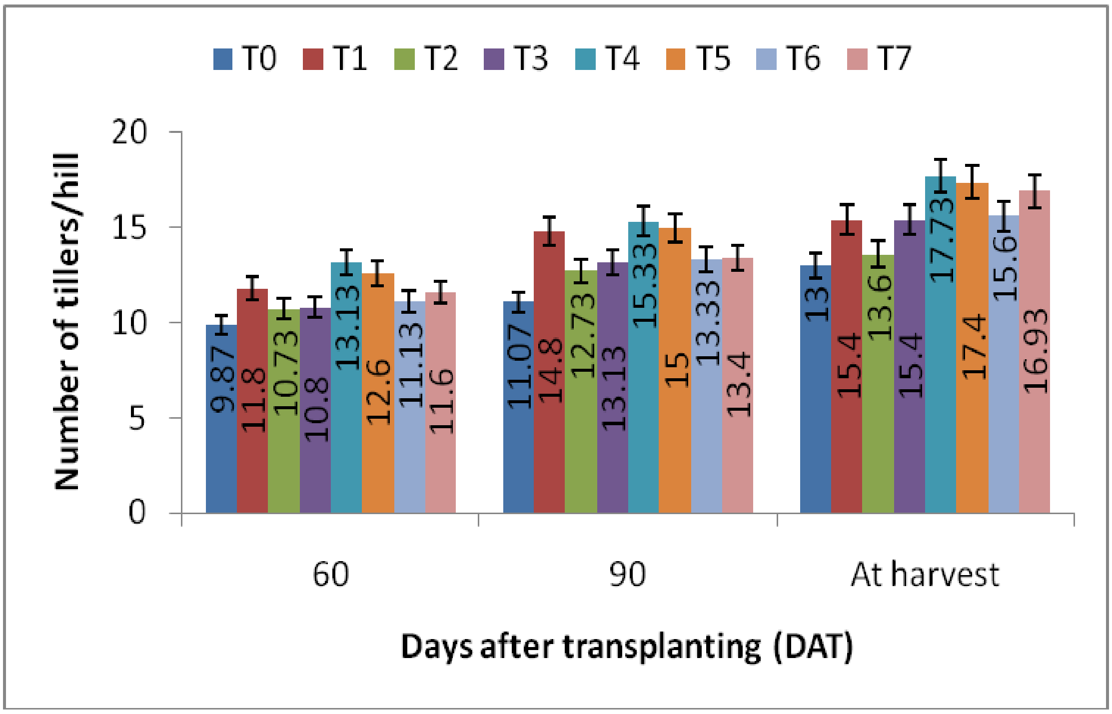

Figure 3. Effect of organic and inorganic fertilizer on number of tillers $hill^{-1}$ of rice (BRRI dhan29) at different growth stages ($LSD_{0.05}$ = 0.763, 0.562 and 0.662 at 60, 90 DAT and at harvest, respectively)

T_0 = control (no fertilizer), T_1 = RDCF ($N_{120}P_{20}K_{40}S_{20}Zn_{2.5}$ -100% chemical fertilizer), T_2 = 100% cowdung - 10 t ha^{-1}, T_3 = 100% poultry manure - 5 t ha^{-1}, T_4 = 50% RDCF + 50% cowdung, T_5 = 50% RDCF + 50% poultry manure, T_6 = 25% RDCF + 75% cowdung, T_7 = 25% RDCF + 75% poultry manure

4.2 Yield contributing parameters

4.2.1 Number of effective tillers hill^{-1}

Number of effective tillers hill^{-1} of rice differed significantly due to different doses of organic and inorganic fertilizer combinations (Table 1 and Appendix VI). It was observed that the treatment T_4 (50% RDCF + 50% cowdung) gave the highest number of effective tillers hill^{-1} (16.33) which was statistically identical with the treatment T_5 (50% RDCF + 50% poultry manure) and T_7 (25% RDCF + 75% poultry manure) (15.87 and 15.60, respectively). On the other hand, the lowest number of effective tillers hill^{-1} (10.80) was given by the control treatment T_0 (no nutrient application), which was significantly different from other treatments. The treatment T_2 (100% cowdung - 10 t ha^{-1}) also performed lower number of effective tillers hill^{-1} (11.93) but significantly higher than T_0 (no nutrient application). Tiller number is one of the most significant components of grain yield, especially the effective tillers, because more highly effective tillers per hill give more grain yield per hectare. Combined application of organic and mineral fertilizers produced a higher number of tillers per hill as compare to all other treatments (Abdul-Rahman, 2019). Organic fertilizer sources offer more balanced nutrition, especially micronutrients which positively affect the number of tillers in rice plants (Belefant 2007). According to Biswas *et al*. (2016) and Mahmud *et al*. (2016) and Belefant (2007), the application of manure or chemical fertilizer alone to soil increases the effective tiller number but combined application of manure and chemical fertilizer resulted in higher number of tillers. According to Mahmud *et al*. (2016), chemical fertilizers applied at different levels also had a significant effect on effective tillers per hill but combined application of manure or chemical fertilizer showed increased effective tillers compared to control.

