# INFLUENCE OF MANURE AND PHOSPHORUS ON GROWTH AND YIELD OF AROMATIC RICE


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# INFLUENCE OF MANURE AND PHOSPHORUS ON GROWTH AND YIELD OF AROMATIC RICE

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## *CERTIFICATE*

*This is to certify that the thesis entitled* ***'INFLUENCE OF MANURE AND PHOSPHORUS ON GROWTH AND YIELD OF AROMATIC RICE'*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (MS)*** *in* ***AGRONOMY,*** *embodies the result of a piece of bona fide research work carried out by* ***TANJIN FATEMA HEYA****, Registration number:* ***14-05928,*** *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 duly been acknowledged.*

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*Dedicated to My Beloved Parents*

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*The Author*

# INFLUENCE OF MANURE AND PHOSPHORUS ON GROWTH AND YIELD OF AROMATIC RICE


## ABSTRACT

The field experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from July 2019 to November 2019 to find out the effect of manure and phosphorus on growth and yield of aromatic rice. Two factors were used in the experiment, *viz*. Manure– $M_0$ (control), $M_1$ (10 t $ha^{-1}$ cowdung) and $M_2$ (5 t $ha^{-1}$ poultry manure) and five levels of phosphorus application- $P_0$ (control), $P_1$ (25% lower dose than recommended dose of P), $P_2$ (recommended dose of P), $P_3$ (25% higher dose than recommended dose of P) and $P_4$ (50% higher dose than recommended dose of P). The experiment was laid out in a Split-plot design with three replications. Data on different growth, yield and yield contributing parameters were recorded. In case of manure, the tallest plant (115.55 cm), maximum tillers $hill^{-1}$ (11.57), effective tillers $hill^{-1}$ (10.68), panicle length (27.52 cm), filled grains $panicle^{-1}$ (172.21), total grains $panicle^{-1}$ (193.89), 1000 grains weight (26.28 g), grain yield (4.36 t $ha^{-1}$), straw yield (5.35 t $ha^{-1}$), biological yield (9.71 t $ha^{-1}$) and harvest index (44.85%) were achieved from the treatment $M_1$ (10 t cowdung $ha^{-1}$) where the lowest recorded from $M_0$ (control) treatment. In case of phosphorus, the tallest plant (123.27 cm), maximum tillers $hill^{-1}$ (11.87), effective tillers $hill^{-1}$ (11.02), panicle length (28.30 cm), filled grains $panicle^{-1}$ (175.08), total grains $panicle^{-1}$ (196.15), weight of 1000 grains (26.55 g), grain yield (4.43 t $ha^{-1}$), straw yield (5.39 t $ha^{-1}$), biological yield (9.83 t $ha^{-1}$) and harvest index (45.09%) were recorded from the treatment $P_3$ (25% higher dose than recommended dose of P) where the lowest on $P_0$ (control) treatment. In case of combined effect, the tallest plant (125.15 cm), maximum tillers $hill^{-1}$ (13.06), effective tillers $hill^{-1}$ (12.41), panicle length (30.85 cm), filled grains $panicle^{-1}$ (188.40), total grains $panicle^{-1}$ (204.93), 1000 grains weight (27.72 g), grain yield (4.87 t $ha^{-1}$), straw yield (5.76 t $ha^{-1}$), biological yield (10.63 t $ha^{-1}$) and harvest index (45.81%) were achieved from $M_1P_3$ treatment combination (10 t cowdung $ha^{-1}$ + 25% higher dose than recommended dose of P) where the lowest achieved from the treatment combination of $M_0P_0$ (control). Although the treatment combination of manure, $M_1$ (10 t cowdung $ha^{-1}$) with phosphorus treatment, $P_4$ (50% higher dose than recommended dose of P) gave similar result with treatment combination of manure $M_1$ (10 t cowdung $ha^{-1}$) with phosphorus treatment $P_3$ (25% higher dose than recommended dose of P) may be recommended for aromatic rice cultivation as this combination required lower dose of phosphorus.

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## LIST OF ACRONYMS

| ACRONYM | | FULL MEANING |
|---|---|---|
| AEZ | = | Agro-Ecological Zone |
| % | = | Percent |
| $^0C$ | = | Degree Celsius |
| BRRI | = | Bangladesh Rice Research Institute |
| cm | = | Centimeter |
| CV% | = | Percentage of coefficient of variance |
| cv. | = | Cultivar |
| DAT | = | Days after transplanting |
| *et al.* | = | And others |
| FAO | = | Food and Agriculture Organization |
| g | = | Gram |
| $ha^{-1}$ | = | Per hectare |
| kg | = | Kilogram |
| LSD | = | Least Significant Difference |
| MoP | = | Muriate of Potash |
| N | = | Nitrogen |
| No. | = | Number |
| NPK | = | Nitrogen, Phosphorus and Potassium |
| SAU | = | Sher-e-Bangla Agricultural University |
| SRDI | = | Soil Resources and Development Institute |
| t | = | Ton |
| TSP | = | Triple Super Phosphate |
| viz. | = | Videlicet (namely) |
| Wt. | = | Weight |

# CHAPTER I

# INTRODUCTION

# CHAPTER I

# INTRODUCTION

Rice (*Oryza sativa* L.) belongs to the Poaceae family of cereal crops. After wheat, in the world cereal crops, rice ranked second. In addition, Bangladesh is the 3$^{rd}$ largest country in the world based on the cultivation of rice (BBS, 2019). In Bangladesh, rice is the main food crop and around 11.35 million ha of the total arable land is used for rice cultivation (FAO, 2017). Rice is used as a staple food by almost half of the world's population. In Asia, over 90% of the rice in the world is grown (BBS, 2013). Rice alone occupies about 77% of the total cultivated area among the 150 different crops grown in Bangladesh. In Bangladesh, the area and production of total rice is approximately 11.35 million hectares and 35.56 million metric tons (BRRI, 2017).

In Bangladesh, annual per capita rice intake is the world's highest (Nasiruddin, 1993). It accounts for 76% of the caloric intake and 66% of the protein intake (BNNC, 2008). Its share of agricultural GDP is about 70%, whereas its share of national income is one-sixth. Bangladesh's population is still growing and will require about 47.26 million tons of rice by 2020 (BBS, 2016). But the average yield (2.98 t ha$^{-1}$) of rice is poor in Bangladesh (BRRI, 2017). Aus, Aman and Boro, there are three rice growing seasons that have appeared distinctly almost all over in Bangladesh. In the seasons of Aus, Aman and Boro, the total yield of rice were 2.92, 15.34 and 19.91 million metric tons, respectively (BBS, 2019).

Most of the aromatic rice varieties in Bangladesh are of traditional type, are sensitive to photoperiods and are grown during the Aman season in lowland rainfall (Das and Baqui, 2000). Thirty percent of the rice land in northern Bangladesh districts was occupied by aromatic rice cultivars during the Aman season. In the international rice trade, aromatic rice plays an important role, as well as other varieties, such as Kataribhog, Bansful and Chinigura, Bangladesh mainly exports Kalizira, a highly aromatic variety. Bangladesh has a promising prospect of earning foreign exchange for exporting fine rice (Islam *et al.*, 2012). Aromatic rice is the most highly valued rice commodity in Bangladesh agricultural trade markets having small grain and pleasant aroma with soft texture upon cooking (Dutta *et al*., 2002). Aromatic rice is mainly used by the people in the preparation of palatable dishes and sold at a higher price in the market due to its special appeal for aroma and acceptability. Most of the rice exported in the international market is par-boiled (Atap) and sticky rice. But 95 per cent of rice produced in Bangladesh is hard grained with hardly any demand in the international market. However, Bangladesh exports about 50,000 tons of fragrant rice to the Middle East, the US and Europe every year. The main consumers of this rice are expatriate Bangladeshis (Mahmud, 2019). Still Bangladesh has a bright prospect for export of this fine rice thereby earning foreign exchange. The yield of aromatic rice is much lower than those of other rice growing countries because of lack of improved variety and judicious fertilizer management (Islam *et al.*, 1996).

Manuring is becoming an increasingly significant part of environmentally healthy and long-term farming. Plant nutrients are replenished in agricultural soils primarily through inorganic, organic and biofertilizers (Havlin and Heiniger, 2020). Inorganic fertilizers are used indefinitely, causing a decline in soil chemical, physical, and biological qualities, as well as soil health (Singh, 2018). Chemical fertilizer's negative effects, combined with rising prices, have sparked a surge in interest in organic fertilizers as a nutritional source (Singh, 2018; Willy *et al.*, 2019). For sustainable agricultural production, the use of organic resources as fertilizers has obtained plenty of attention (Chew *et al.*, 2019; Tahat, 2020). Organic materials have a plenty of potential as a source of numerous nutrients and as a method for improving soil properties (Ding *et al.*, 2016). Organic manure can provide a good amount of plant nutrients, which can help increase rice yield. As a result, in order to achieve a sustainable crop yield without depleting soil fertility, it is necessary to fertilize and manure in a coordinated manner. In a rice–rice cropping pattern, the integrated use of chemical and organic manure is critical for long-term crop productivity and soil fertility (Bilkis *et al.*, 2018). Soil organic matter boosts crop output by improving the physicochemical characteristics of the soil.

Cowdung and poultry manure are the most popular and promising bulky organic manures produced from solid and 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 cow dung, poultry manure and water hyacinth to the crop field is essential for fertility and productivity and maintenance of this soil (Singh *et al.*, 1999). Poultry manure is one of the most promising manure in our country, which provides an opportunity to uptake nutrients by plants for a long time, though the poultry farming is now-a-days getting popularity (Choudhary and Suri, 2009). Application of cowdung and poultry manure alone or in combination with recommended fertilizer dose can play important role in rice cultivation (Hossain *et al.*, 1997 and Chettri *et al.*, 2002).

Among potential of three primary elements (NPK), phosphorus is relatively absorbed by the plants in small amount than other two, but plays an equally important role. Phosphorus is the second most required plant nutrient for field crops. It plays a vital role in several physiological processes of plants (Mandal and Khan, 1972; Singh and Sale, 2000; Chang *et al.*, 2007; Amanullah, 2011; Vahed *et al.*, 2012). Phosphorus is critical in plant metabolism which plays an important role in cellular energy transfer, respiration, photosynthesis and it is a key structural component of nucleic acids coenzymes, phosphorproteins and phospholipids. Phosphorus fertilization is a major input in crop production (Blackshaw *et al.*, 2004). Phosphorus deficiency results in decreased leaf number, leaf blade, reduced panicles plant$^{-1}$, grains panicle$^{-1}$, and reduced filled grain panicle$^{-1}$ (Aide and picker, 1996). Phosphorus status in Bangladesh soil is quite low. So application of phosphatic fertilizer is essential to obtain higher yield.

Integrated use of mineral phosphorus along with animal manures or plant residues can improve rice growth and yield. Management of organic manures and chemical fertilizers account for 50-60% of the increase in field crop productivity (Dipa, 2006). Studies from different parts of the world have suggested that application of animal manures increase the yield of various crops (Olayinka, 1996; Olayinka *et al.*, 1998; Ismail *et al.*, 1990; Adepetu *et al.*, 2005; Ayoola and Makinde, 2008; Hidayatullah *et al.*, 2013; Iqbal *et al.*, 2015; Amanullah and Khalid, 2016).

Keeping the above facts in view the present experiment was undertaken with following objectives:

i. To identify the best manure for growth and yield of aromatic rice,
ii. To find out an appropriate dose of phosphorus for aromatic rice cultivation, and
iii. To select the best combination of manure and phosphorus level on growth and yield of aromatic rice.

# CHAPTER II

# REVIEW OF LITERATURE

# CHAPTER II

# REVIEW OF LITERATURE

Rice is one of the most common and important cereal crops in Bangladesh, as well as many other countries around the world. Organic and inorganic fertilizer management has an impact on growth and yield of aromatic rice. Various researchers from around the world have conducted studies on the effect of manure and phosphorus on growth and yield of rice. Many studies on growth and yield have been conducted in many countries around the world. The work done in Bangladesh thus far has been insufficient and conclusive. Nonetheless, some of the most important and informative works and research findings on this topic have been reviewed in this chapter under the following headings:

## 2.1 Effect of manure on growth, yield contributing parameters and yield of rice

Anisuzzaman *et al.* (2021) conducted a pot experiment at the net house on field 10, University Putra Malaysia, UPM, Malaysia, 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.

Haque *et al.* (2021) conducted a study to evaluate the optimum rate and source of organic amendments on rice productivity and soil fertility along with $CH_4$ emission. A total of nine nutrient combinations were used in the study. The $CH_4$ emission, soil redox potential (Eh), soil pH, soil nitrogen and organic carbon, available phosphorus, rice grain and straw were greatly affected by the application of different rates and sources of the nutrient. However, the soil exchangeable K content, plant height, and harvest index were not affected. Among the treatments, the application of 75% recommended fertilizer (RF) + biosolid 2 t $ha^{-1}$ ($T_3$) was the most effective and showed the superior performance in terms of available P (12.90 ppm), the number of grains $panicle^{-1}$ (121), and 1000-grain weight (24.6 g), rice grain, and straw yield along with the moderate $CH_4$ emission (18.25 mg $m^{-2}h^{-1}$). On the other hand, the lowest soil Eh (-158 mV) and soil pH (6.65) were measured from the treatment $T_3$. The finding of this study revealed that the application of 75% of RF + biosolid 2 t $ha^{-1}$ can be recommended as the preferable soil amendment for boosting rice yield, reduce $CH_4$ emissions, and sustainably maintain soil fertility. Furthermore, this finding may help to introduce preferable soil amendment doses, which will contribute to boosting rice productivity and economic turnouts of the farmers.

Ismael *et al.* (2021) carried out the present study aimed to assess the impact of combined fertilization strategies using urea and animal manure (beef cattle manure and poultry litter manure) on rice yield and nutrient uptake. For this, a field experiment was carried out on a loam sandy soil in the Chokwe Irrigation Scheme. They set seven treatments in a Randomized Complete Block Design (RCBD), namely: $T_0$: no fertilizer, $T_1$: 100% urea, $T_2$: 100% beef cattle manure, $T_3$: 100% poultry litter, $T_4$: 50% urea + 50% beef cattle manure, $T_5$: 50% urea + 50% poultry litter and $T_6$: 40% urea + 30% beef cattle manure + 30% poultry litter, replicated four times each. All treatments, except $T_0$, received an amount of nitrogen (N) equivalent to 100 kg N $ha^{-1}$. Results revealed that the highest yield grain (425 g $m^{-2}$), plant height (115 cm), number of tillers (18) and thousand-grain weight (34 g) were observed in treatments combining urea with manure ($T_4$, $T_5$ and $T_6$) indicating that N supply in the mixture (urea + manure) is more efficient than in isolated applications of N ($T_1$, $T_2$ and $T_3$). The data obtained in this study suggest that a combination of fertilizers ($T_6$) lead to competitive yields and is thus recommended for best soil management practices.

Iqbal *et al.* (2020) carried out a study to evaluate the integrated effect of poultry manure (PM) and cattle manure (CM) with CF on soil properties, plant physiology, and rice grain yield. Additionally, the difference in pre-and post-anthesis dry matter (DM) and nitrogen (N) accumulation and their relationship with grain yield was also determined. Pot experiments were performed in the early and late growing season at the experimental station of Guangxi University, China, in 2018. A total of six treatments, i.e., $T_1$-$CF_0$; $T_2$–100% CF; $T_3$–60% CM + 40% CF; $T_4$–30% CM + 70% CF; $T_5$–60% PM + 40% CF, and $T_6$–30% PM + 70% CF were used in this pot experiment. Results showed that $T_6$ enhanced leaf photosynthetic efficiency by 11% and 16%, chlorophyll content by 8% and 11%, panicle number by 12% and 16%, and grain yield by 11% and 15% in the early and late seasons, respectively, compared to $T_2$. Similarly, post-anthesis N and DM accumulation, N uptake, and soil properties (i.e., soil organic carbon, total N, and bulk density) were improved with integrated CF and manure treatments over the sole CF treatments. Interestingly, increases in post-anthesis N uptake and DM production were further supported by enhanced N-metabolizing enzyme activities (i.e., nitrate reductase, glutamine synthetase, and glutamate oxoglutarate aminotransferase during the grain-filling period in combined treatments. In-addition, the linear regression analysis showed that post-anthesis DM ($R^2$ = 0.95) and N ($R^2$ = 0.96) accumulation were highly associated with grain yield of rice. Thus, the combination of 30% N from PM or CM with 70% N from CF (i.e., urea) is a promising option for improvement of soil quality and rice grain yield. Furthermore, our study provides a sustainable nutrient management plan to increase rice yield with high N use efficiency.

Kakar *et al.* (2020) conducted a research that elucidates 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. Both AMRD and SDRD treatments increased the percentage of protein, amylose, and lipid contents, as well as the percentage of perfect grain compared to the RD treatment. Rice grain in RD treatment had very few protein bodies and their traces (pits), as well as the formation of amyloplasts and starch granules, were normal. However, AMRD and SDRD increased the number of protein bodies and their pits in the rice endosperm. The shapes of the amyloplasts were round and polyhedral with diverse sizes. Starch granules were polygonal with sharply defined edges. This research encourages farmers to adopt the combined application of manures and fertilizers to decrease the dependence on inorganic fertilizers.

Schmidt and Knoblauch (2020) conducted an experiment to evaluate changes in the soil chemical properties, nitrogen use efficiency, and grain yield of flood-irrigated rice fields after the addition of poultry manure during five years. Trials were carried out in a randomized complete block design, with three replicates. The treatments were: chemical fertilizers, N-$P_2O_5$-$K_2O$; control, no fertilizers; and poultry manure doses, 2.5, 5.0, and 10.0 Mg $ha^{-1}$. Poultry manure increased soil pH, base saturation, and phosphorus, potassium, calcium, and zinc contents more than the chemical fertilizers. Adding poultry manure to the soil increased the N ammonification (35 mg $kg^{-1}$ $NH_4^+$-N) from the first to the fourth week after rice was sown. The exclusive use of poultry manure was not sufficient to provide adequate nutrition to rice plants after the decrease in $NH_4^+$-N content in the soil. The cumulative N uptake by plants and rice yield were lower with poultry manure application than with the chemical fertilizers. Adding poultry manure to flood-irrigated rice fields for five years alters soil chemical properties, improves fertility, does not favor nitrogen use efficiency by rice plants, and promotes a lower grain yield than the chemical fertilizers.

Hoque *et al.* (2019) conducted a field experiment at two locations i.e. at Soil Science Field of Bangladesh Agricultural University and at Farmer's field of Fakirakanda village of Mymensingh Sadar to evaluate the effects of different organic fertilizers on the growth and yield of rice (BRRI dhan28). The experiments at each location containing seven treatments were laid out in a randomized complete block design with three replications. The treatments were $T_0$: Control, $T_1$: 75% RFD; $T_2$: 100% RFD, $T_3$: 75% RFD + Kazi Jaibo Shar (5 $tha^{-1}$), $T_4$: 75% RFD + Kazi Jaibo Shar (3 t $ha^{-1}$), $T_5$: 75% RFD + Poultry manure (3 t $ha^{-1}$) and $T_6$: 75% RFD + Cow dung (5 t $ha^{-1}$). Application of poultry manure as well as Kazi Jaibo Shar showed positive effects on yield attributes, grain and straw yields of rice, nutrient (N, P, K and S) contents and uptake by grain, straw and in total. The performance of 75% RFD with poultry manure @ 3 t $ha^{-1}$ was the best in producing yield components, grain and straw yields of rice. At both locations, the performance of same dose (3 t $ha^{-1}$) of poultry manure and Kazi Jaibo Shar was almost similar in producing growth and yield contributing characters, grain and straw yields, nutrient content and uptake by rice while each of these manures compensated up to 25% of recommended chemical fertilizers. Therefore, considering the soil health, poultry manure or Kazi Jaibo Shar @ 3 t $ha^{-1}$ is recommended for growth and yield enhancement in rice.