Table 1. Effect of organic and inorganic fertilizer on effective and non-effective tillers $hill^{-1}$ of rice (BRRI dhan29)

Treatments	Yield contributing parameters	
	Number of effective tillers $hill^{-1}$	Number of non-effective tillers $hill^{-1}$
T_0	10.80 d	2.20
T_1	13.80 b	1.60
T_2	11.93 c	1.67
T_3	13.53 b	1.87
T_4	16.33 a	1.40
T_5	15.87 a	1.53
T_6	13.60 b	2.00
T_7	15.60 a	1.33
LSD 0.05	1.061	0.92^{NS}
CV(%)	8.39	5.69

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

T_0 = control (no fertilizer), T_1 = RDCF ($N_{120}P_{20}K_{40}S_{20}Zn_{2.5}$ -100% chemical fertilizer), T_2 = 100% cowdung - 10 t ha^{-1}, T_3 = 100% poultry manure - 5 t ha^{-1}, T_4 = 50% RDCF + 50% cowdung, T_5 = 50% RDCF + 50% poultry manure, T_6 = 25% RDCF + 75% cowdung, T_7 = 25% RDCF + 75% poultry manure

4.2.2 Number of non-effective tillers $hill^{-1}$

Application of organic and inorganic fertilizer in combinations to rice showed non-significant variation on number of non-effective tillers $hill^{-1}$ (Table 1 and Appendix VI). However, the treatment T_7 (25% RDCF + 75% poultry manure) gave the lowest number of non-effective tillers $hill^{-1}$ (1.33) which was immediately lower than T_4 (50% RDCF + 50% cowdung) (1.40), whereas the control treatment T_0 (no nutrient application) showed the highest number of non-effective tillers $hill^{-1}$ (2.20) followed by T_6 (25% RDCF + 75% cowdung)

(2.00). Similar result was also observed by the findings of Biswas *et al*. (2016) and Mahmud *et al*. (2016).

4.2.3 Flag leaf length (cm)

Flag leaf length of rice differed significantly due to different doses of organic and inorganic fertilizers combinations (Figure 4 and Appendix VI).

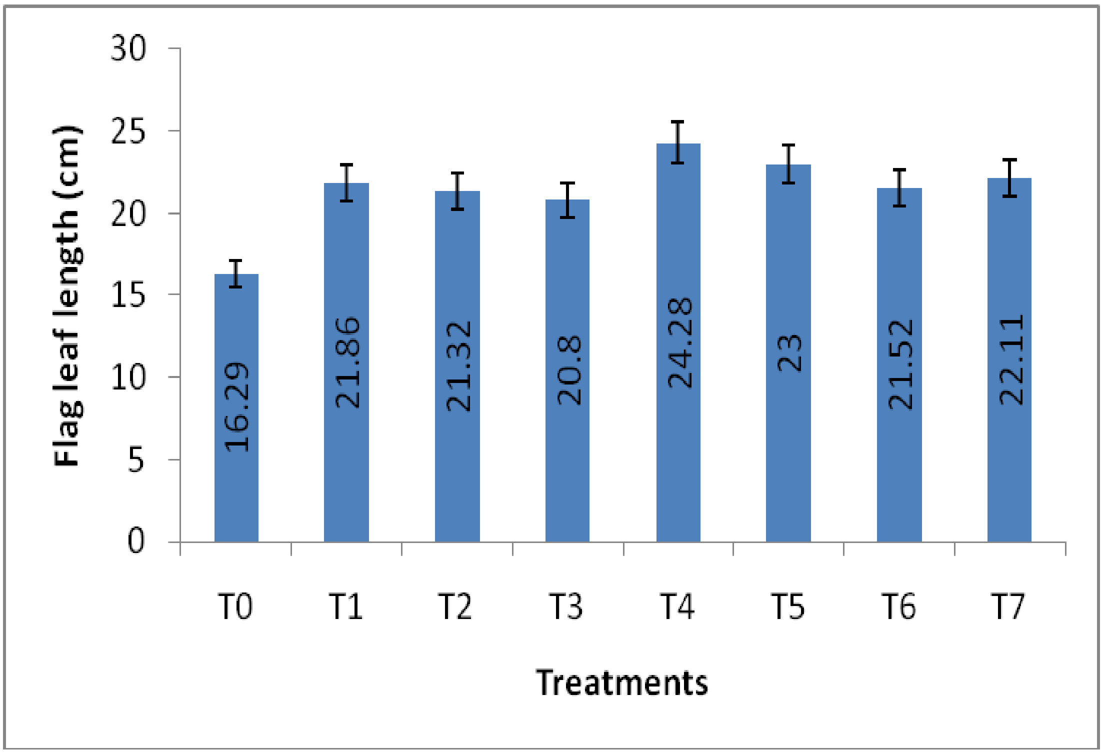

Figure 4. Effect of organic and inorganic fertilizer on flag leaf length of rice (BRRI dhan29) ($LSD_{0.05}$ = 1.451)

T_0 = control (no fertilizer), T_1 = RDCF ($N_{120}P_{20}K_{40}S_{20}Zn_{2.5}$ -100% chemical fertilizer), T_2 = 100% cowdung - 10 t ha^{-1}, T_3 = 100% poultry manure - 5 t ha^{-1}, T_4 = 50% RDCF + 50% cowdung, T_5 = 50% RDCF + 50% poultry manure, T_6 = 25% RDCF + 75% cowdung, T_7 = 25% RDCF + 75% poultry manure

It was observed that the highest flag leaf length (24.28 cm) was given by the treatment T_4 (50% RDCF + 50% cowdung) which was statistically similar with the treatment T_5 (50% RDCF + 50% poultry manure). Between the treatment T_1 (100% RDCF: $N_{120}P_{20}K_{40}S_{20}Zn_{2.5}$ kg ha^{-1}) and T_7 (25% RDCF + 75%

poultry manure) showed non-significant variation on flag leaf length (21.86 and 22.11 cm, respectively) and comparatively higher flag leaf length. The lowest flag leaf length (16.29 cm) was produced by the control treatment T_0 (no nutrient application) which was significantly different from other treatments. Mahmud *et al*. (2016) found maximum flag leaf length with combined application of organic manure (vermicompost) and chemical fertilizer compared to sole application of organic manure or chemical fertilizer which supported the present findings.

4.2.4 Number of filled grains panicle^{-1}

Organic and inorganic fertilizers combinations at different doses applied to rice plants showed significant variation on number of filled grains panicle^{-1} (Table 2 and Appendix VII). Results revealed that the treatment T_4 (50% RDCF + 50% cowdung) gave the maximum number of filled grains panicle^{-1} (165.4) which was statistically similar with the treatment T_5 (50% RDCF + 50% poultry manure) and T_7 (25% RDCF + 75% poultry manure) (160.30 and 158.70, respectively). The minimum number of filled grains panicle^{-1} (134.00) was recorded from the control treatment T_0 (no nutrient application) which was significantly different from other treatments. Treatment T_2 (100% cowdung - 10 t ha^{-1}) also showed lower number of filled grains panicle^{-1} (142.90) which was statistically similar with the treatment T_3 (100% poultry manure - 5 t ha^{-1}) and T_6 (25% RDCF + 75% cowdung) but significantly higher than T_0 (no nutrient application) treatment. Number of filled grains panicle^{-1} is the most important factor to maximize yield of rice which can be increased by combined application of organic manure and chemical fertilizer compared to the sole application or control treatment (Siavoshi *et al*., 2011). Organic manure can be a rich source of available nitrogen, phosphorus, potassium and micronutrients, coupled with high microbial and enzymatic activities (Chaoui *et al*. 2003). Continuous application of compost improves soil organic carbon, soil water retention and transmission which positively affect the physical properties of soils (Das et al. 2016). According to Mahmud *et al*. (2016), Sohel *et al*. (2016) and Sarker *et al*. (2015), organic fertilizers combined with inorganic fertilizer have been shown to improve soil structure, nutrient exchange and maintain soil health, thus providing higher grain yield by achieving more number of filled grains panicle^{-1}.

Table 2. Effect of organic and inorganic fertilizer on filled grains and unfilled grains panicle^{-1} of rice (BRRI dhan29)

Treatments	Yield contributing parameters	
	Number of filled grains panicle^{-1}	Number of unfilled grains panicle^{-1}
T_0	134.00 e	12.55 a
T_1	152.40 bc	8.33 de
T_2	142.90 d	10.56 b
T_3	144.90 cd	10.11 b
T_4	165.40 a	7.55 e
T_5	160.30 ab	9.00 cd
T_6	148.20 cd	9.89 bc
T_7	158.70 ab	5.89 f
LSD 0.05	7.948	0.943
CV(%)	12.12	5.17

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

T_0 = control (no fertilizer), T_1 = RDCF ($N_{120}P_{20}K_{40}S_{20}Zn_{2.5}$ -100% chemical fertilizer), T_2 = 100% cowdung - 10 t ha^{-1}, T_3 = 100% poultry manure - 5 t ha^{-1}, T_4 = 50% RDCF + 50% cowdung, T_5 = 50% RDCF + 50% poultry manure, T_6 = 25% RDCF + 75% cowdung, T_7 = 25% RDCF + 75% poultry manure

4.2.5 Number of unfilled grains panicle^{-1}

The application of different doses of organic and inorganic fertilizer combinations to rice plants showed significant influence on number of unfilled grains panicle^{-1} (Table 2 and Appendix VII). The lowest number of unfilled grains panicle^{-1} (5.89) was found from the treatment T_7 (25% RDCF + 75% poultry manure) which was significantly different from other treatments, the treatment T_4 (50% RDCF + 50% cowdung) also performed lower number of unfilled grains panicle^{-1} (7.55). In contrast, the highest number of unfilled grains panicle^{-1} (12.55) was recorded from the control treatment T_0 (no nutrient application) followed by T_2 (100% cowdung - 10 t ha^{-1}) and T_3 (100% poultry manure - 5 t ha^{-1}).

4.2.6 Panicle length (cm)

Different levels of organic and inorganic fertilizers combinations showed significant variation on panicle length (Figure 5 and Appendix VII). Results indicated that the treatment T_4 (50% RDCF + 50% cowdung) gave the highest panicle length (25.94 cm) followed by T_5 (50% RDCF + 50% poultry manure) (25.06 cm). Treatment T_7 (25% RDCF + 75% poultry manure) also performed comparatively higher panicle length (24.52) which was statistically similar with the treatment T_5 (50% RDCF + 50% poultry manure). The lowest panicle length (17.37 cm) was recorded from the control treatment T_0 (no nutrient application) which was significantly different from other treatments. According to Arif *et al*. (2014), panicle length increased with the application of organic and chemical fertilizers and this could be due to the increase in the absorption of available nutrients. Sarker *et al*. (2015) also stated that the difference in plant height was due to the variation of major nutrients in fertilizer sources. A similar result was observed by Mahmud *et al*. (2016) and Sohel *et al*. (2016).