Bilkis *et al.* (2018) carried out an experiment to evaluate the effect of integrated use of manure and fertilizers on crop yield, nutrient uptake and soil fertility in the Boro-fallow-T. Aman cropping pattern over two years. The experiment was set up at Bangladesh Agricultural University (BAU) farm, Mymensingh under the AEZ 9 (Old Brahmaputra Floodplain). The field trial consisted of eight treatments and control (no fertilizer or manure), 100% chemical fertilizers (CF) and IPNS based six treatments with six types of manure. Cowdung (CD), CD slurry, Trichocompost (TC) and vermicompost (VC) were added to soil at 5 t $ha^{-1}$ and poultry manure (PM) and PM slurry applied at 3 t $ha^{-1}$. For all IPNS treatments, nutrient supply from manure was adjusted with that from chemical fertilizers. In each crop cycle, manure was applied to the first crop (Boro rice) and the residual effect was evaluated on the succeeding crop (T. Aman rice). The IPNS based treatments significantly increased the grain and straw yields of Boro rice and it had also positive residual effect on T. Aman rice. Trichocompost and vermicompost, among the six IPNS treatments, demonstrated higher crop yield and that was followed by poultry manure slurry and cowdung slurry. Integrated use of manure with fertilizers gave on an average 8.3-33.8% and 2.9-18.3% higher grain yield in Boro and T. Aman rice, respectively over sole fertilizers treatment. Higher nutrient uptake by crops (N, P, K and S) was also observed in IPNS treated plots. The IPNS treatments improved soil fertility in terms of increasing organic matter, N, P and S contents of soil after two crop cycles. The study suggests that manure and fertilizers should be used in an integrated manner to achieve sustainable crop yield, without incurring loss to soil fertility.

A field experiment was conducted by Khatun *et al.* (2018) to evaluate the growth, yield and yield characteristics of aromatic rice (cv. Tulshimala) under the fertilization of cow dung (organic manure) and zinc (micronutrient). From the results of the experiment, the application of different levels of cow dung and zinc fertilizers showed that the total number of tillers $hill^{-1}$, productive number of tillers $hill^{-1}$, panicle length, test weight ( g), grain yield $hill^{-1}$ (g), straw yield $hill^{-1}$ (g), grain yield (t $ha^{-1}$), straw yield (t $ha^{-1}$) and biological yields over control were significantly increased. However, the combination of $CD_1Zn_2$ i.e. 10 t $ha^{-1}$ cowdung and 12 kg $ha^{-1}$ $ZnSO_4$ together with other recommended inorganic fertilizer doses produced the highest yield of grain (2.79 t $ha^{-1}$) and straw yield (5.80 t $ha^{-1}$) over other treatments.

An examination was directed by Sarkar *et al.* (2016) to evaluate the yield and nature of aromatic fine rice as influenced by variety and nutrient management during the period from June to December 2013. The test included three aromatic fine rice varieties *viz.* BRRI dhan34, BRRI dhan37 and BRRI dhan38, and eight nutrient management *viz.* control (no manures and fertilizers), suggested portion of inorganic fertilizers, cowdung at 10 t $ha^{-1}$, poultry manure at 5 t $ha^{-1}$, 50% of suggested portion of inorganic fertilizers + 50% cow-dung, 50% of suggested portion of inorganic fertilizers + 50% poultry manure, 75% of suggested portion of inorganic fertilizers + 50% cow-dung and 75% of suggested portion of inorganic fertilizers + 50% poultry manure. The examination was laid out in a randomized complete block design with three replications. The tallest plant (142.7 cm), the most elevated number of effective tillers $hill^{-1}$ (10.02), number of grains $panicle^{-1}$ (152.3), panicle length (22.71 cm), 1000-grain weight (15.55 g) and grain yield (3.71 t $ha^{-1}$) were recorded in BRRI dhan34. The most elevated grain protein content (8.17%) was found in BRRI dhan34 though the most elevated fragrance was found in BRRI dhan37 and BRRI dhan38. The most noteworthy 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 supplement the executives of 75% suggested portion of inorganic fertilizers + 50% cowdung (5 t $ha^{-1}$). The treatment control (no manures and fertilizers) gave the lowest values for these attributes. The most elevated grain yield (4.18 t $ha^{-1}$) was found in BRRI dhan34 combined with 75% suggested portion of inorganic fertilizers + 50% cowdung, which was factually indistinguishable from BRRI dhan34 joined with 75% of suggested portion of inorganic manures + half poultry manure and the least grain yield (2.7 t $ha^{-1}$) was found in BRRI dhan37 in charge (no manures and manures). The most elevated grain protein content (10.9 %) was acquired in the association of BRRI dhan34 with suggested portion of inorganic fertilizers which was in the same class as that of BRRI dhan38 and 75% of suggested portion of inorganic fertilizers + 50% poultry manure. The most noteworthy aroma was found in BRRI dhan38 combined with 75% suggested portion of inorganic fertilizers + 50% cowdung.

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$^{-1}$) and straw yield (7.28 t ha$^{-1}$) 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.

Moe *et al.* (2017) investigated the effect of combining organic and inorganic fertilizers on the growth and yield of hybrid rice (Palethwe-1) in the dry and wet seasons of 2015. Four quantities of inorganic fertilizer were used in the main plot [0%, 50%, 75%, and 100% nitrogen, phosphorus, and potassium (NPK)] based on the recommended amounts of 150 kg N ha$^{-1}$, 70 kg $P_2O_5$ ha$^{-1}$, and 120 kg $K_2O$ ha$^{-1}$, while different organic manures were applied to subplots [no organic manure ($O_0$), cow manure ($O_c$), poultry manure ($O_p$), and vermicompost ($O_v$); all at 5 t ha$^{-1}$] as part of a split-plot experimental design with three replicates. In both seasons, significant differences in growth parameters including number of tillers hill$^{-1}$, soil-plant analysis development (SPAD) values, total dry matter, yield, and yield components were observed in plants supplied with different inorganic fertilizers. The 100% NPK ($I_{100}$) fertilizer produced the maximum yield but similar yields were achieved in plots supplied with 50% NPK ($I_{50}$) and 75% NPK ($I_{75}$). Significant differences in growth and yield parameters were also found in crops supplied with organic manures. Although identical quantities were supplied, $O_p$ produced the best growth parameters in both seasons including total dry matter, yield, and yield components. $O_c$ also performed well. Combining inorganic and organic fertilizers demonstrated that $I_{50}$ together with $O_p$ (5 t ha$^{-1}$) provided similar growth, total dry matter, and yield parameters to $I_{100}$ in both seasons. $O_c$ (5 t $ha^{-1}$) plus $I_{75}$ also achieved similar yields to $I_{100}$. This study demonstrates that the combined application of inorganic fertilizers and organic manures has the potential to reduce chemical fertilizer usage without decreasing the yield of hybrid rice, and can enhance the growth, yield, and yield components of Palethwe-1.

Arif *et al.* (2014) conducted a field experiment to evaluate the integrated use of organic and inorganic manures on the yield of rice at Chakkanwali Reclamation Research Station, District Gujranwala, Pakistan during kharif 2012. The organic sources used were farmyard manure, poultry manure, rice straw, sesbania, compost and mung bean residues alone and in combinations with 50% of recommended dose of fertilizer (RDF). Recommended dose of fertilizer (150-90-60 kg NPK $ha^{-1}$) 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 $ha^{-1}$), grain yield (4.47 t $ha^{-1}$) 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.

Siavoshi *et al.* (2011) carried out an experiment in 2008 and 2009, in randomized block design based on 4 replications. The chicken manure, cow manure and paddy rice were mixed together in 1:1:0.5 ratio to from organic fertilizer. The treatments of organic fertilizer were given in 5 levels (0.5, 1.0, 1.5, 2.0 and 2.5 ton/ha). At one level organic fertilizer 1.5 ton $ha^{-1}$ was mixed with inorganic fertilizers (N-50, P-25, K-25 kg $ha^{-1}$) and recommended dose of inorganic fertilizer-NPK (N=100, P=50, K=50 kg $ha^{-1}$) was used as check. The plants without treatments were served as control. Grain yield and its components were significantly increased in all the treatments over control. The maximum grain yield in 2008 (4335.88 kg $ha^{-1}$) was noted in plants treated with 2 ton $ha^{-1}$ organic fertilizer and it was (4662.71 kg $ha^{-1}$) for 2009 for plant treated with combination of chemical fertilizer + 1.5 ton $ha^{-1}$ organic fertilizer. An increase in the grain yield at the abovementioned treatments was may be due to the increase of 1000-seed weight, panicle number, number of fertile tiller, flag leaf length, number of spikelet, panicle length and decrease number of hollow spikelet per panicle.

Hasanuzzaman *et al.* (2010) conducted an experiment at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh (90°33' E longitude and 23°77' N latitude) during June to November, 2008 with a view to observe the comparative performance of different organic manures and inorganic fertilizers on the growth and productivity of transplanted rice. The experiment comprises of 10 treatments viz. $T_1$ (Control), $T_2$ (Green manure @ 15 t $ha^{-1}$), $T_3$ (Green manure @ 15 t $ha^{-1}$ + $N_{40}P_6K_{36}S_{10}$ i.e.50% NPK), $T_4$ (Poultry manure @ 4 t $ha^{-1}$), $T_5$ (Poultry manure @ 4 t $ha^{-1}$ + $N_{40}P_6K_{36}S_{10}$ i.e. 50% NPK), $T_6$ (Cowdung @ 12 t $ha^{-1}$), $T_7$ (Cowdung @ 12 t $ha^{-1}$ + $N_{40}P_6K_{36}S_{10}$ i.e. 50% NPK), $T_8$ (Vermicompost @ 8 t $ha^{-1}$), $T_9$ (Vermicompost @ 8 t $ha^{-1}$ + $N_{40}P_6K_{36}S_{10}$ i.e. 50% NPK) and $T_{10}$ ($N_{80}P_{12}K_{72}S_{10}$ i.e.100% NPK). Plant characters, yield attributes and yield were significantly influenced by different treatments. Except plant height, total tiller per hills and biological yield all the parameters were found to be highest with the treatment $T_5$ (Poultry manure @ 4 t $ha^{-1}$ + $N_{40}P_6K_{36}S_{10}$ i.e. 50% NPK). From our study we observed that among the treatments $T_5$ (Poultry manure @ 4 t $ha^{-1}$ + 50% of recommended NPK) produced the highest grain yield (4.79 t $ha^{-1}$) of rice which was statistically identical to $T_{10}$ (100% of recommended NPK) and $T_9$ (Vermicompost @ 8 t $ha^{-1}$ + $N_{40}P_6K_{36}S_{10}$) which resulted grain yield of 4.57 t $ha^{-1}$ and 4.51 t $ha^{-1}$, respectively. Vermicompost was found as the best manures when it was applied alone. The economic analysis also showed that the application of $T_5$ maximized the profit and benefit-cost ratio (BCR) was the height (1.75) in the treatment which was almost similar to $T_{10}$. The lowest BCR (1.07) was obtained from control treatment ($T_1$).

Xu *et al.* (2008) conducted an experiment to evaluate the effect of organic manure application with chemical fertilizers on rice yield and soil fertility under long-term double-rice cropping system. Four different treatments, i.e., no nitrogen with chemical P and K (PK), swine manure only (M), N, P and K chemical fertilizers only (NPK), and half chemical fertilizers combined with half swine manure (NPKM) with four replications were included. Each N, P and K application rate was the same at all the treatments (except the N application rate at PK) and N application rate was 150 kg N $ha^{-1}$. All fertilizers were applied to soil tillage layer with once application as basal fertilizers. The nutrients uptake rate, grain yield, nitrogen use efficiency, and soil organic matter content at each treatment were investigated. The NPKM treatment achieved the highest mean annual yield of 12.2 t $ha^{-1}$ (68% higher than that of PK). Higher dry matter accumulation and nutrients absorption were observed during the middle-late growth period in the NPKM treatment, with higher panicle number per unit and filled-grain number per panicle. Its average nitrogen use efficiency was 36.3% and soil organic matter increased by 18.5% during the experimental period in the NPKM treatment, which were significantly higher than those in the NPK treatment. Organic manure application with chemical fertilizers increased the yield and nitrogen use efficiency of rice, reduced the risk of environmental pollution and improved soil fertility greatly. It could be a good practical technique that protects the environment and raises the rice yield in this region.

### 2.2 Effect of phosphorus on growth, yield contributing parameters and yield of rice

Moe *et al.* (2019) carried out two-year's field experiments, the nitrogen, phosphorus, and potassium (NPK) status, growth characteristics and yield of rice were examined by application of poultry manure (PM), cow manure (CM) and compost (CP). Organic fertilizers were applied as EMN (estimated mineralizable N) based on their total N content. Six treatments were assigned in a randomized complete block design: (1) no-N fertilizer ($N_0$); (2) 50% CF ($CF_{50}$), (3) 100% CF ($CF_{100}$); 50% CF + 50% EMN from (4) PM or (5) CM or (6) CP. Compared with $CF_{100}$, the $CF_{50}PM_{50}$ (total N ≥ 4%) accumulated higher N, P and K content in leaf, sheath, panicle and seeds, resulting in greater growth and yield. The $CF_{50}PM_{50}$ increased yield by 8.69% and 9.70%, dry matter by 4.76% and 5.27% over $CF_{100}$ in both years. The continuous application of $CF_{50}CM_{50}$ (total N < 4%) and $CF_{50}CP_{50}$ (total N < 4%) treatments led to similar NPK contents but higher yields than those of $CF_{100}$ treatment in 2018. In conclusion, the organic fertilizer (total N ≥ 4%) with the EMN method enhances higher N availability in each year. Continuous application of organic fertilizer (total N < 4%) over two years effectively increased N availability in the second year. The 50% organic fertilizer (total N ≥ 4%) and 50% CF led to increased NPK availability and rice yields over the 100% CF treatment, reducing CF usage and leading for sustainable agriculture.

Nahar (2018) conducted a study to determine the effect of bio-organic fertilizer with reduced chemical fertilizer for rice yield maximization. The treatments were (i) control (without fertilizer), (ii) N, P, K at recommended rate i.e. 100% (120, 30, 60 kg ha-1), (iii) N and P (75%), and K (recommended rate) with biofertilizer (5 t $ha^{-1}$) and (iv) N and P (50%), and K (recommended rate) with biofertilizer (10 t $ha^{-1}$). Results showed that N and P (50%) with biofertilizer (10 t $ha^{-1}$) increased the number of tillers (29), panicle length (28 cm), weight of 1000 grain (21.31 g), and produced the highest grain yield (7.26 t $ha^{-1}$). There was no significant difference found among the N, P (75%) with biofertilizer (5 t $ha^{-1}$) and N, P (50%) with biofertilizer (10 t $ha^{-1}$) treatments for plant height, number of panicle $plant^{-1}$ and harvest index (%). The application of biofertilizer with beneficial microbes improved the leaf chlorophyll, plant nutrient uptake and grain protein content in rice. Hence, the use of chemical N and P fertilizer can be minimized by 50 percent and improve rice yield with the supplement of 5 ton $ha^{-1}$ of bio-organic fertilizer.

Sharada and Sujathamma (2018) conducted an experiment aimed to test the effect of the different organic fertilizer and combinations of organic and inorganic fertilizers on the qualitative and quantitative parameters of two cultivars of rice as DRR Dhan 39 and RP.BIO.226. The experiment was conducted on the farm located at Fasalwadi village, Sangareddy district, Telangana during *kharif* season in randomized complete block design with three replications. The treatment included two controls and 10 combinations of four organic fertilizers as farmyard manure, vermicompost, Panchagavya, Jeevamrutha and inorganic fertilizers as combination of 60:75:75 levels of N, P and K. Grain and straw samples were collected and physical parameters were measured at harvest stage. The results indicated that the variety DRR Dhan 39 gave the statistically significant ($P<0.0001$) higher grain yield of 8713 kg $ha^{-1}$ and straw yield of 9483 kg $ha^{-1}$ with 50% organic fertilizers of Vermicompost, Jeevamrutha 5% and Panchagavya 3% and 50% inorganic fertilizer of NPK. On the other hand, the variety of RP.BIO.226 gave the highest grain yield of 6390 kg $ha^{-1}$ with Vermicompost, Jeevamrutha 5% and Panchagvya 3% (8 t $ha^{-1}$, foliar spray and 500 litres $ha^{-1}$) and highest straw yield of 7430 kg $ha^{-1}$ with $T_{10}$ treatment (50% organic fertilizers of Vermicompost, Jeevamrutha 5% and Panchagavya 3% and 50% inorganic fertilizer of NPK). Both varieties of rice poorly responded to inorganic fertilizers with lower grain and straw yield. Statistically significant differences were observed in both varieties of grain crude protein (CP%), straw acid detergent fiber (ADF%), crude fiber (CF%) and acid detergent lignin (ADL%) with different fertilizers.

Massawe and Mrema (2017) conducted an experiement to investigate the effects of phosphorus (P) from Minjingu Phosphate Rock (MPR), Minjingu mazao and Triple Super Phosphate (TSP) fertilizers under irrigated rice (*Oryza sativa* L.) production was conducted in two sites of Lekitatu village, Meru district, Arusha region, Tanzania. The fertility status of the soils and their suitability for rice production at two experimental sites were evaluated based on technical indicators of soil fertility. The major soil fertility limitations included low soil organic matter, low total nitrogen and medium available phosphorus hence the rice soils in Lekitatu village were categorized as of low fertility status and moderately suitable for rice production. A Randomized Complete Block Design (RCBD) with three replications was adopted. Phosphorus was applied at the rates of 0, 20, 40 and 60 kg P $ha^{-1}$ as MPR, Minjingu mazao and TSP. Nitrogen was applied uniformly at a rate of 60 kg N $ha^{-1}$ as urea to the MPR, Minjingu mazao and TSP treatments plots taking into account the 10% N contained in the Minjingu mazao fertilizer. The P fertilizers were broadcasted and incorporated into the soils before transplanting the rice seedlings and N was applied at two equal splits, namely at tillering and panicle initiation stages. The ranges in yield components between the control (0 kg P $ha^{-1}$) and the highest levels of P fertilizer (60 kg P $ha^{-1}$) were 23.47-64.97, 23.47-66.17 and 23.47-60.03 cm plant heights, 12-22, 12-19 and 12-22 number of tillers per plant, 7.67-25.97, 7.67-26.83 and 7.67-30.20 t $ha^{-1}$ dry matter yields, 3.97-15.70, 3.97-17.03 and 3.97-15.77 $tha^{-1}$ straw dry matter yields and 1.5-8.63, 1.5-9.23 and 1.5-10.43 $tha^{-1}$ grain yields for MPR, TSP and Minjingu mazao, respectively. The P fertilizers applications increased rice yield components as the levels of P increased from 0 to 60 kg P $ha^{-1}$ for all P sources. The yield components increased significantly ($P<0.05$) with increasing rates of P application. The increases were due to increased availability and uptake of plant nutrients particularly P. Based on the generated yields data, it was thus concluded that: Minjingu mazao at the rates of (40 to 60 kg P $ha^{-1}$), MPR and TSP at a rate of 60 kg P $ha^{-1}$, respectively could be adopted for increased and sustainable rice production in Lekitatu village.

Sarkar *et al*. (2014) conducted an experiment to examine the yield and quality of aromatic fine rice as influenced by variety and fertilizer management. The experiment contained three aromatic fine rice varieties *viz*. BRRI dhan34, BRRI dhan37 and BRRI dhan38. The highest plant height (142.7 cm), the highest number of effective tillers hill$^{-1}$ (10.02), grains number panicle$^{-1}$ (152.3), panicle length (22.71cm), 1000-grain weight (15.55g) and grain yield (3.71 t ha$^{-1}$) were achieved in BRRI dhan34.

Tadesse *et al.* (2013) conducted a field experiment to assess the effects of combined application of farm yard manure (FYM) and inorganic NP fertilizers on soil physico-chemical properties and nutrient balance in a rain-fed lowland rice production system in Fogera plain, northwestern Ethiopia. The study was carried out during the main cropping seasons of 2010 and 2011. Twenty-seven treatments comprising a factorial combination of three rates of FYM (0, 7.5, and 15 t ha$^{-1}$), three rates of nitrogen (0, 60, 120 kg N ha$^{-1}$) and three rates of phosphorus (0, 50 and 100 kg $P_2O_5$ ha$^{-1}$) were tested. The experiments were laid out as a randomized complete block design with three replications. Bulk density, organic matter content, and available water holding capacity, total N, and available P of the soil were measured just after harvesting the rice crop. Results showed that application of 15 t FYM ha$^{-1}$ significantly increased soil organic matter and available water holding capacity but decreased the soil bulk density, creating a good soil condition for enhanced growth of the rice crop. Application of 15 t FYM ha$^{-1}$ increased the level of soil total nitrogen from 0.203% to 0.349%. Combined application of 15 t ha$^{-1}$ FYM and 100 kg $P_2O_5$ ha$^{-1}$ increased the available phosphorous from 11.9 ppm to 38.1 ppm. Positive balances of soil N and P resulted from combined application of FYM and inorganic N and P sources. Application of 15 t ha$^{-1}$ FYM and 120 kg N ha$^{-1}$resulted in 214.8 kg ha$^{-1}$ N positive balance while application of 15 t ha$^{-1}$ FYM and 100 kg $P_2O_5$ ha$^{-1}$ resulted in a positive balance of 69.3 kg $P_2O_5$ ha$^{-1}$ available P. From the results of this experiment, it could be concluded that combined application of FYM and inorganic N and P fertilizers improved the chemical and physical properties, which may lead to enhanced and sustainable production of rice in the study area.

Mamun *et al.* (2011) carried out a field experiment at the Bangladesh Agricultural University Farm 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 dhan41. The experiment was set up in a randomized complete block design with three replications. 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 increases grain yield significantly over 70% NPKS application. The relative performances of organic manures were in the order of PM>DH>CD.

Hasanuzzaman *et al.* (2010) conducted an experiment at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh (90°33' E longitude and 23°77' N latitude) during June to November, 2008 with a view to observe the comparative performance of different organic manures and inorganic fertilizers on the growth and productivity of transplanted rice. The experiment comprises of 10 treatments viz. $T_1$ (Control), $T_2$ (Green manure @ 15 t $ha^{-1}$), $T_3$ (Green manure @ 15 t $ha^{-1}$ + $N_{40}P_6K_{36}S_{10}$ i.e.50% NPK), $T_4$ (Poultry manure @ 4 t $ha^{-1}$), $T_5$ (Poultry manure @ 4 t $ha^{-1}$ + $N_{40}P_6K_{36}S_{10}$ i.e. 50% NPK), $T_6$ (Cowdung @ 12 t $ha^{-1}$), $T_7$ (Cowdung @ 12 t $ha^{-1}$ + $N_{40}P_6K_{36}S_{10}$ i.e. 50% NPK), $T_8$ (Vermicompost @ 8 t $ha^{-1}$), $T_9$ (Vermicompost @ 8 t $ha^{-1}$ + $N_{40}P_6K_{36}S_{10}$ i.e. 50% NPK) and $T_{10}$ ($N_{80}P_{12}K_{72}S_{10}$ i.e.100% NPK). Plant characters, yield attributes and yield were significantly influenced by different treatments. Except plant height, total tiller per hills and biological yield all the parameters were found to be highest with the treatment $T_5$ (Poultry manure @ 4 t $ha^{-1}$ + $N_{40}P_6K_{36}S_{10}$ i.e. 50% NPK). From our study we observed that among the treatments $T_5$ (Poultry manure @ 4 t $ha^{-1}$ + 50% of recommended NPK) produced the highest grain yield (4.79 t $ha^{-1}$) of rice which was statistically identical to $T_{10}$ (100% of recommended NPK) and $T_9$ (Vermicompost @ 8 t $ha^{-1}$ + $N_{40}P_6K_{36}S_{10}$) which resulted grain yield of 4.57 t $ha^{-1}$ and 4.51 t $ha^{-1}$, respectively. Vermicompost was found as the best manures when it was applied alone. The economic analysis also showed that the application of $T_5$ maximized the profit and benefit-cost ratio (BCR) was the height

(1.75) in the treatment which was almost similar to $T_{10}$. The lowest BCR (1.07) was obtained from control treatment ($T_1$).

A field experiment was conducted by Alam *et al.* (2009) at the Agronomic field of the Sher-e-Bangla Agricultural University to study the relative performance of inbreed and hybrid rice varieties at different levels of P. Three varieties of inbreed and hybrid (BRRI dhan48, Aloron and Hira 2) and five levels of P fertilizer (0, 24, 48, 72 and 96 kg P $ha^{-1}$) were used as treatment. They reported that plant height and growth rate varied significantly due to variation of P and tallest plant was obtained with 96 kg P $ha^{-1}$.

Alam *et al.* (2009) suggested that filled grain $panicle^{-1}$, unfilled grain $panicle^{-1}$, spikelet sterility, 1000 grain weight and grain yield had a significant effect with the application of P fertilizer.

Choudhury *et al.* (2007) conducted an experiment to better understand P fertilization in rice culture, including P nutrition of rice, P response of rice plant, P availability in rice soils, and P adsorption in rice soils. A significant amount of applied P, as well as soil P, is lost from rice fields to water bodies, causing environmental pollution problems due to eutrophication. These pollution problems can be reduced by using the proper source of P as fertilizer, the proper timing and methods of P fertilizer application, soil P management, transport management, the use of plant growth promoting microorganisms that aid in the efficient use of P by crops, and the use of green manure crops that aid in the efficient use of P by crops.

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

A field experiment was conducted by Haque and Biswash (2014) in Rangpur, Bangladesh in a silt loam soil to evaluate the effect of nitrogen, phosphorous and potassium levels on growth yield and quality (protein) of hybrid rice (*Oryza sativa*). Optimum nitrogen level was found to be 184.07 kg ha$^{-1}$. In case of phosphorus and potassium, higher doses each of 80 kg ha$^{-1}$ $P_2O_5$ and $K_2O$ were found to be better to obtain higher production and good quality (protein) of hybrid rice. The maximum grain yield was recorded with 200 kg N ha$^{-1}$, 80 kg $P_2O_5$ ha$^{-1}$ and 80 kg $K_2O$ ha$^{-1}$.

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

From the above review of literature it is evident that manure has a significant influence on growth and yield of aromatic rice. It is also evident that manure itself influenced the soil health as well as the yield of aromatic rice. Phosphorus itself influenced the growth and seed yield of rice. The literature revealed that accurate knowledge of the optimum doses of phosphorus for any particular aromatic rice variety at a particular area is critical to achieve a higher grain yield of aromatic rice.

# CHAPTER III

# MATERIALS AND METHODS

# CHAPTER III

# MATERIALS AND METHODS

The experiment was carried out at the research farm of Sher-e-Bangla Agricultural University, Dhaka during the period from July 2019 to November 2019. This chapter deals with the materials and methods of the experiment with a brief description on experimental site, climate, soil, land preparation, planting materials, experimental design, land preparation, fertilizer and manures application, transplanting, irrigation and drainage, intercultural operation, data collection, data recording and procedure of their analysis. The details of investigation for achieving stated objectives are described below.

## 3.1 Site description

The experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Dhaka, in the Agro-ecological Zone "Modhupur Tract", AEZ-28. The experimental site was located at 23°47′ North latitude and 90°35′ East longitude at an altitude of 8.2 meters above sea level. The experimental site is shown for better understanding in the AEZ Map of Bangladesh in Appendix I.

## 3.2 Climate and weather

The geographical location of the experimental area was under the sub-tropical climate 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). Information respect to monthly maximum and minimum temperature, rainfall, relative humidity and sunshine during the period of study of the experimental site was collected from Bangladesh Meteorological Department, Agargaon and is presented in Appendix II.

## 3.3 Soil characteristics

The experiment was done in the soil belonging to the Madhupur Tract. The experimental site belongs to the General soil type, Red Brown Terrace Soils under Tejgaon Series. Top soils were silty 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 experimental site was a medium high land. It 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 at Soil Resources and Development Institute (SRDI), Dhaka. The physicochemical properties of the soil are presented in Appendix III.

### 3.4 Treatments of the experiment

The experiment consisted of two factors as mentioned below:

**Factor A**: Manure (3) *viz:*

$M_0$ = Control
$M_1$ = Cowdung (10 t $ha^{-1}$)
$M_2$ = Poultry manure (5 t $ha^{-1}$)

**Factor B**: Phosphorus level (5) *viz:*

$P_0$ = Control (no phosphorus)
$P_1$ = 25% lower dose of recommended P
$P_2$ = Recommended dose of P
$P_3$ = 25% higher dose of recommended P
$P_4$ = 50% higher dose of recommended P

A total of 15 treatment combinations:

| | | | | |
|---|---|---|---|---|
| $M_0P_0$ | $M_0P_1$ | $M_0P_2$ | $M_0P_3$ | $M_0P_4$ |
| $M_1P_0$ | $M_1P_1$ | $M_1P_2$ | $M_1P_3$ | $M_1P_4$ |
| $M_2P_0$ | $M_2P_1$ | $M_2P_2$ | $M_2P_3$ | $M_2P_4$ |

### 3.5 Experimental design and layout

The experiment was carried out in a Split-plot design with three replications (block) having manure in the main plots and level of phosphorus application in the sub-plot. Each replication was first divided into 15 sub plots where treatment combinations were assigned. Thus the total number of unit plots was 15 × 3 = 45. The size of the unit plot was 2.50 m × 2.00 m (5.00 $m^2$). The distance maintained between two unit plots was 0.50 m for drainage channel and that between blocks was 1.00 m. The treatments were distributed to the plots within each replication. The layout of the experimental field is shown in Appendix IV.

### 3.6 Seed collection and sprouting

Seed of BRRI dhan80 was collected from BRRI (Bangladesh Rice Research Institute), Gazipur. For seedlings clean and healthy seeds selected by specific gravity method and then immersed in water bucket for 24 hours and then those were 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

According to BRRI recommendation seedbed was prepared with 1 m wide adding nutrients according to the requirements of soil. Sufficient amount of seeds were sown in the seed bed on 30 June, 2019 in order to have seedling of 25 days old and then transplant the seedlings in the main field.

### 3.8 Preparation of experimental land

The selected plot for the experiment was opened in 7 July, 2019 with a power tiller, and was exposed to the sun for a week. On 15 July, the selected land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed and a desired tilth was obtained of soil finally for transplanting of seedlings.

### 3.9 Application of manures and fertilizers

The following doses of manures and fertilizers were applied for cultivation of crop as recommended by BRRI (2016).

| Nutrient/Fertilizer | Rate (Dose) | Fertilizer applied |
|---|---|---|
| Nitrogen | 120 kg $ha^{-1}$ | Urea |
| Phosphorus | As per treatment | TSP |
| Potassium | 70 kg $ha^{-1}$ | MoP |
| Sulphur | 60 kg $ha^{-1}$ | Gypsum |
| Boron | 10 kg $ha^{-1}$ | Borax |

Fertilizers like as Urea, TSP, MoP, Gypsum, Zinc sulphate and Borax were used as sources for N, P, K, S, Zn and B, respectively. Fertilizers were applied to the each plot as recommended doses. The full doses of TSP, MoP, gypsum, zinc sulphate and borax were applied during the final preparation of plot land. TSP was applied to each plot as par treatment. At 7 days before the transplantation, well rotten cowdung at the rate of 10 t $ha^{-1}$ and poultry manure at the rate of 5 t $ha^{-1}$ were applied to the each plot according to the treatment. Urea was applied in three equal installments at after recovery, tillering and before panicle initiation stage of crop.

### 3.10 Seedlings uprooting

Seedlings of 25 days old were uprooted carefully and were kept in soft mud in shade. The seed beds were made wet by application of water in previous day before uprooting the seedlings to minimize mechanical injury of roots. The seedlings were uprooted on 24 July, 2019 without causing much mechanical injury to the roots.

### 3.11 Seedlings transplanting in the main field

The seedlings were transplanted as per the experimental treatment in the main field on 24 July, 2019 with a line to line distance was 20 cm and hill to hill distance was 15 cm.

### 3.12 Intercultural operations

After establishment of seedlings, different intercultural operations were performed during the course of experimentation for better growth and development of the rice seedlings.

#### 3.12.1 Irrigation and drainage

Irrigated the experimental field was with adequate water and was maintained a constant level of standing water upto 3 cm in the early stages to enhance tillering and 4-5cm in the later stage to discourage late tillering. A good drainage facility was also maintained for immediate release of excess rainwater from the field. The field was finally dried out at 15 days before harvesting.

#### 3.12.2 Gap filling

Minor gap filling was done for all of the plots at 7-10 days after transplanting (DAT) by planting same aged seedlings.

### 3.12.3 Weeding

Experimental plots were 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 20, 40 and 60 days of transplanting.

### 3.12.4 Top dressing

Top-dressed of urea fertilizer was done in 3 equal installments at 10 days after transplanting, at tillering stage and before panicle initiation stage.

## 3.13 Plant protection

In the experimental plots, some plants were infested with grasshopper, rice stem borer, rice ear cutting caterpillar, thrips, leaf roller and rice bug to some extent; which was successfully controlled by application of insecticides spraying (Virtako+ Advantage + Cypermethrine) and Curatter 5 G. Brown spot of rice was controlled by spraying Tilt 250 EC. Crop was protected from birds and rats during the grain-filling period. For controlling birds, scarecrow and net were given and watching was done properly; especially during morning and afternoon.

## 3.14 Harvesting, threshing and cleaning

The rice plant was harvested depending upon the maturity of plant. Harvesting was done manually from each plot. Maturity of crop was determined when 80% of the grains become golden yellow in color. The harvested crop of each plot was bundled separately, tagged properly and brought to the threshing floor. Proper care was taken for harvesting, threshing and cleaning of rice seed. Fresh weight of grain and straw were recorded plot wise. The grains were cleaned and sun dried. Finally the weight was adjusted to a moisture content of 12%. The straw was also sun dried properly and the yields of grain and straw plot$^{-1}$ were recorded and converted to t ha$^{-1}$.

## 3.15 Experimental field observation

The experimental field was observed time to time to detect visual difference among the treatment and detect 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 collected during the experimentation:

#### 3.16.1. Crop growth characters

i) Plant height (cm)

ii) Number of tillers hill$^{-1}$

#### 3.16.2 Yield contributing parameters

i) Number of effective tillers hill$^{-1}$

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

iii) Panicle length (cm)

iv) Number of filled grains panicle$^{-1}$

v) Number of unfilled grains panicle$^{-1}$

vi) Number of total grains panicle$^{-1}$

vii) 1000 grains weight (g)

#### 3.16.3 Yield parameters

i) Grain yield (t ha$^{-1}$)

ii) Straw yield (t ha$^{-1}$)

iii) Biological yield (t ha$^{-1}$)

iv) Harvest index (%)

### 3.17 Procedures of recording data

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

#### 3.17.1 Crop growth characters

##### 3.17.1.1 Plant height

Plant height was recorded in centimeter (cm) at the time of 30, 50, 70, 90 DAT and at harvest. Data were recorded as the average of same 5 plants pre-selected at random from the inner rows of each plot. The plant height was measured from the ground level to tip of the plant.

### 3.17.1.2 Number of tillers hill$^{-1}$

The number of total tillers hill$^{-1}$ was recorded at 30, 60, 90 DAT and at harvest by counting total tillers as the average of same 5 hills pre-selected at random from the inner rows of each plot.

### 3.17.2 Yield contributing characters

### 3.17.2.1 Number of effective tillers hill$^{-1}$

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

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

The tillers having no grain in the panicle were regarded as non-effective tiller. The total number of non-effective tillers hill$^{-1}$ was counted from 5 selected hills at the time of harvest and average value was recorded.

### 3.17.2.3 Panicle length

Measurement of panicle length was taken with a meter scale from 5 selected panicles and the average value was recorded.

### 3.17.2.4 Number of filled grains panicle$^{-1}$

Panicle was considered to be fertile if any kernel was present therein. The total number of filled grains was collected randomly from selected 5 plants of a plot and then average number of filled grains panicle$^{-1}$ was recorded.

### 3.17.2.5 Number of unfilled grains panicle$^{-1}$

Panicle was considered to be sterile if no kernel was present therein. The total number of unfilled grains was collected randomly from selected 5 plants of a plot and then average number of unfilled grains panicle$^{-1}$ was recorded.

### 3.17.2.6 Number of total grains panicle$^{-1}$

The total number of grains panicle$^{-1}$ was counted from 5 selected panicles and average value was recorded.

#### 3.17.2.7 Weight of 1000 grains

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

### 3.17.3 Yield parameters

#### 3.17.3.1 Grain yield

Grain yield was determined from the central 1 $m^2$ area of each plot and expressed as t $ha^{-1}$ on 12% moisture basis. Grain moisture content was measured by using a digital moisture tester.

#### 3.17.3.2 Straw yield

Yield of straw was determined from the central 1 $m^2$ area of each plot, after separating the grains. The sub-samples were oven dried to a constant weight and finally converted to t $ha^{-1}$.

#### 3.17.3.3 Biological yield

Biological yield is the summation of grain yield and straw yield. Biological yield was determined using the following formula:

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

#### 3.17.3.4 Harvest index

Harvest index denotes the ratio of grain yield to biological yield and was calculated with the following formula:

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

## 3.18 Statistical analysis

The collected data were compiled and tabulated. Statistical analysis was done on various characters to find out the significance of variance resulting from the experimental treatments. Data were analyzed using analysis of variance (ANOVA) technique with the help of computer package program MSTAT-C (software) and the mean differences were adjudged by least significant difference test (LSD) as laid out by Gomez and Gomez (1984).