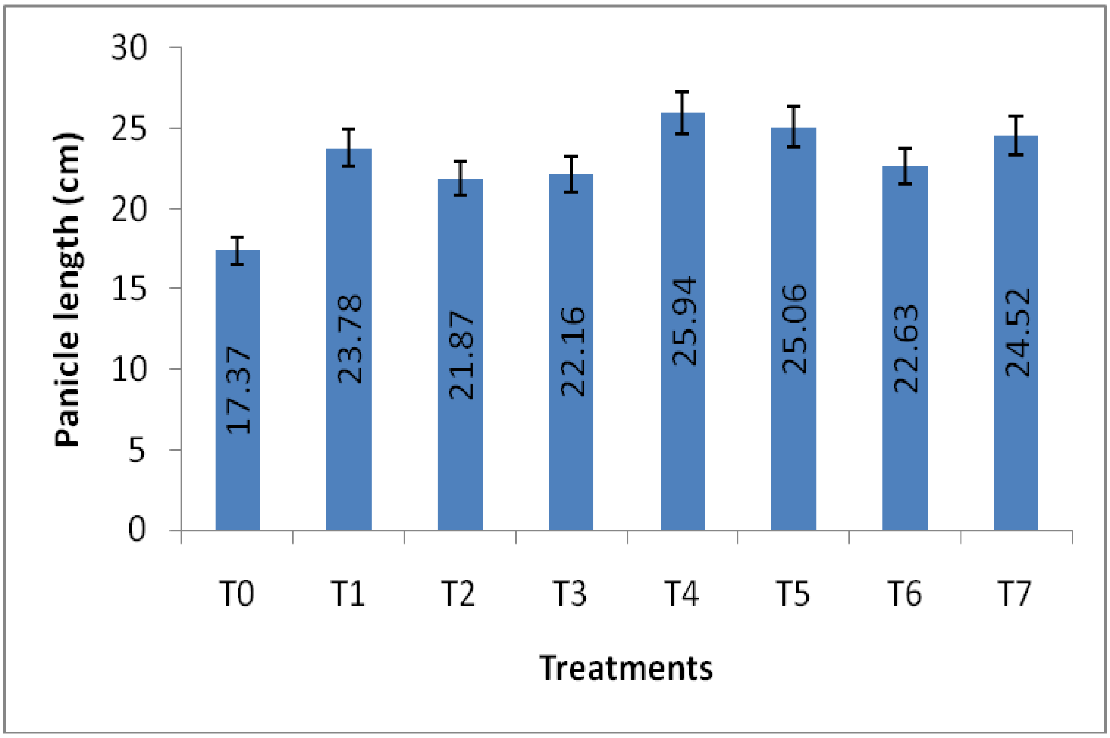

Figure 5. Effect of organic and inorganic fertilizer on panicle length of rice (BRRI dhan29) ($LSD_{0.05}$ = 0.787)

T_0 = control (no fertilizer), T_1 = RDCF ($N_{120}P_{20}K_{40}S_{20}Zn_{2.5}$ -100% chemical fertilizer), T_2 = 100% cowdung - 10 t ha^{-1}, T_3 = 100% poultry manure - 5 t ha^{-1}, T_4 = 50% RDCF + 50% cowdung, T_5 = 50% RDCF + 50% poultry manure, T_6 = 25% RDCF + 75% cowdung, T_7 = 25% RDCF + 75% poultry manure

4.2.7 Weight of 1000 grains

Application of different doses of organic and inorganic fertilizer combinations showed significant variation on 1000 grain weight (Table 3 and Appendix VII). Result revealed that the maximum 1000 grain weight (21.90 g) was given by the treatment T_4 (50% RDCF + 50% cowdung) which was statistically identical with the treatment T_5 (50% RDCF + 50% poultry manure) (21.60 g) followed by T_7 (25% RDCF + 75% poultry manure). The lowest 1000 grain weight (17.57 g) was performed by the control treatment T_0 (no nutrient application) which was significantly different from other treatments. Siavoshi *et al.* (2011) observed that 1000-grain weight increased with the application of organic and chemical fertilizers and this could be due to the increase in the absorption of available nutrients. Mahmud *et al*. (2016), Arif *et al*. (2014) and Islam *et al*. (2013) also found maximum 1000-grain weight with the application of organic and chemical fertilizers which supported the present study.

Table 3. Effect of organic and inorganic fertilizer on 1000 grain weight of rice (BRRI dhan29)

Treatments	1000 grain weight (g)
T_0	17.57 f
T_1	20.55 c
T_2	19.23 e
T_3	19.54 e
T_4	21.90 a
T_5	21.60 a
T_6	20.19 d
T_7	21.00 b
LSD 0.05	0.308
CV(%)	6.87

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

T_0 = control (no fertilizer), T_1 = RDCF ($N_{120}P_{20}K_{40}S_{20}Zn_{2.5}$ -100% chemical fertilizer), T_2 = 100% cowdung - 10 t ha^{-1}, T_3 = 100% poultry manure - 5 t ha^{-1}, T_4 = 50% RDCF + 50% cowdung, T_5 = 50% RDCF + 50% poultry manure, T_6 = 25% RDCF + 75% cowdung, T_7 = 25% RDCF + 75% poultry manure

4.3 Yield parameters

4.3.1 Grain yield ha^{-1}

Grain yield of rice differed significantly due to different doses of organic and inorganic fertilizers combinations (Table 4 and Appendix VIII). It was observed that the treatment T_4 (50% RDCF + 50% cowdung) gave the highest grain yield (7.66 t ha^{-1}) which was statistically identical with the treatment T_5 (50% RDCF + 50% poultry manure) (7.46 t ha^{-1}). Treatment T_7 (25% RDCF + 75% poultry manure) also showed comparatively higher grain yield (7.14 t ha^{-1}) but significantly differed with T_4 (50% RDCF + 50% cowdung). The lowest grain yield (4.43 t ha^{-1}) was given by the control treatment T_0 (no nutrient application) which was significantly different from other treatments. Combined application of compost and chemical fertilizer at different levels on rice plants greatly influenced the grain yield due to the increased in plant height, tiller number, panicle length, grains per panicle and 1000 seed weight in a study by Alim (2012). This could have been due to the availability of major nutrient sources for plant growth and yield. While chemical fertilizers render nutrients which are readily accessible in soil solution and thereby making them instantaneously available, organic fertilizers provide nutrients through microbial activities (Mahmud *et al*. 2016). Similarly, Alam *et al*. (2021), Singh *et al*. (2018), Sarker *et al*. (2015), Islam *et al*. (2013) and Islam *et al*. (2015) reported that combined application of organic manure and nitrogenous fertilizer increased grain yield in rice.