# CHAPTER IV

# RESULTS AND DISCUSSION

# CHAPTER IV

# RESULTS AND DISCUSSION

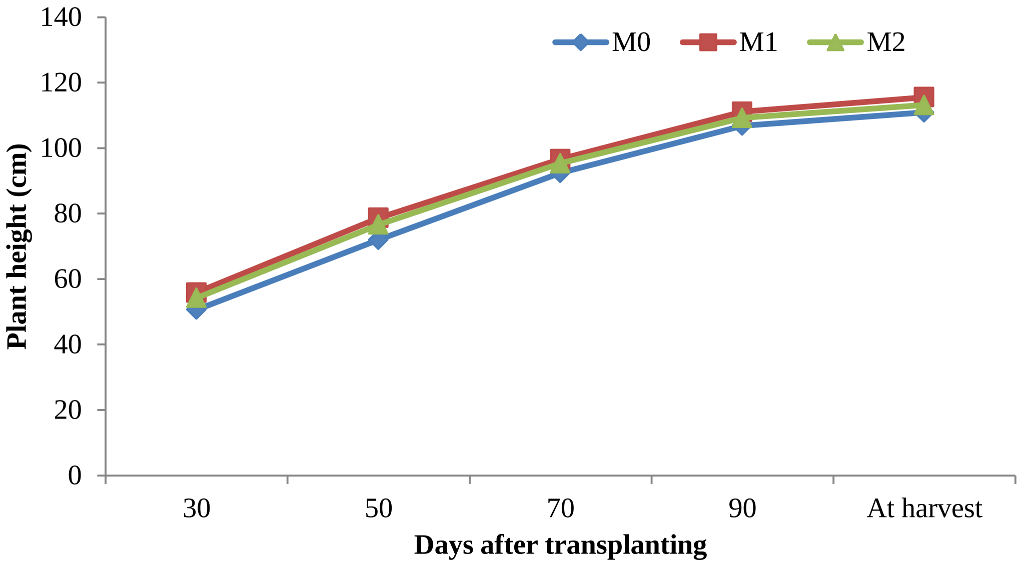
The experiment was conducted to study the influence of manure and phosphorus on growth and yield of aromatic rice. The results have been presented and discusses with the help of table and graphs and possible interpretations given under the following headings:

## 4.1 Growth parameters

### 4.1.1 Plant height

#### 4.1.1.1 Effect of manure

Significant influenced was observed on plant height by application of different manure at different growth stages of aromatic rice (Figure 1). Results found that the tallest plant (55.84, 78.69, 96.64, 111.09 and 115.55 cm at 30, 50, 70, 90 DAT and at harvest, respectively) was achieved from the treatment $M_1$ (cowdung) where the shortest plant (50.64, 72.00, 92.42, 106.86 and 110.87 cm at 30, 50, 70, 90 DAT and at harvest, respectively) was observed from the treatment $M_0$ (control). The result of the experiment was in coincide with the findings of Ismael *et al.* (2021) who reported that organic manure increases the plant height. They suggested that 40% urea + 30% beef cattle manure + 30% poultry litter in a combination lead to competitive yields and is thus recommended for best soil management practices. Sohel *et al.* (2016) reported that growth and yield contributing characters like plant height, effective tillers hill$^{-1}$, panicle length and filled grains panicle$^{-1}$ were varied significantly influenced positively in treatment having quarter doses of cow dung, poultry manure and water hyacinth over recommended dose. Arif *et al.* (2014) found that growth and yield of rice can be increase significantly with the combined use of organic manure with chemical fertilizers.

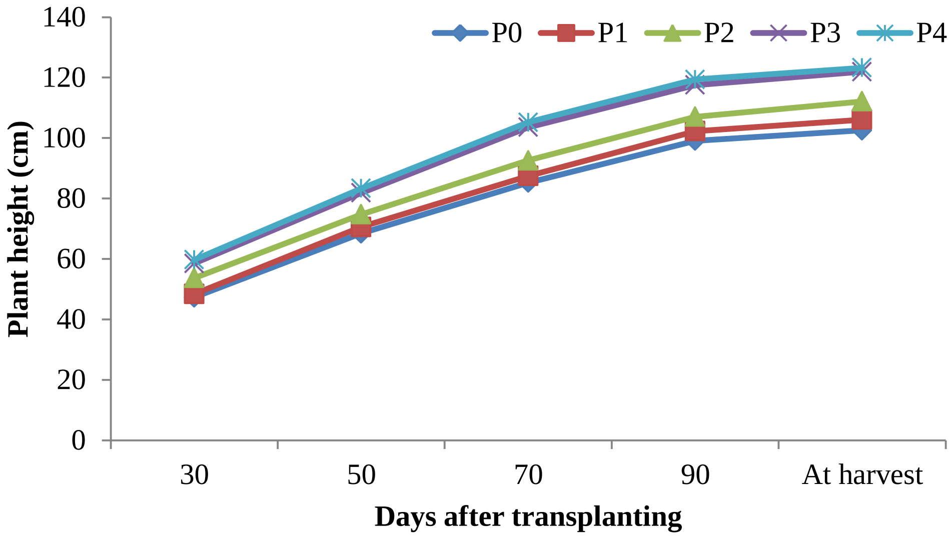



$M_0$= Control, $M_1$= Cowdung @ 10 t $ha^{-1}$ and $M_2$= Poultry manure @ 5 t $ha^{-1}$

**Figure 1. Effect of manure on plant height (cm) at different days after transplanting (DAT) of BRRI dhan80** ($LSD_{0.05}$= 0.93, 0.75, 2.76, 3.46 and 3.80 at 30, 50, 70, 90 and at harvest, respectively).

#### 4.1.1.2 Effect of phosphorus

Plant height at different growth stages was significantly influenced by applying different rates of phosphorus in the study (Figure 2). It was observed that the tallest plant (59.73, 83.31, 105.21, 119.40 and 123.27 cm at 30, 50, 70, 90 DAT and at harvest, respectively) was obtained from the treatment $P_4$ (50% higher dose of recommended P) where the shortest plant (47.25, 68.42, 85.22, 99.11 and 102.53 cm at 30, 50, 70, 90 DAT and at harvest, respectively) was found from the treatment $P_0$ (control). Similar result was observed by Nahar (2018) who reported that plant height was increased by applying phosphorus fertilizer to the soil. Massawe and Mrema (2017) reported that P fertilizers applications increased rice yield components as the levels of P increased from 0 to 60 kg P $ha^{-1}$ for all P sources. The yield components increased significantly ($P<0.05$) with increasing rates of P application. The increases were due to increased availability and uptake of plant nutrients particularly P. Based on the generated yields data, it was thus concluded that at the rates of (40 to 60 kg P $ha^{-1}$) could be adopted for increased and sustainable rice production.




$P_0$= Control, $P_1$= 25% lower dose of recommended P, $P_2$= Recommended dose of P, $P_3$= 25% higher dose of recommended P and $P_4$= 50% higher dose of recommended P

**Figure 2. Effect of phosphorus on plant height (cm) at different days after transplanting (DAT) of BRRI dhan80** ($LSD_{0.05}$= 1.34, 2.06, 3.52, 5.06 and 2.41 at 30, 50, 70, 90 and at harvest, respectively).

#### 4.1.1.3 Combined effect of manure and phosphorus

Combined effect of manure and phosphorus showed an increasing trend with advances of growth period in respect of plant height (Table 1 and Appendix V). The increasing rate was much higher in the early stages of growth from 30 DAT to 70 DAT. After that the increasing rate was much slower up to harvest. Results observed that the tallest plant height (62.11, 86.90, 107.20, 121.61 and 125.15 cm at 30, 50, 70, 90 DAT and at harvest, respectively) was found from $M_1P_4$ treatment combination which was statistically similar with $M_1P_3$ at 30, 50, 70, 90 DAT and harvest; with $M_2P_4$ at 30, 70, 90 DAT and harvest; with $M_2P_3$ and $M_0P_4$ at 70, 90 DAT and harvest. The shortest plant height (44.91, 65.75, 83.76, 98.35 and 99.26 cm at 30, 50, 70, 90 DAT and at harvest, respectively) was obtained from the treatment combination of $M_0P_0$ which was statistically similar with $M_0P_1$ at 30, 50, 70, 90 DAT and harvest; with $M_2P_0$ at 50, 70, 90 DAT and at harvest; with $M_1P_0$ and $M_2P_1$ at 70 and 90 DAT.

**Table 1. Combined effect of manure and phosphorus on plant height (cm) at different days after transplanting (DAT) of BRRI dhan80**

| Treatment Combinations | Plant height (cm) at different days after transplanting | | | | |
|---|---|---|---|---|---|
| | 30 | 50 | 70 | 90 | At harvest |
| $M_0P_0$ | 44.91 g | 65.75 h | 83.76 g | 98.35 f | 99.26 h |
| $M_0P_1$ | 46.13 fg | 67.72 gh | 84.71 fg | 99.35 ef | 104.20 g |
| $M_0P_2$ | 50.72 d | 69.62 e-g | 90.34 d-f | 104.02 d-f | 109.97 d-f |
| $M_0P_3$ | 55.33 c | 77.38 d | 100.69 bc | 115.17 a-c | 119.60 bc |
| $M_0P_4$ | 56.09 c | 79.57 cd | 102.59 ab | 117.29 ab | 121.31 ab |
| $M_1P_0$ | 49.62 d | 70.64 e-g | 85.32 fg | 100.48 ef | 105.71 fg |
| $M_1P_1$ | 50.01 d | 72.32 e | 89.71 d-g | 104.71 d-f | 107.71 e-g |
| $M_1P_2$ | 56.12 c | 78.03 d | 95.08 cd | 109.36 b-d | 114.83 cd |
| $M_1P_3$ | 61.32 ab | 85.54 ab | 105.89 ab | 119.27 a | 124.37 ab |
| $M_1P_4$ | 62.11 a | 86.90 a | 107.20 a | 121.61 a | 125.15 a |
| $M_2P_0$ | 47.21 ef | 68.87 f-h | 86.57 e-g | 98.49 f | 102.63 gh |
| $M_2P_1$ | 48.91 de | 71.65 ef | 87.97 e-g | 102.69 d-f | 106.42 fg |
| $M_2P_2$ | 54.24 c | 76.64 d | 92.27 de | 107.78 c-e | 111.55 de |
| $M_2P_3$ | 59.75 b | 82.59 bc | 104.05 ab | 118.05 a | 121.78 ab |
| $M_2P_4$ | 60.98 ab | 83.47 b | 105.84 ab | 119.29 a | 123.36 ab |
| **$LSD_{(0.05)}$** | **2.32** | **3.57** | **6.10** | **8.75** | **4.17** |
| **CV(%)** | **2.57** | **2.80** | **3.82** | **4.76** | **2.19** |

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

**Notes *viz:***

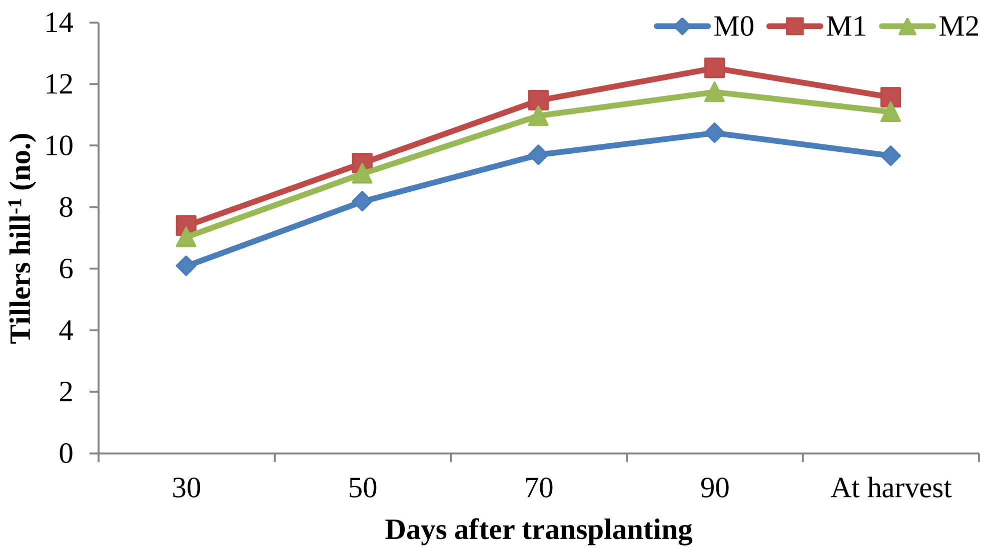
$M_0$= Control (no organic manure)
$M_1$= Cowdung (10 t $ha^{-1}$)
$M_2$= Poultry manure (5 t $ha^{-1}$)

$P_0$= Control (no Phosphorus)
$P_1$= 25% lower dose than recommended dose of P
$P_2$= Recommended dose of P
$P_3$= 25% higher dose than recommended dose of P
$P_4$= 50% higher dose than recommended dose of P

### 4.1.2 Number of tillers hill$^{-1}$

#### 4.1.2.1 Effect of manure

Significant influence was observed on number of tillers hill$^{-1}$ by application of different manure at different growth stages of aromatic rice (Figure 3). Results found that the maximum number of tillers hill$^{-1}$ (7.40, 9.43, 11.47, 12.52 and 11.57 at 30, 50, 70, 90 DAT and at harvest, respectively) was achieved from the treatment $M_1$ (cowdung) where the minimum number of tillers hill$^{-1}$ (6.09, 8.19, 9.70, 10.41 and 9.67 at 30, 50, 70, 90 DAT and at harvest, respectively) was observed from the treatment $M_0$ (control). The result of the experiment was in coincide with the findings of Ismael *et al.* (2021) who reported that use of 40% urea + 30% beef cattle manure + 30% poultry litter in a combination lead to competitive yields and is thus recommended for best soil management practices. Khatun *et al.* (2018) reported that the application of different levels of cow dung and zinc fertilizers showed that the total number of tillers hill$^{-1}$ and productive number of tillers hill$^{-1}$ over control were significantly increased. Sarkar *et al.* (2016) reported that total number of tillers hill$^{-1}$ and productive number of tillers hill$^{-1}$ were significantly increased by applying 75% suggested portion of inorganic fertilizers + 50% cowdung (5 t ha$^{-1}$).

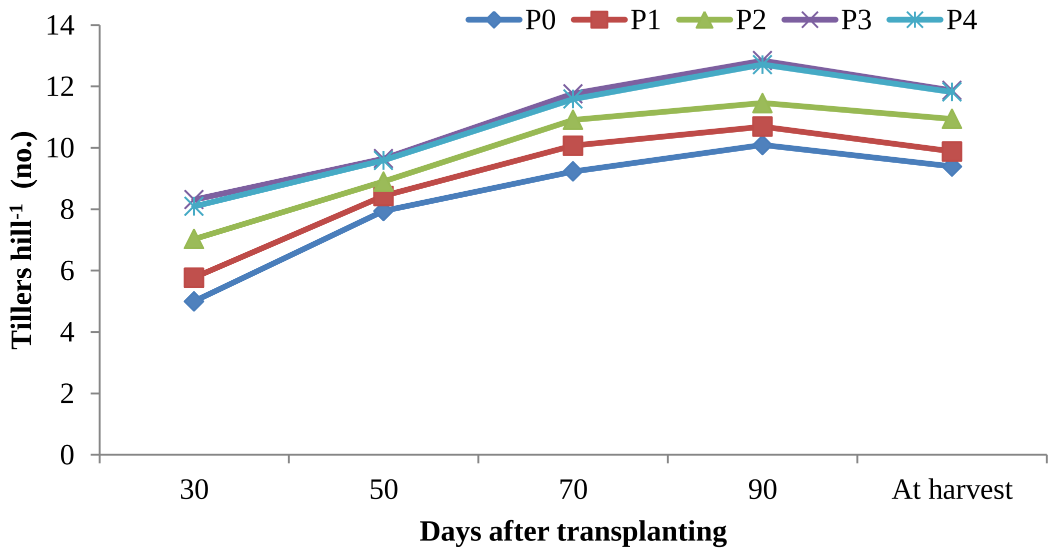



$M_0$= Control, $M_1$= Cowdung @ 10 t ha$^{-1}$ and $M_2$= Poultry manure @ 5 t ha$^{-1}$

**Figure 3. Effect of manure on number of tillers hill$^{-1}$ at different days after transplanting of BRRI dhan80** ($LSD_{0.05}$= 0.49, 0.14, 0.48, 0.45 and 0.75 at 30, 50, 70, 90 and at harvest, respectively).

#### 4.1.2.2 Effect of phosphorus

Number of tillers hill$^{-1}$ at different growth stages of rice was significantly affected by different rate of phosphorus (Figure 4). Results showed that the highest number of tillers hill$^{-1}$ (8.31, 9.65, 11.76, 12.84 and 11.87 at 30, 50, 70, 90 DAT and at harvest, respectively) was achieved from the treatment $P_3$ which was statistically similar with $P_4$ where the lowest number of tillers hill$^{-1}$ (5.00, 7.94, 9.23, 10.09 and 9.39 at 30, 50, 70, 90 DAT and at harvest, respectively) was obtained from the treatment $P_0$ (control). Similar results were observed by Moe *et al.* (2019), Nahar (2018), Massawe and Mrema (2017), Sarkar *et al*. (2014) and Mamun *et al.* (2011). They reported that yield attributing parameters like plant height, number of effective tillers hill$^{-1}$, panicle length, and number of field grains per panicle were significantly influenced by phosphorus application along with cowdung or poultry manure.




$P_0$= Control, $P_1$= 25% lower dose of recommended P, $P_2$= Recommended dose of P, $P_3$= 25% higher dose of recommended P and $P_4$= 50% higher dose of recommended P

**Figure 4. Effect of phosphorus on number of tillers hill$^{-1}$ at different days after transplanting (DAT) of BRRI dhan80** ($LSD_{0.05}$= 0.40, 0.40, 0.37, 0.55 and 0.61 at 30, 50, 70, 90 and at harvest, respectively).

#### 4.1.2.3 Combined effect of manure and phosphorus

Significant difference was remarked for number of tillers hill$^{-1}$ at different growth stages of rice due to combined effect of manure and different rate of phosphorus (Table 2 and Appendix VI). Results showed that the highest number of tillers hill$^{-1}$ (9.23, 10.47, 13.07, 14.59 and 13.06 at 30, 50, 70, 90 DAT and at harvest, respectively) was achieved from the treatment combination of $M_1P_3$ which was statistically similar with $M_1P_4$ and $M_2P_3$ at 30, 50, 90 DAT and harvest. On the other hand the lowest number of tillers hill$^{-1}$ (4.78, 7.61, 8.53, 9.63 and 8.75 at 30, 50, 70, 90 DAT and harvest, respectively) was revealed from the treatment combination of $M_0P_0$ which was statistically similar with $M_0P_1$ and $M_2P_0$ at 30, 50, 70, 90 DAT and harvest; with $M_1P_0$ at 30, 50 DAT and harvest.

**Table 2. Combined effect of manure and phosphorus on number of tillers hill$^{-1}$ at different days after transplanting of BRRI dhan80**

| Treatment Combinations | Number of tillers hill$^{-1}$ at different days after transplanting | | | | |
|---|---|---|---|---|---|
| | 30 | 50 | 70 | 90 | At harvest |
| $M_0P_0$ | 4.78 h | 7.61 i | 8.53 j | 9.63 j | 8.75 h |
| $M_0P_1$ | 5.40 f-h | 7.72 i | 8.84 ij | 9.81 ij | 9.06 gh |
| $M_0P_2$ | 6.13 e | 8.02 hi | 9.67 h | 10.33 h-j | 9.71 f-h |
| $M_0P_3$ | 7.13 d | 8.55 f-h | 10.40 fg | 10.77 gh | 10.03 e-g |
| $M_0P_4$ | 7.00 d | 9.05 c-f | 11.06 c-e | 11.53 e-g | 10.81 c-e |
| $M_1P_0$ | 5.23 gh | 8.23 g-i | 9.83 gh | 10.60 g-i | 9.89 e-h |
| $M_1P_1$ | 6.04 ef | 8.85 d-g | 10.85 d-f | 11.32 e-g | 10.44 d-f |
| $M_1P_2$ | 7.42 cd | 9.48 b-d | 11.62 bc | 12.19 de | 11.67 bc |
| $M_1P_3$ | 9.23 a | 10.47 a | 13.07 a | 14.59 a | 13.06 a |
| $M_1P_4$ | 9.10 a | 10.13 ab | 11.97 b | 13.92 ab | 12.77 a |
| $M_2P_0$ | 5.00 h | 7.97 hi | 9.33 hi | 10.03 h-j | 9.53 f-h |
| $M_2P_1$ | 5.87 e-g | 8.73 e-g | 10.52 e-g | 10.95 f-h | 10.15 e-g |
| $M_2P_2$ | 7.53 cd | 9.21 c-e | 11.43 b-d | 11.86 d-f | 11.43 cd |
| $M_2P_3$ | 8.57 ab | 9.92 ab | 11.81 b | 13.17 bc | 12.51 ab |
| $M_2P_4$ | 8.17 bc | 9.61 bc | 11.75 bc | 12.67 cd | 11.90 a-c |
| **$LSD_{(0.05)}$** | **0.68** | **0.69** | **0.64** | **0.95** | **1.05** |
| **CV(%)** | **5.96** | **4.61** | **3.54** | **4.89** | **5.80** |

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

**Notes *viz:***

$M_0$= Control (no organic manure)
$M_1$= Cowdung (10 t ha$^{-1}$)
$M_2$= Poultry manure (5 t ha$^{-1}$)

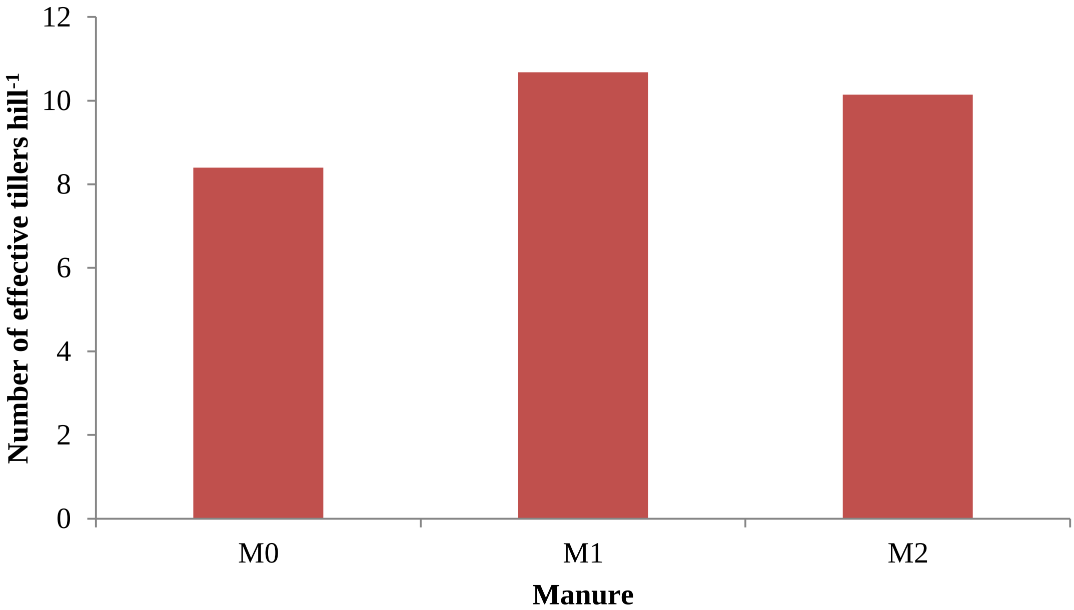
$P_0$= Control (no Phosphorus)
$P_1$= 25% lower dose than recommended dose of P
$P_2$= Recommended dose of P
$P_3$= 25% higher dose than recommended dose of P
$P_4$= 50% higher dose than recommended dose of P

### 4.2 Yield contributing parameters

#### 4.2.1 Number of effective tillers hill$^{-1}$

##### 4.2.1.1 Effect of manure

Significant difference was observed on number of effective tillers hill$^{-1}$ due to different manure (Figure 5). Results revealed that the highest number of effective tillers hill$^{-1}$ (10.68) was obtained from the treatment $M_1$ (cowdung) where the lowest number of effective tillers hill$^{-1}$ (8.40) was observed from the treatment $M_0$ (control). The result of the experiment was in agreement with the findings of Ismael *et al.* (2021) who reported that use of 40% urea + 30% beef cattle manure + 30% poultry litter in a combination lead to competitive yields and is thus recommended for best soil management practices. Khatun *et al.* (2018) reported that the application of different levels of cow dung and zinc fertilizers showed that the total number of tillers hill$^{-1}$ and productive number of tillers hill$^{-1}$ over control were significantly increased. Sarkar *et al.* (2016) reported that total number of tillers hill$^{-1}$ and productive number of tillers hill$^{-1}$ were significantly increased by applying 75% suggested portion of inorganic fertilizers + 50% cowdung (5 t ha$^{-1}$).

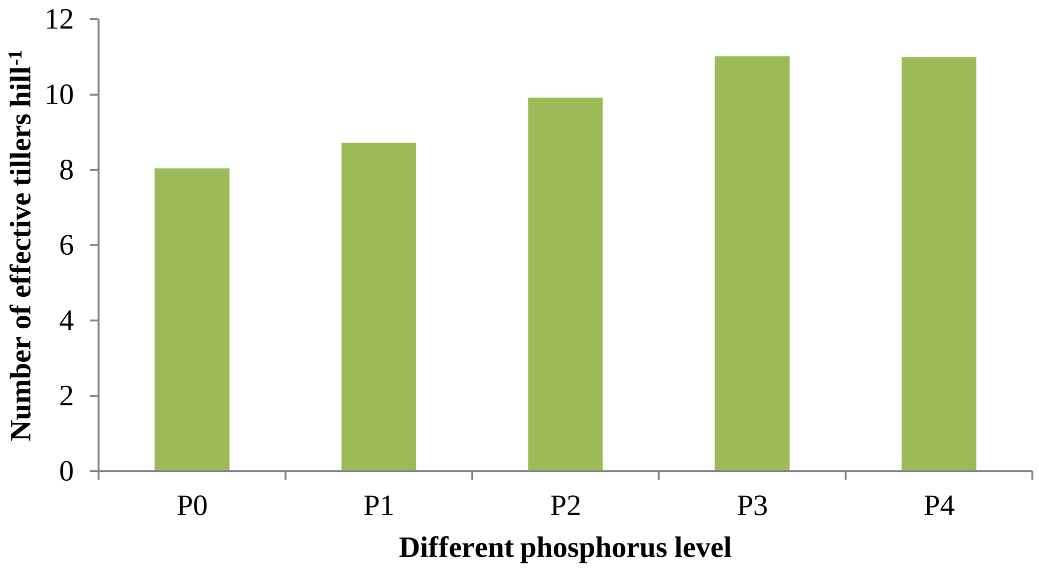



$M_0$= Control, $M_1$= Cowdung @ 10 t ha$^{-1}$ and $M_2$= Poultry manure @ 5 t ha$^{-1}$

**Figure 5. Effect of manure on number of effective tillers hill$^{-1}$ of BRRI dhan80** ($LSD_{0.05}$= 0.13).

#### 4.2.1.2 Effect of phosphorus

Number of effective tillers hill$^{-1}$ of rice was significantly affected by different rate of phosphorus (Figure 6). Results exposed that the highest number of effective tillers hill$^{-1}$ (11.02) was observed from the treatment $P_3$ (25% higher dose of recommended P) which was statistically similar with $P_4$. On the other hand the lowest number of effective tillers hill$^{-1}$ (8.04) was obtained from the treatment $P_0$ (control). Mamun *et al*. (2011) reported that yield attributing parameters like number of effective tillers hill$^{-1}$, panicle length, and number of field grains per panicle was significantly influenced by phosphorus application along with cowdung or poultry manure. The dhaincha or cowdung along with 70% NPKS increases the yield contributing characters of rice.




$P_0$= Control, $P_1$= 25% lower dose of recommended P, $P_2$= Recommended dose of P, $P_3$= 25% higher dose of recommended P and $P_4$= 50% higher dose of recommended P

**Figure 6. Effect of phosphorus on number of effective tillers hill$^{-1}$ of BRRI dhan80** ($LSD_{0.05}$= 0.49).

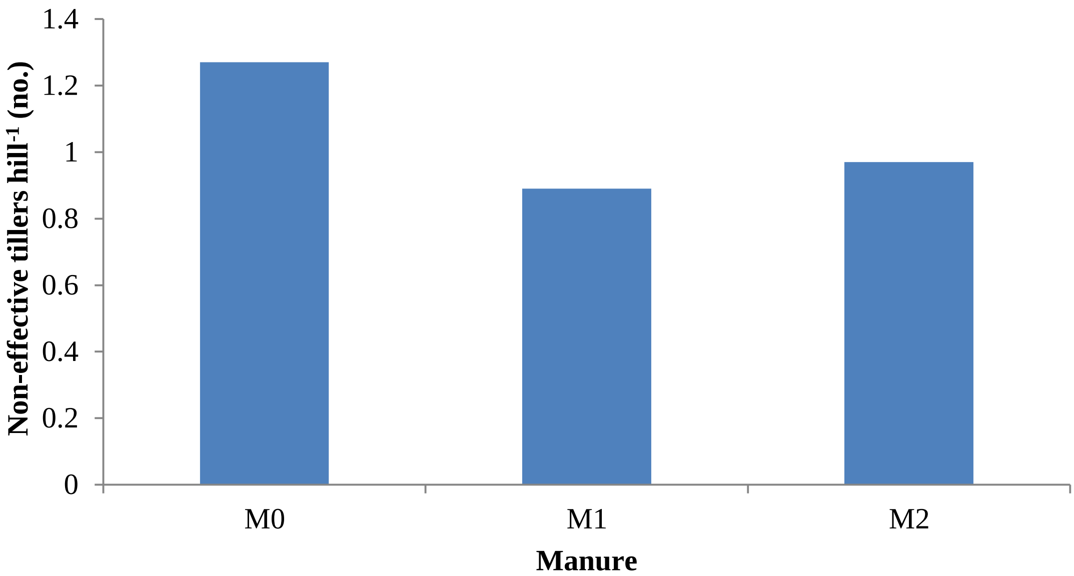
#### 4.2.1.3 Combined effect of manure and phosphorus

Significant difference was observed for number of effective tillers hill$^{-1}$ of rice influenced by combined effect of manure and different rate of phosphorus (Table 3 and Appendix VII). It was remarked that the highest number of effective tillers hill$^{-1}$ (12.41) was obtained from the treatment combination of $M_1P_3$ which was statistically as par with $M_1P_4$ and $M_2P_3$. On the other hand the lowest number of effective tillers hill$^{-1}$ (7.23) was obtained from the treatment combination of $M_0P_0$ which was statistically similar with $M_0P_1$ treatment combination.

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

#### 4.2.2.1 Effect of manure

Number of non-effective tillers hill$^{-1}$ was significantly influenced by different manure under the present study (Figure 7). The highest number of non-effective tillers hill$^{-1}$ (1.27) was obtained from the treatment $M_0$ (control) where the lowest number of non-effective tillers hill$^{-1}$ (0.89) was observed from the treatment $M_1$ (cowdung) which was statistically similar with $M_2$. The findings of the experiment was also in agreement with the finding of Ismael *et al.* (2021) who reported that using organic manure decreases the non-effective tillers hill$^{-1}$ than control.

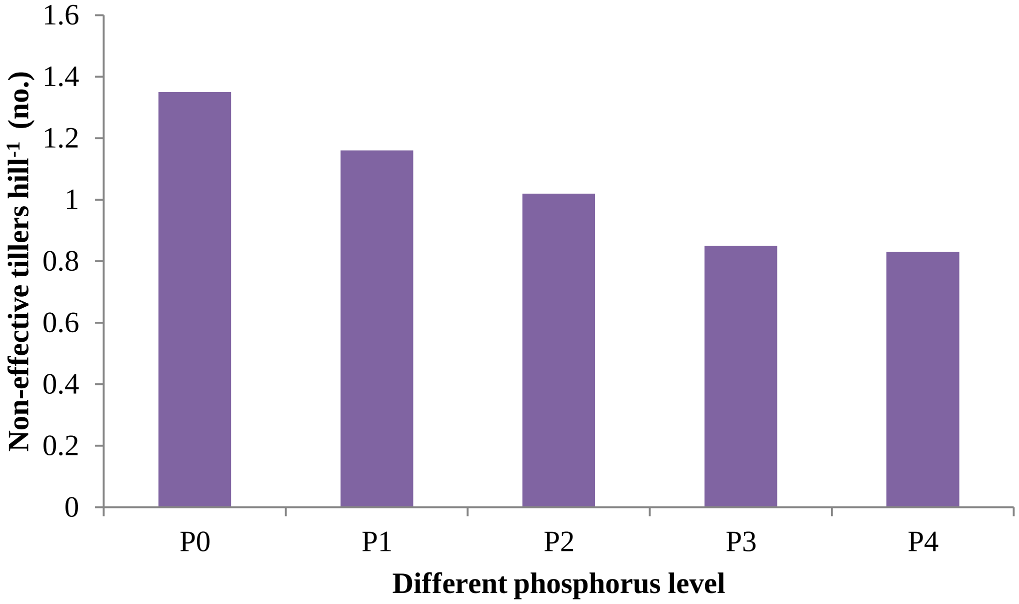



$M_0$= Control, $M_1$= Cowdung @ 10 t ha$^{-1}$ and $M_2$= Poultry manure @ 5 t ha$^{-1}$

**Figure 7. Effect of manure on number of non-effective tillers hill$^{-1}$ of BRRI dhan80** ($LSD_{0.05}$= 0.16).

#### 4.2.2.2 Effect of phosphorus

Significant difference was found in terms of number of non-effective tillers hill$^{-1}$ of rice influenced by different rates of phosphorus (Figure 8). The highest number of non-effective tillers hill$^{-1}$ (1.35) was obtained from the treatment $P_0$ where the lowest number of non-effective tillers hill$^{-1}$ (0.83) was obtained from the treatment $P_4$ which was close to $P_3$ (0.85). The findings of the experiment was similar with the findings of Mamun *et al.* (2011) reported that using dhaincha or cowdung along with 70% NPKS decreases the number of non-effective tillers hill$^{-1}$ significantly over control.




$P_0$= Control, $P_1$= 25% lower dose of recommended P, $P_2$= Recommended dose of P, $P_3$= 25% higher dose of recommended P and $P_4$= 50% higher dose of recommended P

**Figure 8. Effect of phosphorus on number of non-effective tillers hill$^{-1}$ of BRRI dhan80** ($LSD_{0.05}$= 0.12).

#### 4.2.2.3 Combined effect of manure and phosphorus

Combined effect of manure and different rates of phosphorus showed significant variation on number of non-effective tillers hill$^{-1}$ (Table 3 and Appendix VII). It was found that the highest number of non-effective tillers hill$^{-1}$ (1.52) was observed from the treatment combination of $M_0P_0$ followed by $M_0P_1$ and $M_2P_0$ where the lowest number of non-effective tillers hill$^{-1}$ (0.65) was obtained from the treatment combination of $M_1P_3$ which was statistically similar with $M_1P_4$ and $M_2P_3$.

**Table 3. Combined effect of manure and phosphorus on number of effective tillers hill$^{-1}$ and number of non-effective tillers hill$^{-1}$ of BRRI dhan80**

| Treatment combinations | Effective tillers hill$^{-1}$ (no.) | Non-effective tillers hill$^{-1}$ (no.) |
|---|---|---|
| $M_0P_0$ | 7.23 j | 1.52 a |
| $M_0P_1$ | 7.65 ij | 1.41 ab |
| $M_0P_2$ | 8.44 g-i | 1.27 b-d |
| $M_0P_3$ | 8.87 f-h | 1.16 c-f |
| $M_0P_4$ | 9.83 de | 0.98 e-h |
| $M_1P_0$ | 8.68 f-h | 1.21 b-e |
| $M_1P_1$ | 9.43 ef | 1.01 e-h |
| $M_1P_2$ | 10.80 c | 0.87 g-i |
| $M_1P_3$ | 12.41 a | 0.65 j |
| $M_1P_4$ | 12.06 a | 0.71 ij |
| $M_2P_0$ | 8.20 hi | 1.33 a-c |
| $M_2P_1$ | 9.08 e-g | 1.07 d-g |
| $M_2P_2$ | 10.53 cd | 0.93 f-i |
| $M_2P_3$ | 11.78 ab | 0.73 ij |
| $M_2P_4$ | 11.09 bc | 0.81 h-i |
| **$LSD_{(0.05)}$** | **0.85** | **0.20** |
| **CV(%)** | **5.19** | **11.44** |

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

**Notes *viz:***

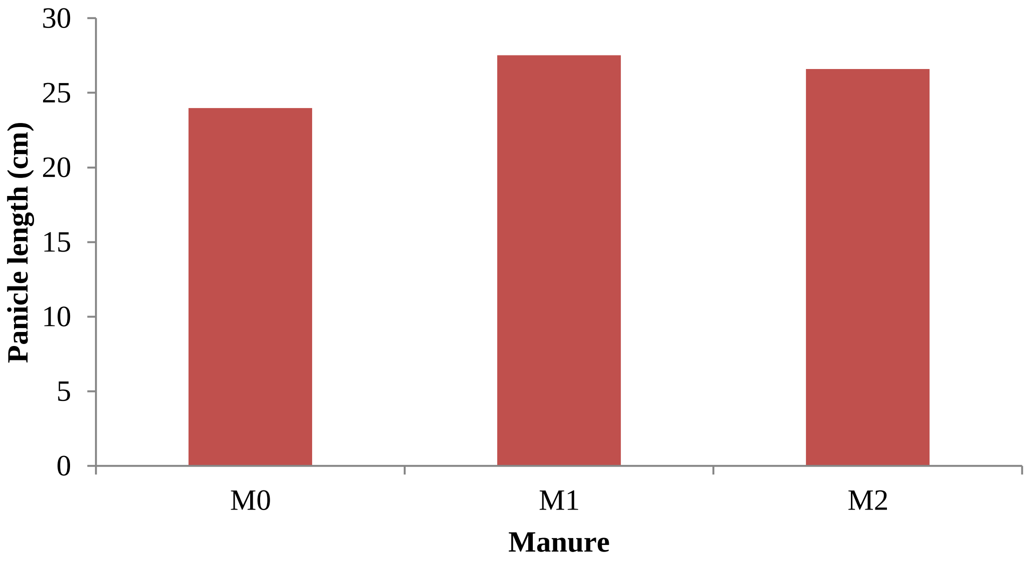
$M_0$= Control (no organic manure)
$M_1$= Cowdung (10 t ha$^{-1}$)
$M_2$= Poultry manure (5 t ha$^{-1}$)

$P_0$= Control (no Phosphorus)
$P_1$= 25% lower dose than recommended dose of P
$P_2$= Recommended dose of P
$P_3$= 25% higher dose than recommended dose of P
$P_4$= 50% higher dose than recommended dose of P

### 4.2.3 Panicle length

#### 4.2.3.1 Effect of manure

Significant variation on panicle length was obtained due to different manure under the present study (Figure 9). It was revealed from the figure that the highest panicle length (27.52 cm) was observed from the treatment $M_1$ (cowdung) where the lowest panicle length (23.97 cm) was achieved from the treatment $M_0$ (control). The results of the experiment was supported by the findings of Khatun *et al.* (2018) who reported that the application of different levels of cow dung and zinc fertilizers showed that the panicle length over control were significantly increased. Sarkar *et al.* (2016) reported that the most noteworthy numbers of effective tillers hill$^{-1}$ (11.59), panicle length (24.31 cm) were recorded in the supplement the executives of 75% suggested portion of inorganic fertilizers + 50% cowdung (5 t ha$^{-1}$).