4.3.2 Straw yield ha^{-1}

Application of different organic and inorganic fertilizer combinations showed significant variation on straw yield (Table 4 and Appendix VIII). Treatment T_4 (50% RDCF + 50% cowdung) gave the highest straw yield (8.96 t ha^{-1}) which was statistically identical with the treatment T_5 (50% RDCF + 50% poultry manure) and T_7 (25% RDCF + 75% poultry manure). The minimum straw yield (6.77 t ha^{-1}) was obtained from control treatment T_0 (no nutrient application) that was significantly different to other treatments. Treatment T_2 (100% cowdung - 10 t ha^{-1}) also performed lower straw yield (7.58 t ha^{-1}) but significantly differed with control treatment. Alam *et al*. (2021), Chakraborty *et al*. (2020) and Islam *et al*. (2016) also found higher straw yield with combined application of organic and inorganic nutrients to soil in rice field compared to sole application or control which supported the present findings.

Table 4. Effect of organic and inorganic fertilizer on yield parameters (grain and straw yield) of rice (BRRI dhan29)

Treatments	Yield parameters	
	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_0	4.43 f	6.77 f
T_1	6.84 c	8.58 bc
T_2	6.01 e	7.58 e
T_3	6.11 e	7.94 d
T_4	7.66 a	8.96 a
T_5	7.46 a	8.89 a
T_6	6.38 d	8.33 c
T_7	7.14 b	8.73 ab
LSD 0.05	0.241	0.248
CV(%)	10.14	8.71

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

T_0 = control (no fertilizer), T_1 = RDCF ($N_{120}P_{20}K_{40}S_{20}Zn_{2.5}$ -100% chemical fertilizer), T_2 = 100% cowdung - 10 t ha^{-1}, T_3 = 100% poultry manure - 5 t ha^{-1}, T_4 = 50% RDCF + 50% cowdung, T_5 = 50% RDCF + 50% poultry manure, T_6 = 25% RDCF + 75% cowdung, T_7 = 25% RDCF + 75% poultry manure

4.3.3 Harvest index

Harvest index of rice differed significantly due to different doses of organic and inorganic fertilizers combinations (Figure 6 and Appendix VIII).

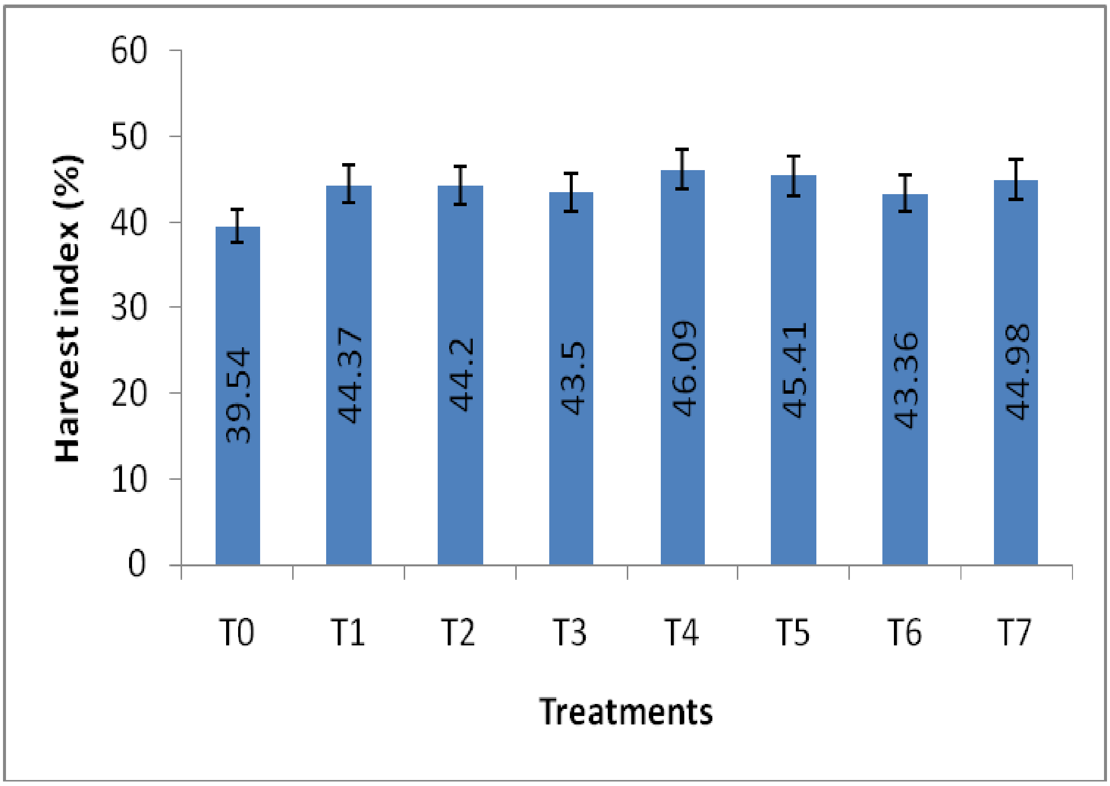

Figure 6. Effect of organic and inorganic fertilizer on harvest index of rice (BRRI dhan29) ($LSD_{0.05}$ = 0.583)

T_0 = control (no fertilizer), T_1 = RDCF ($N_{120}P_{20}K_{40}S_{20}Zn_{2.5}$ -100% chemical fertilizer), T_2 = 100% cowdung - 10 t ha^{-1}, T_3 = 100% poultry manure - 5 t ha^{-1}, T_4 = 50% RDCF + 50% cowdung, T_5 = 50% RDCF + 50% poultry manure, T_6 = 25% RDCF + 75% cowdung, T_7 = 25% RDCF + 75% poultry manure

It was observed that the treatment T_4 (50% RDCF + 50% cowdung) gave the highest harvest index (46.09%) followed by T_5 (50% RDCF + 50% poultry manure) (45.41%) and T_7 (25% RDCF + 75% poultry manure) (44.98). The control treatment T_0 (no nutrient application) showed the lowest harvest index (39.54%) that was significantly different from other treatments. Arif *et al.* (2014) found similar result with the present study and reported higher harvest index with organic manure combined with NPK fertilizer. Similar result was also observed by Islam *et al.* (2015) and reported that combined application of organic manure and nitrogenous fertilizer increased grain yield and harvest index in rice.