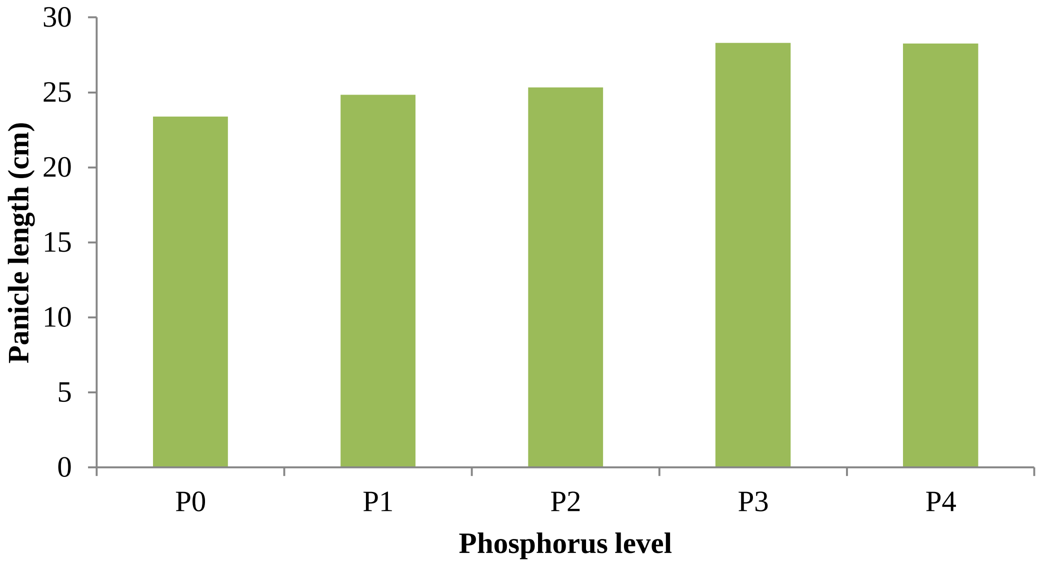

$M_0$= Control, $M_1$= Cowdung @ 10 t ha$^{-1}$ and $M_2$= Poultry manure @ 5 t ha$^{-1}$

**Figure 9. Effect of manure on panicle length (cm) of BRRI dhan80** ($LSD_{0.05}$= 0.53).

#### 4.2.3.2 Effect of phosphorus

Significant variation was observed in terms of panicle length influenced by different rates of phosphorus (Figure 10). It was achieved that the highest panicle length (28.30 cm) was obtained from the treatment $P_3$ (25% higher dose of recommended P) which was statistically similar with $P_4$ (28.26 cm) where the lowest panicle length (23.38

cm) was obtained from the treatment $P_0$ (control). Nahar (2018) also found the similar results. Sarkar *et al*. (2014) and Mamun *et al.* (2011) reported that yield attributing parameters like number of effective tillers hill$^{-1}$, panicle length were significantly influenced due to different treatments. Dhaincha or cowdung along with 70% NPKS increases panicle length significantly over 70% NPKS application.




$P_0$= Control, $P_1$= 25% lower dose of recommended P, $P_2$= Recommended dose of P, $P_3$= 25% higher dose of recommended P and $P_4$= 50% higher dose of recommended P

**Figure 10. Effect of phosphorus on panicle length (cm) of BRRI dhan80** ($LSD_{0.05}$= 1.29).

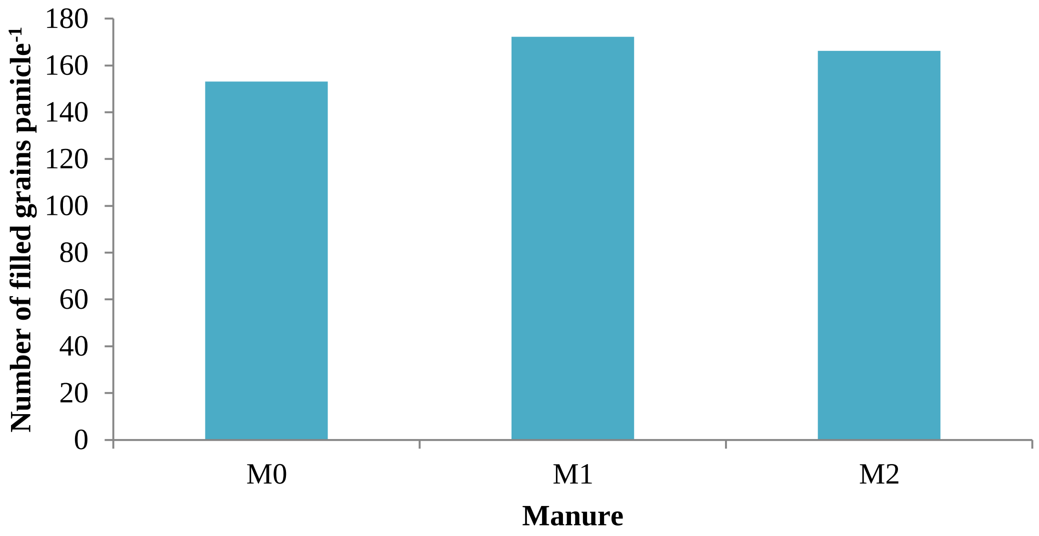
**4.2.3.3 Combined effect of manure and phosphorus**

Panicle length was significantly influenced by combined effect of manure and different rates of phosphorus (Table 4 and Appendix VIII). Results showed that the highest panicle length (30.85 cm) was obtained from the treatment combination of $M_1P_3$ which was statistically similar with $M_1P_4$ and $M_2P_3$. The lowest panicle length (22.71 cm) was achieved by the treatment combination of $M_0P_0$ which was statistically similar with $M_0P_1$, $M_2P_0$, $M_0P_2$, $M_1P_0$ and $M_0P_3$.

**4.2.4 Number of filled grains panicle$^{-1}$**

**4.2.4.1 Effect of manure**

Significant difference was observed on number of filled grains panicle$^{-1}$ due to different manure under the present study (Figure 11). Results stated that the highest number of filled grains panicle$^{-1}$ (172.21) was obtained the treatment M1 (cowdung) which was statistically similar with $M_2$ where the lowest number of filled grains panicle$^{-1}$ (153.07) was achieved from the treatment $M_0$ (control). Similar trends were also observed by Sohel *et al.* (2016). They reported that 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. 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.

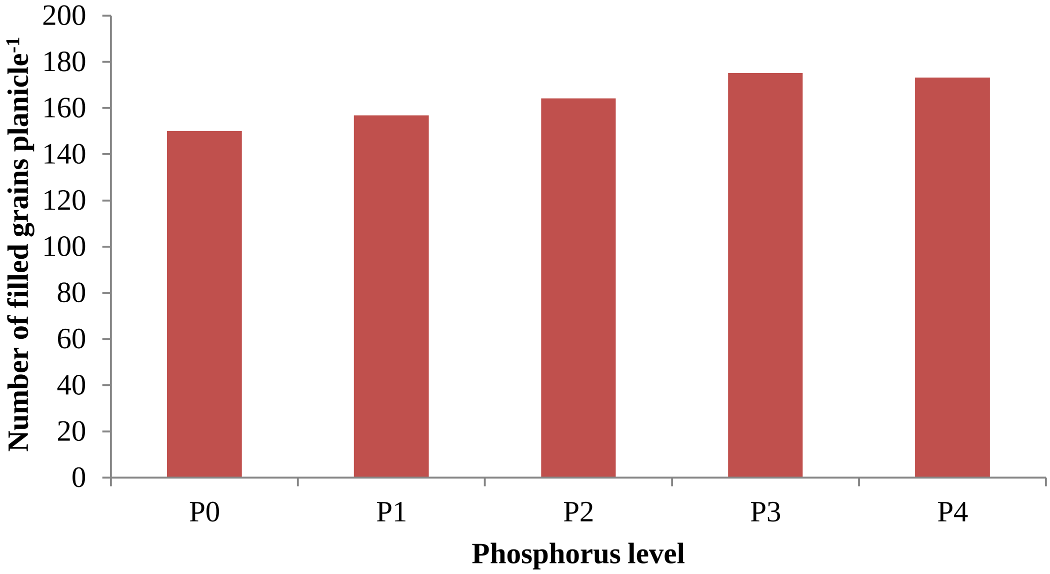



$M_0$= Control, $M_1$= Cowdung @ 10 t ha$^{-1}$ and $M_2$= Poultry manure @ 5 t ha$^{-1}$

**Figure 11. Effect of manure on number of filled grains panicle$^{-1}$ of BRRI dhan80** ($LSD_{0.05}$= 7.02).

### 4.2.4.2 Effect of phosphorus

Number of filled grains panicle$^{-1}$ of rice was significantly influenced by different rate of phosphorus (Figure 12). It was found that the highest number of filled grains panicle$^{-1}$ (175.08) was achieved from the treatment $P_3$ followed by $P_4$ (173.13). The lowest number of filled grains panicle$^{-1}$ (150.05) was observed from the treatment $P_0$ (control) which was statistically similar with $P_1$. The result of the experiment was supported by the findings of Nahar (2018) who reported that phosphorus application increases the number of filled grains panicle$^{-1}$. Massawe and Mrema (2017) reported that P fertilizers applications increased rice yield components as the levels of P increased from 0 to 60 kg P $ha^{-1}$ for all P sources. The yield components increased significantly (P<0.05) with increasing rates of P application. The increases were due to increased availability and uptake of plant nutrients particularly P.




$P_0$= Control, $P_1$= 25% lower dose of recommended P, $P_2$= Recommended dose of P, $P_3$= 25% higher dose of recommended P and $P_4$= 50% higher dose of recommended P

**Figure 12. Effect of phosphorus on number of filled grains panicle$^{-1}$ of BRRI dhan80** ($LSD_{0.05}$= 7.32).

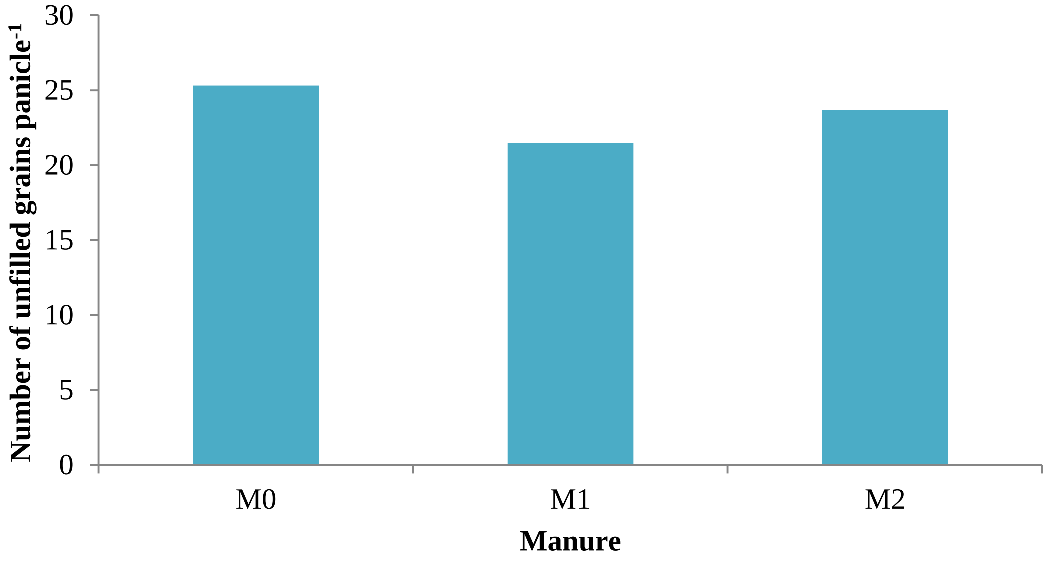
### 4.2.4.3 Combined effect of manure and phosphorus

Significant difference was observed for number of filled grains panicle$^{-1}$ of rice due to combined effect of manure and different rate of phosphorus (Table 4 and Appendix VIII). Results showed that the highest number of filled grains panicle$^{-1}$ (188.40) was obtained from the treatment combination of $M_1P_3$ followed by $M_1P_4$ and $M_2P_3$. The lowest number of filled grains panicle$^{-1}$ (142.07) was revealed from the treatment combination of $M_0P_0$, which was statistically similar with $M_0P_1$, $M_0P_2$ and $M_2P_0$.

### 4.2.5 Number of unfilled grains panicle$^{-1}$

### 4.2.5.1 Effect of manure

Significantly influenced by different manure on number of unfilled grains panicle$^{-1}$ was observed under the study (Figure 13). It was revealed that the highest number of unfilled grains panicle$^{-1}$ (25.32) was found from the treatment $M_0$ (control) which was statistically similar with $M_2$ (poultry manure) where the lowest number of unfilled grains panicle$^{-1}$ (21.48) was achieved from the treatment $M_1$ (cowdung). The result of the experiment were in coincided with Anisuzzaman *et al.* (2021), Haque *et al.* (2021), Ismael *et al.* (2021), Kakar *et al.* (2020) and Hoque *et al.* (2019). They reported that application of organic manure decreases the unfilled grains per panicle.

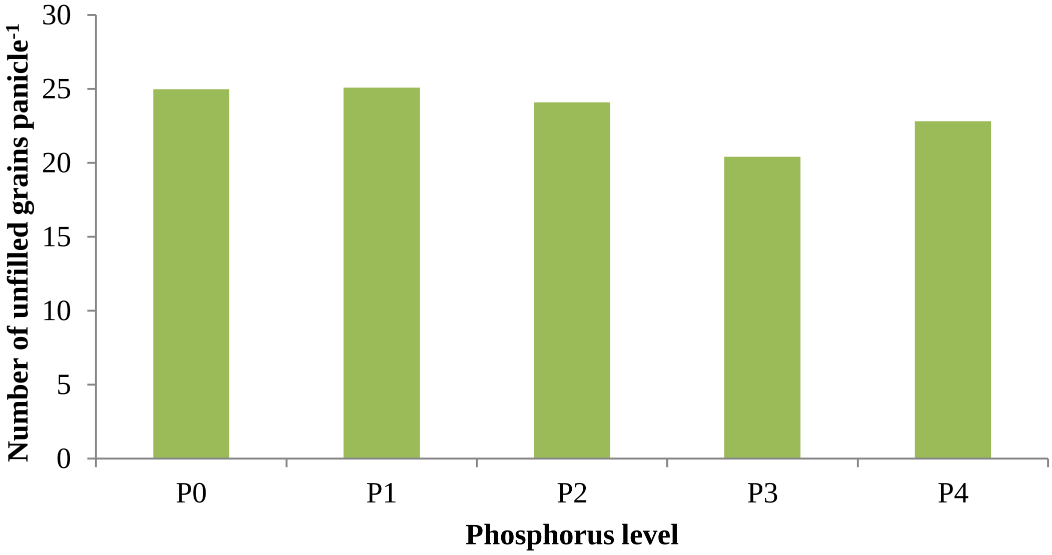



$M_0$= Control, $M_1$= Cowdung @ 10 t ha$^{-1}$ and $M_2$= Poultry manure @ 5 t ha$^{-1}$

**Figure 13. Effect of manure on number of unfilled grains panicle$^{-1}$ of BRRI dhan80** ($LSD_{0.05}$= 1.97).

**4.2.5.2 Effect of phosphorus**

Significant difference was found in terms of number of unfilled grains panicle$^{-1}$ of rice influenced by different rates of phosphorus (Figure 14). Results showed that the lowest number of unfilled grains panicle$^{-1}$ (20.41) was exhibited from the treatment $P_3$ where the highest number of unfilled grains panicle$^{-1}$ (25.09) was found from the treatment $P_1$ which was statistically similar with $P_0$. Similar result was also observed by Moe *et al.* (2019), Massawe and Mrema (2017), Sarkar *et al.* (2014), Alam *et al.* (2009) and Mamun *et al.* (2011). They reported that filled grain panicle$^{-1}$, unfilled grain panicle$^{-1}$, spikelet sterility, 1000 grain weight and grain yield had a significant effect with the application of P fertilizer.




$P_0$= Control, $P_1$= 25% lower dose of recommended P, $P_2$= Recommended dose of P, $P_3$= 25% higher dose of recommended P and $P_4$= 50% higher dose of recommended P

**Figure 14. Effect of phosphorus on number of unfilled grains panicle$^{-1}$ of BRRI dhan80** ($LSD_{0.05}$= 2.12).

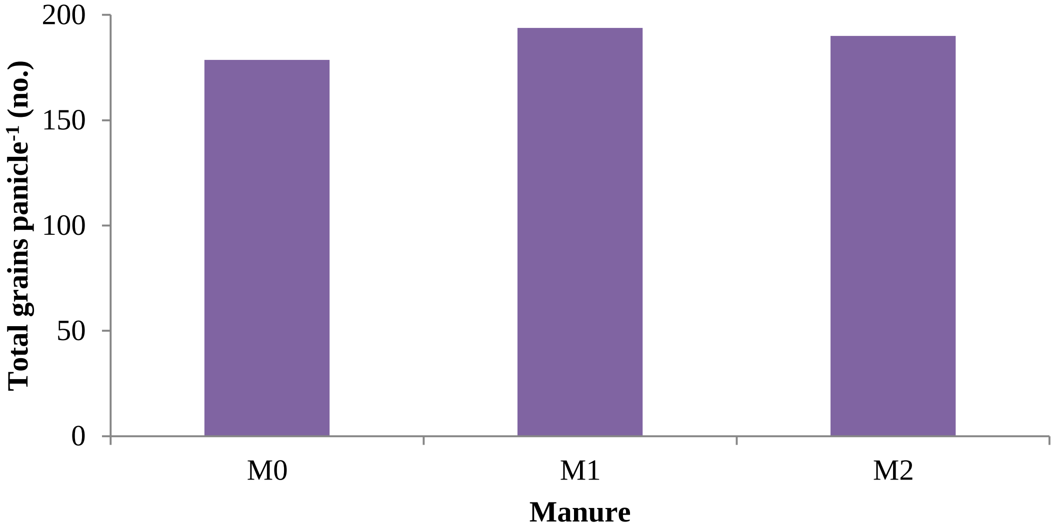
### 4.2.5.3 Combined effect of manure and phosphorus

Significant difference on number of unfilled grains panicle$^{-1}$ was observed by combined effect of manure and different rates of phosphorus under the present study (Table 4 and Appendix VIII). It was revealed that the lowest number of unfilled grains panicle$^{-1}$ (16.53) was observed from the treatment combination of $M_1P_3$ which was statistically similar with $M_1P_4$. The highest number of unfilled grains panicle$^{-1}$ (28.13) was achieved from the treatment combination of $M_0P_0$, which was statistically similar with $M_0P_4$, $M_0P_1$, $M_1P_1$, $M_2P_0$ and $M_2P_2$.