4.4 Soil analysis

4.4.1 Particle density

Different doses of organic and inorganic fertilizer combinations showed non-significant variation for particle density of post harvest soil (Table 5 and Appendix IX). However, the highest particle density of post harvest soil (2.63 g cm^{-3}) was recorded by the control treatment T_0 (no nutrient application) whereas the lowest particle density of post harvest soil (2.44 g cm^{-3}) was found by the treatment T_4 (50% RDCF + 50% cowdung).

4.4.2 pH

Non-significant influence was observed by different doses of organic and inorganic fertilizer combinations for pH of post harvest soil (Table 5 and Appendix IX). However, the highest pH of post harvest soil (6.33) was recorded by the treatment T_4 (50% RDCF + 50% cowdung) whereas the lowest pH of post harvest soil (6.20) was found by the control treatment T_0 (no nutrient application).

4.4.3 Organic carbon content

Different doses of organic and inorganic fertilizers combinations gave non-significant variation for organic carbon content of post harvest soil (Table 5 and Appendix IX). However, the highest organic carbon content of post harvest soil (0.61%) was given by the treatment T_2 (100% cowdung - 10 t ha^{-1}) whereas the lowest organic carbon content of soil (0.51%) was shown by the control treatment T_0 (no nutrient application).

Table 5. Effect of organic and inorganic fertilizer on quality of post harvest soil (particle density, pH, organic carbon, available phosphorus, available sulphur)

Treatments	Soil analysis (particle density, pH, organic carbon, available phosphorus, available sulphur)				
	Particle density (g cm^{-3})	pH	Organic carbon (%)	Available phosphorus (ppm)	Available sulphur (ppm)
T_0	2.63	6.20	0.51	18.47 d	21.11 f
T_1	2.55	6.27	0.53	20.37 c	23.44 d
T_2	2.59	6.23	0.61	20.18 c	22.24 e
T_3	2.56	6.24	0.60	20.31 c	22.36 e
T_4	2.44	6.33	0.57	23.42 a	27.40 a
T_5	2.47	6.31	0.55	23.04 a	27.32 a
T_6	2.52	6.25	0.58	21.97 b	25.12 c
T_7	2.48	6.28	0.57	22.14 b	26.17 b
$LSD_{0.05}$	0.437^{NS}	0.611^{NS}	0.332^{NS}	0.507	0.603
CV(%)	3.63	4.26	3.71	5.28	6.11

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

T_0 = control (no fertilizer), T_1 = RDCF ($N_{120}P_{20}K_{40}S_{20}Zn_{2.5}$ -100% chemical fertilizer), T_2 = 100% cowdung - 10 t ha^{-1}, T_3 = 100% poultry manure - 5 t ha^{-1}, T_4 = 50% RDCF + 50% cowdung, T_5 = 50% RDCF + 50% poultry manure, T_6 = 25% RDCF + 75% cowdung, T_7 = 25% RDCF + 75% poultry manure

4.4.4 Available phosphorus (P) content

Significant influence was observed by different doses of organic and inorganic fertilizer combinations on available P content in soil after harvest of rice (Table 5 and Appendix IX). It was found that the treatment T_4 (50% RDCF + 50% cowdung) showed the highest P content of post harvest soil (23.42 ppm) which was statistically identical to T_5 (50% RDCF + 50% poultry manure) (23.04 ppm) while the lowest P content of post harvest soil (18.47 ppm) was given by the control treatment T_0 (no nutrient application).

4.4.5 Sulphur (S) content

Data on S content in post harvest soil of rice varied significantly by different doses of organic and inorganic fertilizer combinations (Table 5 and Appendix IX). It was observed that the treatment T_4 (50% RDCF + 50% cowdung) showed the highest S content of post harvest soil (27.40 ppm) which was statistically similar to T_5 (50% RDCF + 50% poultry manure) whereas the lowest S content in soil (21.11 ppm) was given by the control treatment T_0 (no nutrient application) that was significantly different from other treatments.

CHAPTER V

SUMMARY AND CONCLUSION

This experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207 during the period from November December 2020 to May 2021 to study the effect of organic and inorganic fertilizer application on rice production (BRRI dhan29). Single factor experiment was considered for the present study with eight treatments *viz.* T_0 = control (no nutrient application), T_1 = RDCF ($N_{120}P_{20}K_{40}S_{20}Zn_{2.5}$ -100% chemical fertilizer), T_2 = 100% cowdung - 10 t ha^{-1}, T_3 = 100% poultry manure - 5 t ha^{-1}, T_4 = 50% RDCF + 50% cowdung, T_5 = 50% RDCF + 50% poultry manure, T_6 = 25% RDCF + 75% cowdung and T_7 = 25% RDCF + 75% poultry manure. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The data on different growth parameter and yield were recorded.

Significant variation was found for the most of the parameters of the study influence by different organic and inorganic fertilizers combinations. For growth parameters, treatment T_1 (100% RDCF: $N_{120}P_{20}K_{40}S_{20}Zn_{2.5}$ kg ha^{-1}) exhibited the highest plant height at 60, 90 DAT and at harvest (83.73, 95.87 and 94.37 cm, respectively) but the treatment T_4 (50% RDCF + 50% cowdung) showed the highest number of tillers $hill^{-1}$ (13.13, 15.33 and 17.73, respectively), whereas control treatment T_0 (no nutrient application) showed the lowest plant height (70.05, 79.73 and 85.37 cm, respectively) and lowest number of tillers $hill^{-1}$ (9.87, 11.07 and 13.00, respectively).

For yield contributing parameters and yield, treatment T_4 (50% RDCF + 50% cowdung) performed best and showed the highest number of effective tillers $hill^{-1}$ (16.33), flag leaf length (24.28 cm), number of filled grains $panicle^{-1}$ (165.40), panicle length (25.94 cm), 1000 seed weight (21.90 g), grain yield (7.66 t ha^{-1}), straw yield (8.96 t ha^{-1}) and harvest index (46.09%) followed by

T_5 (50% RDCF + 50% poultry manure) and T_7 (25% RDCF + 75% poultry manure). On the other hand, the control treatment T_0 (no nutrient application) performed the lowest number of effective tillers hill^{-1} (10.80), flag leaf length (16.29 cm), number of filled grains panicle^{-1} (134.00), panicle length (17.37 cm), 1000 seed weight (17.57 g), grain yield (4.43 t ha^{-1}), straw yield (6.77 t ha^{-1}) and harvest index (39.54%). The minimum number of non-effective tillers hill^{-1} (1.33) and number of unfilled grains panicle^{-1} (5.89) were achieved by the treatment T_7 (25% RDCF + 75% poultry manure) while the maximum number of non-effective tillers hill^{-1} (2.20) and number of unfilled grains panicle^{-1} (12.55) were recorded from the control treatment T_0 (no nutrient application).

Regarding the status of post harvest soil, particle density, pH and organic carbon content were not influenced by different doses of organic and inorganic fertilizer combinations, however, the maximum particle density (2.63), pH (6.33) and organic carbon (0.61%) were recorded from T_0 (no nutrient application), T_4 (50% RDCF + 50% cowdung) and T_2 (100% cowdung - 10 t ha^{-1}), respectively. The lowest particle density (2.44) was recorded from T_4 (50% RDCF + 50% cowdung) treatment but the lowest pH (6.20) and organic carbon (0.51%) were recorded from T_0 (no nutrient application) treatment. The available P and S content of post harvest soil affected significantly by different doses of organic and inorganic fertilizers combinations and the maximum available P (23.42 ppm) and S (27.40 ppm) were recorded from the treatment T_4 (50% RDCF + 50% cowdung) whereas the lowest (18.47 ppm and 21.11 ppm, respectively) were recorded from the control treatment T_0 (no nutrient application).

From the above results, it can be concluded that the treatment T_4 (50% RDCF + 50% cowdung) was very much promising for higher rice production (BRRI dhan29) compared to other treatment combination. Treatment T_5 (50% RDCF + 50% poultry manure) and T_7 (25% RDCF + 75% poultry manure) also showed better performance. Whereas the control treatment T_0 (no nutrient application) showed the lowest performance. In terms of analysis of post harvest soil, particle density, pH and organic carbon content were not varied significantly among the treatments of organic and inorganic fertilizers combinations but available P and S of post harvest soil affected significantly. The treatment T_4 (50% RDCF + 50% cowdung) showed highest P and S content of post harvest soil followed by T_5 (50% RDCF + 50% poultry manure). So, the treatment T_4 (50% RDCF + 50% cowdung) was the best under the present study followed by T_5 (50% RDCF + 50% poultry manure) compared to other treatment combinations for rice production.

Recommendation

The present research work was carried out at the Sher-e-Bangla Agricultural University in one season only. Further trial of this work in different locations of the country is needed to justify the present results.

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APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location