### 4.2.6 Number of total grains panicle$^{-1}$

### 4.2.6.1 Effect of manure

Significant difference was observed on number of total grains panicle$^{-1}$ due to different manure (Figure 15). Results exhibit that the highest number of total grains panicle$^{-1}$ (193.89) was obtained the treatment $M_1$ (cowdung) where the lowest number of total grains panicle$^{-1}$ (178.58) was observed from the treatment $M_0$ (control). Similar result was also observed by Sarkar *et al.* (2016) who reported that the most noteworthy number of effective tillers hill$^{-1}$ (11.59), number of grains panicle$^{-1}$ (157.6), were recorded in the supplement the executives of 75% suggested portion of inorganic fertilizers + 50% cowdung (5 t $ha^{-1}$). Sohel *et al.* (2016) revealed that 1/3 Cow dung + 1/3 Poultry Manure + 1/3 water hyacinth + Fertilizers increases the grains per panicle, 1000 grain weight as well as grain yield of rice.

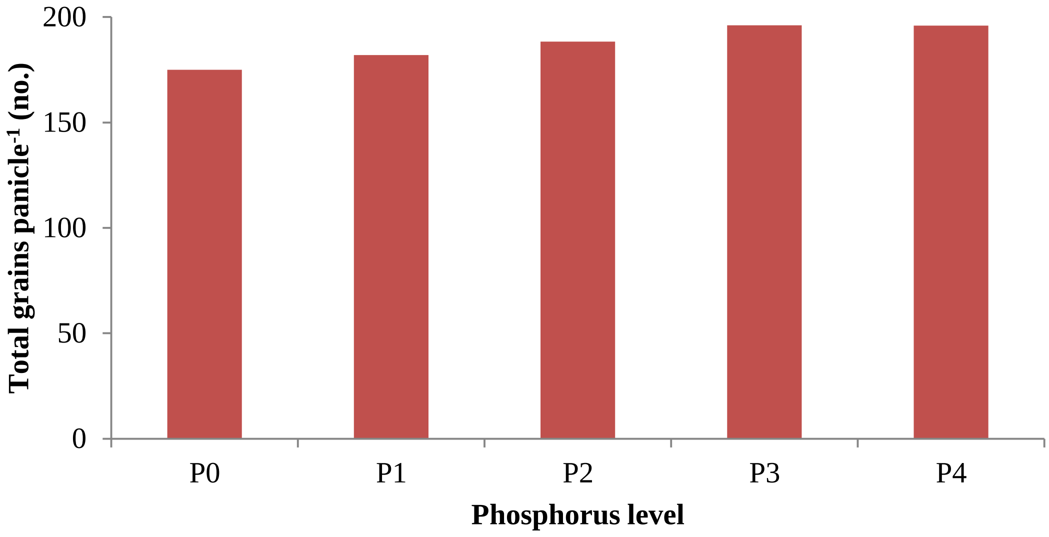



$M_0$= Control, $M_1$= Cowdung @ 10 t $ha^{-1}$ and $M_2$= Poultry manure @ 5 t $ha^{-1}$

**Figure 15. Effect of manure on number of total grains panicle$^{-1}$ of BRRI dhan80** ($LSD_{0.05}$= 3.03).

### 4.2.6.2 Effect of phosphorus

Number of total grains panicle$^{-1}$ of rice was significantly affected by different rates of phosphorus (Figure 16). It was observed that the highest number of total grains panicle$^{-1}$ (196.15) was obtained from the treatment $P_3$ followed by $P_4$ (195.96). The lowest number of total grains panicle$^{-1}$ (175.03) was obtained from the treatment $P_0$ which was statistically similar with $P_1$. Sarkar *et al*. (2014) observed similar findings that grains number panicle$^{-1}$ (152.3) in BRRI dhan34 using higher amount of NPK than recommended dose of NPK. Alam *et al.* (2009) also found that filled grain panicle$^{-1}$, unfilled grain panicle$^{-1}$, spikelet sterility, 1000 grain weight and grain yield had a significant effect with the application of P fertilizer.




$P_0$= Control, $P_1$= 25% lower dose of recommended P, $P_2$= Recommended dose of P, $P_3$= 25% higher dose of recommended P and $P_4$= 50% higher dose of recommended P

**Figure 16. Effect of phosphorus on number of total grains panicle$^{-1}$ (no.) of BRRI dhan80** ($LSD_{0.05}$= 8.29).

#### 4.2.6.3 Combined effect of manure and phosphorus

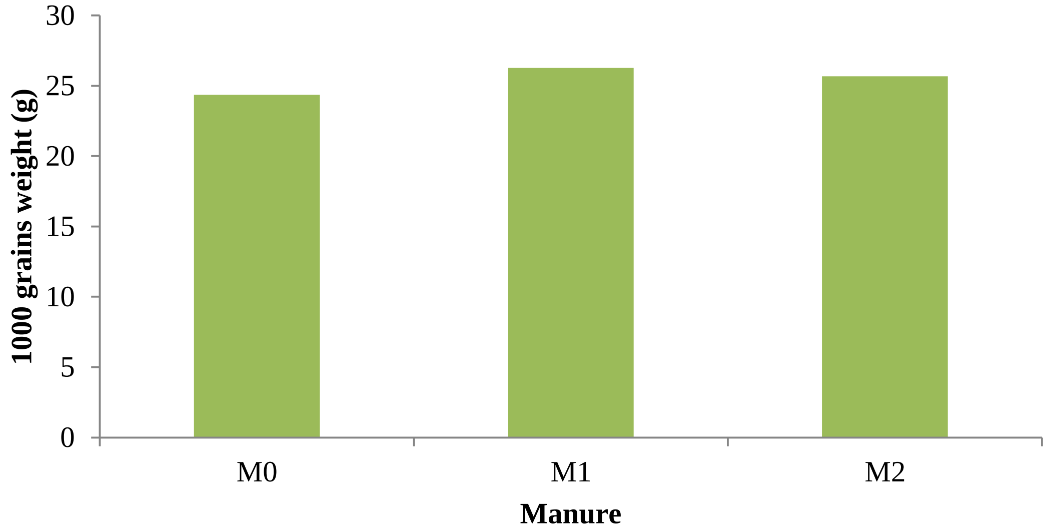
Significant variation was remarked for number of total grains panicle$^{-1}$ of rice due to combined effect of manure and different rates of phosphorus (Table 4 and Appendix VIII). Among the different treatment combinations the highest number of total grains panicle$^{-1}$ (204.93) was achieved from the treatment combination of $M_1P_3$ which was statistically similar with $M_1P_4$ followed by $M_2P_3$. The lowest number of total grains panicle$^{-1}$ (170.20) was obtained from the treatment combination of $M_0P_0$, which was statistically similar with $M_0P_1$, $M_2P_0$ and $M_0P_2$.

### 4.2.7 Weight of 1000 grains

#### 4.2.7.1 Effect of manure

Weight of 1000 grains was significantly influenced by different manure (Figure 17). It was remarked that the highest 1000 grains weight (26.28 g) was obtained from the treatment $M_1$ (cowdung) which was statistically similar with $M_2$ (poultry manure) where the lowest 1000 grains weight (24.35 g) was achieved from the treatment M0 (control). The result agreed with the findings of Haque *et al.* (2021) who reported that 1000-grain weight increases in the application of 75% of RF + biosolid 2 t ha$^{-1}$. It can be recommended as the preferable soil amendment for boosting rice yield, reduce

$CH_4$ emissions, and sustainably maintain soil fertility. Sarkar *et al.* (2016) also reported that 1000-grain weight (15.55 g) and grain yield (3.71 t $ha^{-1}$) were recorded in BRRI dhan34 when combined with 75% suggested portion of inorganic fertilizers + 50% cowdung.

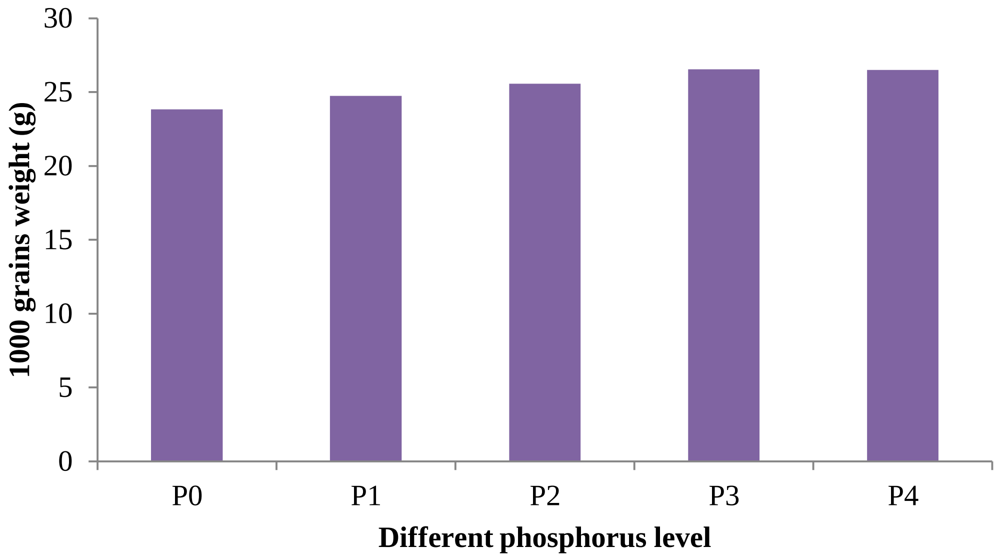



$M_0$= Control, $M_1$= Cowdung @ 10 t $ha^{-1}$ and $M_2$= Poultry manure @ 5 t $ha^{-1}$

**Figure 17. Effect of manure on weight of 1000 grains (g) of BRRI dhan80** ($LSD_{0.05}$= 0.63).

**4.2.7.2 Effect of phosphorus**

Significant difference was found in terms of 1000-grain weight of rice affected by different rates of phosphorus (Figure 18). It was noted that the highest 1000-grain weight (26.55 g) was achieved from the treatment $P_3$ which was statistically similar with $P_4$. The lowest 1000-grain weight (23.83 g) was observed from the treatment $P_0$. Similar trends of result was also observed by Nahar (2018) who reported that 1000 grains weight (21.31 g) and produced the highest grain yield (7.26 t $ha^{-1}$) were obtained from application of bio-fertilizer with P fertilizer. Mamun *et al.* (2011) revealed that dhaincha or cowdung along with 70% NPKS increases 1000- grain weight and grain yield significantly over 70% NPKS application. The relative performances of organic manures were in the order of PM>DH>CD. Alam *et al.* (2009) suggested that filled grain $panicle^{-1}$, unfilled grain $panicle^{-1}$, spikelet sterility, 1000 grains weight and grain yield had a significant effect with the application of P fertilizer.




$P_0$= Control, $P_1$= 25% lower dose of recommended P, $P_2$= Recommended dose of P, $P_3$= 25% higher dose of recommended P and $P_4$= 50% higher dose of recommended P

**Figure 18. Effect of phosphorus on weight of 1000 grains (g) of BRRI dhan80** ($LSD_{0.05}$= 0.83).

### 4.2.7.3 Combined effect of manure and phosphorus

Significant variation on 1000 grains weight was influenced by combined effect of manure and different rates of phosphorus (Table 4 and Appendix VIII). Among the different treatment combinations, the highest 1000 grains weight (27.72 g) was obtained from the treatment combination of $M_1P_3$ which was statistically similar with $M_1P_4$ followed by $M_2P_3$ and $M_2P_4$. The lowest 1000 grains weight (22.97 g) was achieved from the treatment combination of $M_0P_0$, which was statistically similar with the treatment combinations of $M_0P_1$ and $M_2P_0$.

**Table 4. Combined effect of manure and phosphorus on panicle length and grain characters of BRRI dhan80**

| Treatment combinations | Panicle length (cm) | Filled grains panicle$^{-1}$ (no.) | Unfilled grains panicle$^{-1}$ (no.) | Total grains panicle$^{-1}$ (no.) | Weight of 1000 grains (g) |
|---|---|---|---|---|---|
| $M_0P_0$ | 22.71 h | 142.07 i | 28.13 a | 170.20 i | 22.97 h |
| $M_0P_1$ | 22.87 h | 147.77 hi | 25.56 a-c | 173.33 hi | 23.60 gh |
| $M_0P_2$ | 24.05 f-h | 153.47 g-i | 23.53 b-d | 177.00 f-i | 24.55 e-g |
| $M_0P_3$ | 24.65 e-h | 159.57 e-h | 23.10 b-d | 182.67 d-i | 24.86 d-g |
| $M_0P_4$ | 25.57 d-f | 163.47 d-g | 26.27 ab | 189.74 b-f | 25.63 c-e |
| $M_1P_0$ | 24.25 f-h | 157.20 f-h | 22.45 c-e | 179.65 e-i | 24.69 e-g |
| $M_1P_1$ | 25.03 d-g | 162.33 d-g | 25.53 a-c | 187.87 b-g | 25.54 c-e |
| $M_1P_2$ | 27.01 cd | 171.40 b-e | 23.80 b-d | 195.20 a-d | 26.23 b-d |
| $M_1P_3$ | 30.85 a | 188.40 a | 16.53 f | 204.93 a | 27.72 a |
| $M_1P_4$ | 30.45 ab | 182.73 ab | 19.07 ef | 201.80 ab | 27.23 ab |
| $M_2P_0$ | 23.18 gh | 150.87 g-i | 24.38 a-d | 175.25 g-i | 23.82 f-h |
| $M_2P_1$ | 26.66 c-e | 160.47 e-h | 24.20 b-d | 184.67 c-h | 25.12 d-f |
| $M_2P_2$ | 24.97 d-g | 167.73 c-f | 25.00 a-d | 192.73 a-e | 25.91 b-e |
| $M_2P_3$ | 29.40 ab | 179.27 a-c | 21.60 de | 200.87 ab | 27.07 ab |
| $M_2P_4$ | 28.75 bc | 173.20 b-d | 23.13 b-d | 196.33 a-c | 26.67 a-c |
| **$LSD_{(0.05)}$** | **2.23** | **12.68** | **3.67** | **14.36** | **1.44** |
| **CV(%)** | **5.09** | **4.59** | **9.27** | **4.55** | **3.36** |

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

**Notes** ***viz:***

$M_0$= Control (no organic manure)
$M_1$= Cowdung (10 t ha$^{-1}$)
$M_2$= Poultry manure (5 t ha$^{-1}$)

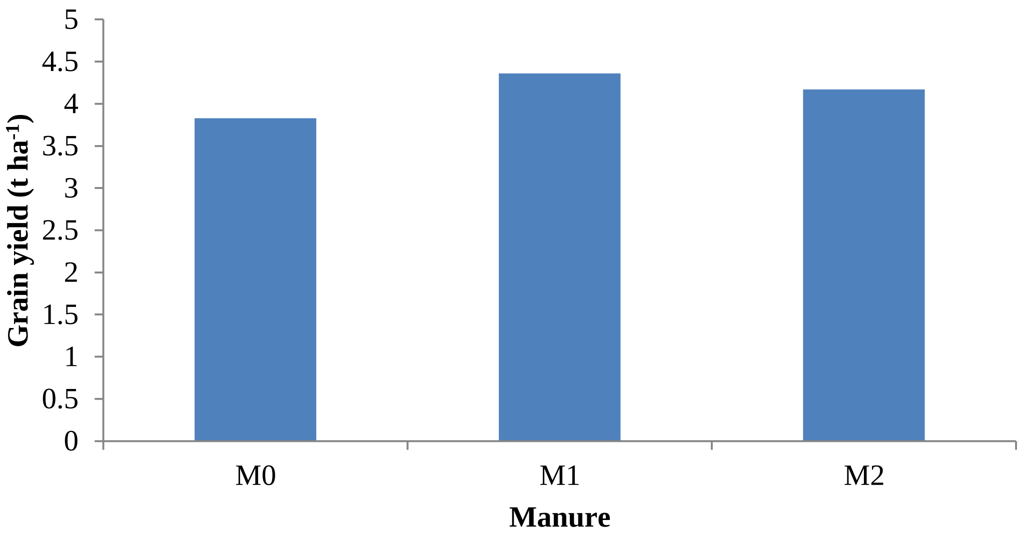
$P_0$= Control (no Phosphorus)
$P_1$= 25% lower dose than recommended dose of P
$P_2$= Recommended dose of P
$P_3$= 25% higher dose than recommended dose of P
$P_4$= 50% higher dose than recommended dose of P

### 4.3 Yield parameters

#### 4.3.1 Grain yield

##### 4.3.1.1 Effect of manure

Grain yield was significantly affected by different manure under the present experiment (Figure 19). It was observed that the highest grain yield (4.36 t $ha^{-1}$) was obtained from the treatment $M_1$ (cowdung) where the lowest grain yield (3.83 t $ha^{-1}$) was found from the treatment $M_0$ (control). Similar trends were also found by Iqbal *et al.* (2020) who reported that the combination of 30% N from PM or CM with 70% N from CF (i.e., urea) is a promising option for improvement of soil quality and rice grain yield. Furthermore, our study provides a sustainable nutrient management plan to increase rice yield with high N use efficiency. Schmidt and Knoblauch (2020) reported that adding poultry manure to flood-irrigated rice fields for five years alters soil chemical properties, improves fertility, does not favor nitrogen use efficiency by rice plants, and promotes a lower grain yield than the chemical fertilizers. Khatun *et al.* (2018) reported the similar trends of result. The application of different levels of cowdung and zinc fertilizers showed that the grain yield (t $ha^{-1}$) over control was significantly increased.