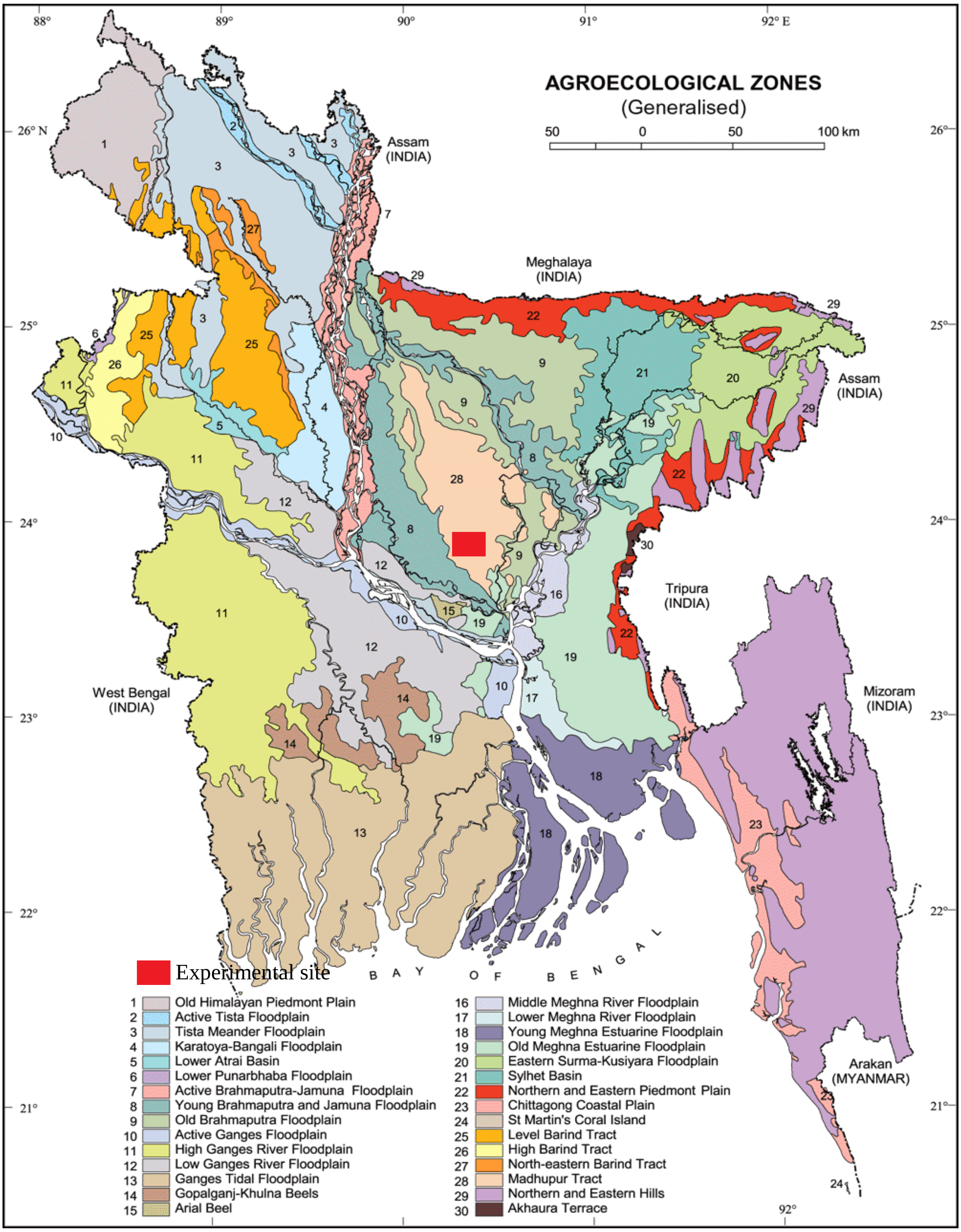

Figure 7. Experimental site

Appendix II. Monthly records of air temperature, relative humidity and rainfall during the period from December 2020 to May 2021.

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)
		Max	*Min*	*Mean*		
2020	December	25.50	6.70	16.10	54.80	0.0
2021	January	23.80	11.70	17.75	46.20	0.0
2021	February	22.75	14.26	18.51	37.90	0.0
2021	March	35.20	21.00	28.10	52.44	20.4
2021	April	34.70	24.60	29.65	65.40	165.0
2021	May	32.64	23.85	28.25	68.30	182.2

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka.

Appendix III. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
Particle size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam
pH	6.25
Organic carbon (%)	0.45
Organic matter (%)	0.78
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	23

Appendix IV. Effect of organic and inorganic fertilizer on plant height of rice (BRRI dhan29) at different growth stages

Sources of variation	Degrees of freedom	Mean square of plant height (cm)		
		60 DAT	90 DAT	At harvest
Replication	2	94.638	64.762	94.195
Treatment	7	96.450*	98.967*	44.976*
Error	14	3.823	5.893	5.322

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix V. Effect of organic and inorganic fertilizer on number of tillers $hill^{-1}$ of rice (BRRI dhan29) at different growth stages

Sources of variation	Degrees of freedom	Mean square of nnumber of tillers $hill^{-1}$		
		60 DAT	90 DAT	At harvest
Replication	2	0.982	2.285	5.807
Treatment	7	3.362**	5.958*	8.743*
Error	14	0.190	0.103	0.143

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VI. Effect of organic and inorganic fertilizer on effective and non-effective tillers $hill^{-1}$ and flag leaf length of rice (BRRI dhan29)

Sources of variation	Degrees of freedom	Mean square of yield contributing parameters		
		Number of Effective tillers $hill^{-1}$	Number of non-effective tillers $hill^{-1}$	Flag leaf length (cm)
Replication	2	5.407	0.260	13.933
Treatment	7	11.307*	0.270^{NS}	6.566*
Error	14	0.367	0.276	0.687

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VII. Effect of organic and inorganic fertilizer on filled grains and unfilled grains panicle^{-1}, panicle length and 1000 seed weight of rice (BRRI dhan29)

Sources of variation	Degrees of freedom	Mean square of yield contributing parameters			
		Number of filled grains panicle^{-1}	Number of unfilled grains panicle^{-1}	Panicle length (cm)	1000 seed weight (g)
Replication	2	329.824	27.089	0.108	0.052
Treatment	7	324.224*	12.368*	13.241*	5.969**
Error	14	20.601	0.290	0.202	0.031

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VIII. Effect of organic and inorganic fertilizer on yield parameters of rice (BRRI dhan29)

Sources of variation	Degrees of freedom	Mean square of yield parameters		
		Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
Replication	2	0.018	0.011	0.729
Treatment	7	3.205**	1.708**	12.015*
Error	14	0.019	0.020	0.111

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix IX. Effect of organic and inorganic fertilizer on quality of post harvest soil (particle density, pH, organic carbon, available phosphorus, available sulphur)

Sources of variation	Degrees of freedom	Mean square of analytical properties of post harvest soil of rice				
		Particle density (g cm^{-3})	pH	Organic carbon (%)	Available phosphorus (ppm)	Available sulphur (ppm)
Replication	2	0.014	0.022	0.001	1.052	1.106
Treatment	7	2.012^{NS}	5.104^{NS}	0.344^{NS}	16.307*	21.024*
Error	14	0.003	0.002	0.001	0.113	0.213

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Plate 1. Sprouting of seed

Plate 2. Layout with seedling transplanting

Plate 3. Transplanting of seedlings

Plate 4. Irrigation after transplantation

Plate 5. Weeding in rice field

Plate 6. Maximum tillering stage

Plate 7. Ripening stage of rice

Plate 8. Threshing of rice