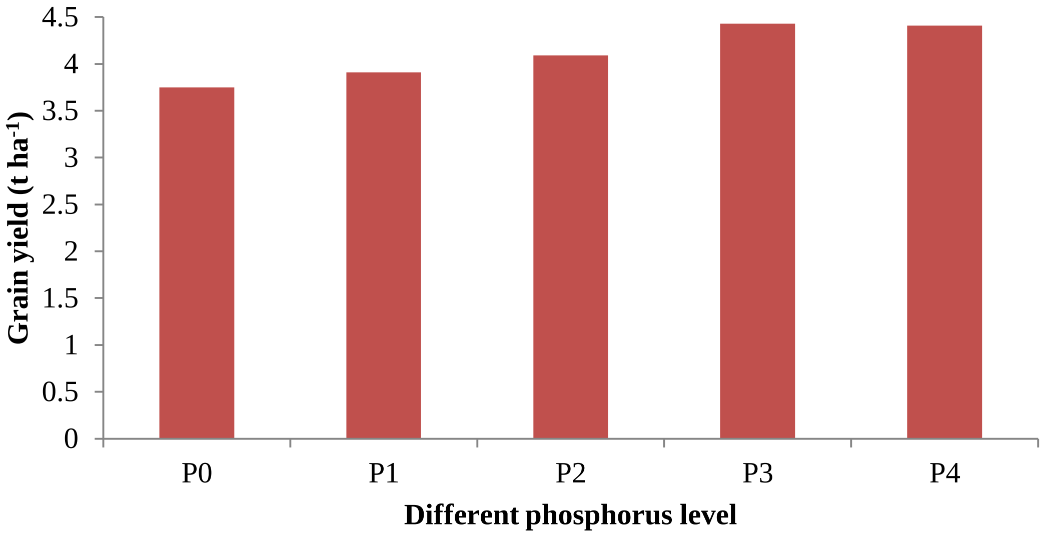



$M_0$= Control, $M_1$= Cowdung @ 10 t $ha^{-1}$ and $M_2$= Poultry manure @ 5 t $ha^{-1}$

**Figure 19. Effect of manure on grain yield (t $ha^{-1}$) of BRRI dhan80** ($LSD_{0.05}$= 0.16).

### 4.3.1.2 Effect of phosphorus

Significant difference was found in terms of grain yield affected by different rates of phosphorus (Figure 20). Results showed that the highest grain yield (4.43 t $ha^{-1}$) was obtained from the treatment $P_3$ followed by $P_4$ (4.41 t $ha^{-1}$) where the lowest grain yield (3.75 t $ha^{-1}$) was found from the treatment $P_0$. Similar result was also observed by Nahar (2018) who reported that using phosphorus fertilizer with bio-fertilizer increases the grain yield. Massawe and Mrema (2017) reported that the P fertilizers were broadcasted and incorporated into the soils before transplanting the rice seedlings and N was applied at two equal splits, namely at tillering and panicle initiation stages. The ranges in yield components between the control (0 kg P $ha^{-1}$) and the highest levels of P fertilizer (60 kg P $ha^{-1}$) were 1.5-8.63, 1.5-9.23 and 1.5-10.43 $tha^{-1}$ grain yields for MPR, TSP and Minjingu mazao, respectively. Sarkar *et al*. (2014) revealed that grain yield (3.71 t $ha^{-1}$) was observed when phosphorus applied higher than the control. Mamun *et al.* (2011) also reported that the dhaincha or cowdung along with 70% NPKS increases the grain yield significantly over 70% NPKS application. The relative performances of organic manures were in the order of PM>DH>CD. Hasanuzzaman *et al.* (2010) reported that among the treatments $T_5$ (Poultry manure @ 4 t $ha^{-1}$ + 50% of recommended NPK) produced the highest grain yield (4.79 t $ha^{-1}$) of rice which was statistically identical to $T_{10}$ (100% of recommended NPK) and $T_9$ (Vermicompost @ 8 t $ha^{-1}$ + $N_{40}P_6K_{36}S_{10}$) which resulted grain yield of 4.57 t $ha^{-1}$ and 4.51 t $ha^{-1}$, respectively. Alam *et al.* (2009) suggested that filled grain $panicle^{-1}$, unfilled grain $panicle^{-1}$, spikelet sterility, 1000 grain weight and grain yield had a significant effect with the application of P fertilizer. Khan *et al*. (2007) reported the similar trends. They revealed that the rice showed positively response to P application and hence both yield and yield parameters were significantly greater in the P than in the check treatment. Paddy yield was increased significantly by P application up to 75% over control. Haque and Biswash (2014) revealed that in case of phosphorus and potassium, higher doses each of 80 kg $ha^{-1}$ $P_2O_5$ and $K_2O$ were found to be better to obtain higher production and good quality (protein) of hybrid rice. The maximum grain yield was recorded with 200 kg N $ha^{-1}$, 80 kg $P_2O_5$ $ha^{-1}$ and 80 kg $K_2O$ $ha^{-1}$.




$P_0$= Control, $P_1$= 25% lower dose of recommended P, $P_2$= Recommended dose of P, $P_3$= 25% higher dose of recommended P and $P_4$= 50% higher dose of recommended P

**Figure 20. Effect of phosphorus on grain yield (t ha$^{-1}$) of BRRI dhan80** ($LSD_{0.05}$= 0.15).

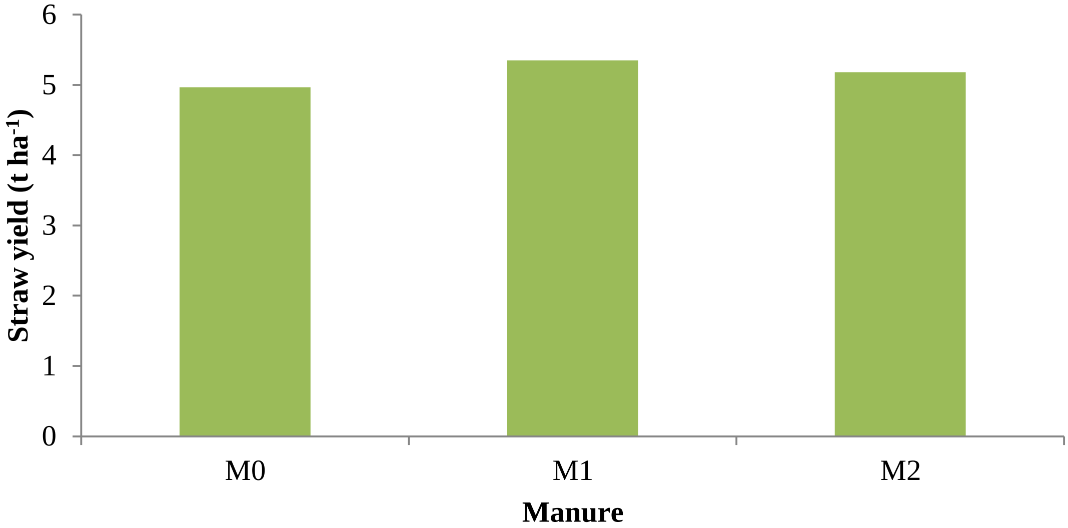
#### 4.3.1.3 Combined effect of manure and phosphorus

Significant variation on grain yield of rice was observed by combined effect of manure and different rates of phosphorus (Table 5 and Appendix IX). It was noted that the highest grain yield (4.87 t ha$^{-1}$) was obtained from the treatment combination of $M_1P_3$ which was statistically similar with $M_1P_4$ where the lowest grain yield (3.62 t ha$^{-1}$) was obtained from the treatment combination of $M_0P_0$ which was statistically similar with $M_0P_1$, $M_0P_2$, $M_1P_0$ and $M_2P_0$.

### 4.3.2 Straw yield

#### 4.3.2.1 Effect of manure

Significant influence on straw yield was found because of different manure (Figure 21). Considering treatment variation, the highest straw yield (5.35 t ha$^{-1}$) was observed from the treatment $M_1$ (cowdung) which was statistically similar with $M_2$ (poultry manure) where the lowest straw yield (4.97 t ha$^{-1}$) was obtained from the treatment $M_0$ (control). The result of the experiment was in agreement with the findings of Haque *et al.* (2021) who reported that straw yield increases in the application of 75% of RF + biosolid 2 t ha$^{-1}$ which can be recommended as the preferable soil amendment for boosting rice yield, reduce $CH_4$ emissions, and sustainably maintain soil fertility. Ismael *et al.* (2021) observed the similar results. They reported that treatments combining urea with manure indicating that N supply in the mixture (urea + manure) is more efficient than in isolated applications of N. The data obtained in this study suggest that a combination of fertilizers ($T_6$-40% urea + 30% beef cattle manure + 30% poultry litter) lead to competitive grain and straw yields and is thus recommended for best soil management practices. Sohel *et al.* (2016) reported the similar trends of result. They revealed that straw yield (7.28 t $ha^{-1}$) was obtained from 1/3 cowdung + 1/3 poultry manure + 1/3 water hyacinth + chemical fertilizers over control treatments.



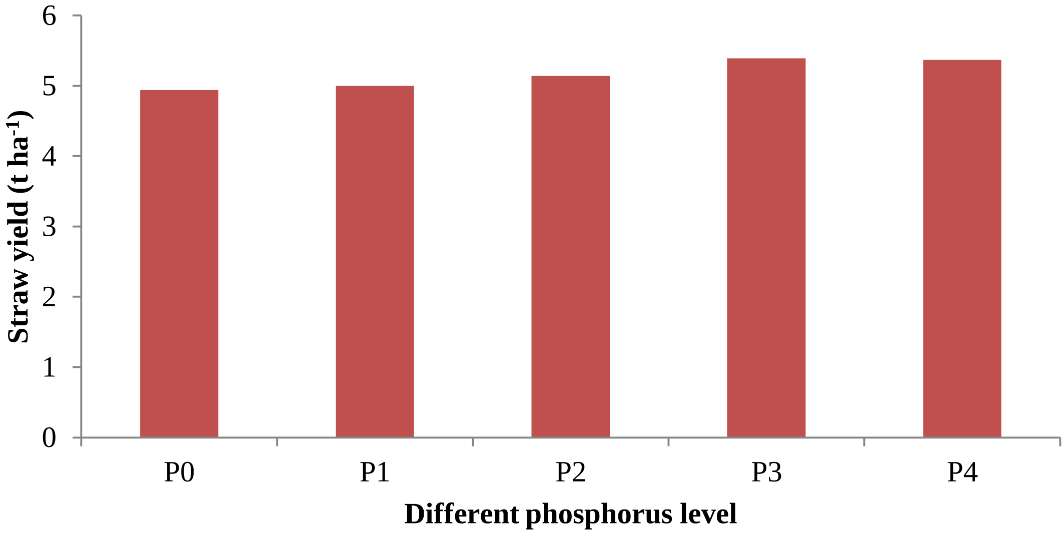

$M_0$= Control, $M_1$= Cowdung @ 10 t $ha^{-1}$ and $M_2$= Poultry manure @ 5 t $ha^{-1}$

**Figure 21. Effect of manure on straw yield (t $ha^{-1}$) of BRRI dhan80** ($LSD_{0.05}$= 0.24).

#### 4.3.2.2 Effect of phosphorus

Significant impact was observed in terms of straw yield influenced by different rates of phosphorus under the study (Figure 22 and Appendix IX). Among the different phosphorus treatment the highest straw yield (5.39 t $ha^{-1}$) was noted from the treatment $P_3$ which was statistically similar with $P_4$ (5.37 t $ha^{-1}$) where the lowest straw yield (4.94 t $ha^{-1}$) was observed from the treatment $P_0$ which was statistically similar with $P_1$ (5.00 t $ha^{-1}$) followed by $P_2$. Sharada and Sujathamma (2018) observed the similar trends. They revealed that highest straw yield of 7430 kg $ha^{-1}$ with $T_{10}$ treatment (50% organic fertilizers of Vermicompost, Jeevamrutha 5% and

Panchagavya 3% and 50% inorganic fertilizer of NPK). Mamun *et al.* (2011) revealed the similar result. They reported that dhaincha or cowdung along with 70% NPKS increases grain and straw yield significantly over 70% NPKS application. The relative performances of organic manures were in the order of PM>DH>CD.




$P_0$= Control, $P_1$= 25% lower dose of recommended P, $P_2$= Recommended dose of P, $P_3$= 25% higher dose of recommended P and $P_4$= 50% higher dose of recommended P

**Figure 22. Effect of phosphorus on straw yield (t ha$^{-1}$) of BRRI dhan80** ($LSD_{0.05}$= 0.23).

#### 4.3.2.3 Combined effect of manure and phosphorus

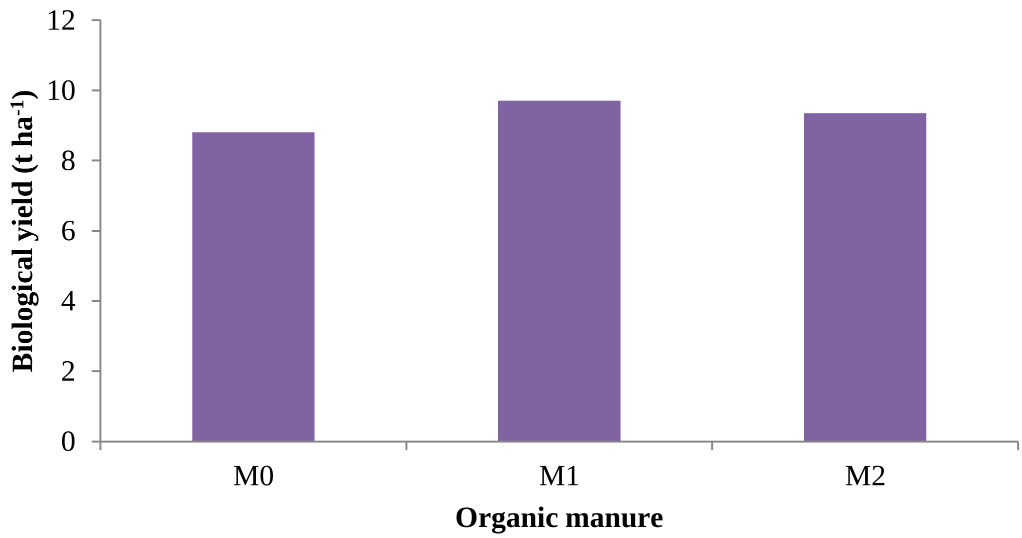
Significant variation on straw yield of rice was observed by combined effect of manure and different rates of phosphorus (Table 5 and Appendix IX). It was noted that the highest straw yield (5.76 t ha$^{-1}$) was obtained from the treatment combination of $M_1P_3$ which was statistically similar with $M_1P_4$ followed by $M_2P_3$ and $M_2P_4$ where the lowest straw yield (4.85 t ha$^{-1}$) was obtained from the treatment combination of $M_0P_0$, which was statistically similar with $M_0P_1$, $M_0P_2$, $M_1P_0$ and $M_2P_0$.

### 4.3.3 Biological yield

#### 4.3.3.1 Effect of manure

Significant difference was observed on biological yield because of different manure under the study (Figure 23). It was found that the highest biological yield (9.71 t ha$^{-1}$) was obtained from the treatment $M_1$ (cowdung) where the lowest biological yield

(8.81 t $ha^{-1}$) was observed from the treatment $M_0$ (control). Khatun *et al.* (2018) reported that the application of different levels of cowdung and zinc fertilizers showed that the grain yield (t $ha^{-1}$), straw yield (t $ha^{-1}$) and biological yields over control were significantly increased. Arif *et al.* (2014) revealed that biological yield (10.19 t $ha^{-1}$) was 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. Hasanuzzaman *et al.* (2010) reported that biological yield was found to be highest with the treatment $T_5$ (Poultry manure @ 4 t $ha^{-1}$ + $N_{40}P_6K_{36}S_{10}$ i.e. 50% NPK).

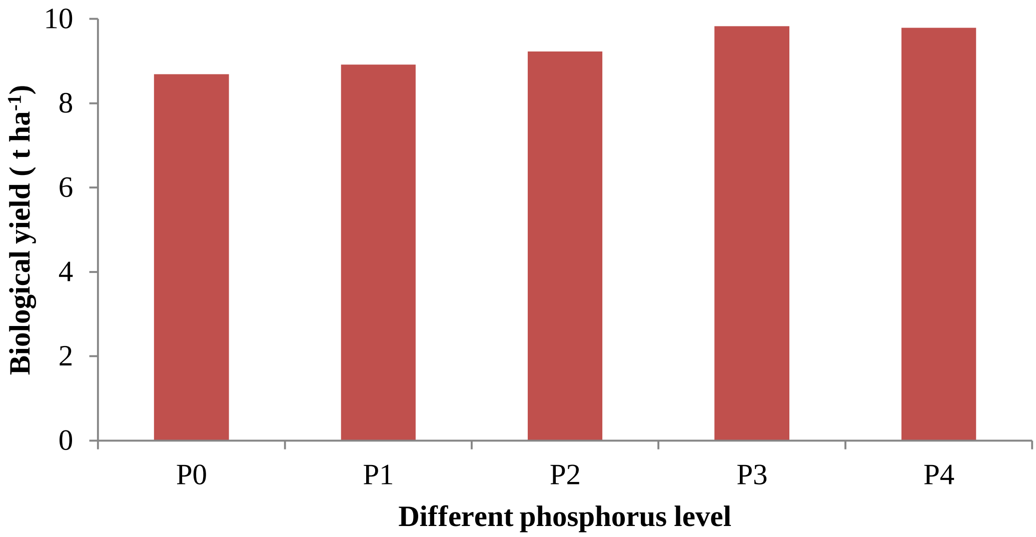



$M_0$= Control, $M_1$= Cowdung @ 10 t $ha^{-1}$ and $M_2$= Poultry manure @ 5 t $ha^{-1}$

**Figure 23. Effect of manure on biological yield (t $ha^{-1}$) of BRRI dhan80** ($LSD_{0.05}$= 0.06).

### 4.3.3.2 Effect of phosphorus

Biological yield of rice was significantly influenced by different rates of phosphorus (Figure 24). Results showed that the highest biological yield (9.83 t $ha^{-1}$) was achieved from the treatment $P_3$ which was statistically similar with the treatment $P_4$ where the lowest biological yield (8.69 t $ha^{-1}$) was observed from the treatment $P_0$ which was statistically similar with treatment $P_1$. Haque and Biswash (2014) revealed that in case of phosphorus and potassium, higher doses each of 80 kg $ha^{-1}$ $P_2O_5$ and $K_2O$ were found to be better to obtain higher production and good quality (protein) of hybrid rice. Khan *et al*. (2007) revealed that rice showed positively response to P application and hence both yield and yield parameters were significantly greater in the P than in the check treatment.




$P_0$= Control, $P_1$= 25% lower dose of recommended P, $P_2$= Recommended dose of P, $P_3$= 25% higher dose of recommended P and $P_4$= 50% higher dose of recommended P

**Figure 24. Effect of phosphorus on biological yield (t ha$^{-1}$) of BRRI dhan80** ($LSD_{0.05}$= 0.42).

### 4.3.3.3 Combined effect of manure and phosphorus

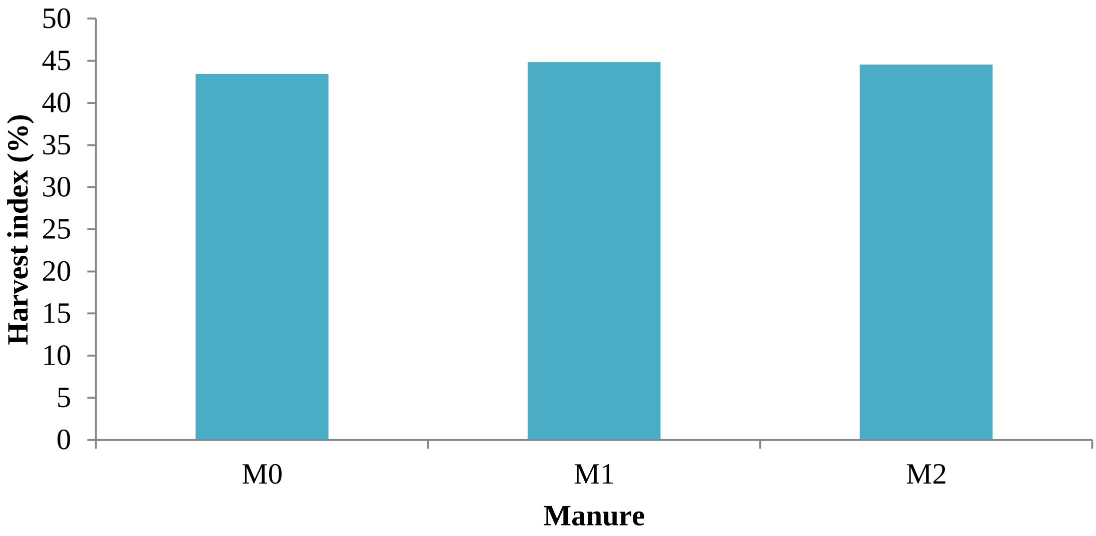
Significant difference was notable for biological yield of rice because of combined effect of manure and different rates of phosphorus (Table 5 and Appendix IX). It was remarked that the highest biological yield (10.63 t ha$^{-1}$) was achieved from the treatment combination of $M_1P_3$ which was statistically similar with $M_1P_4$. On the other hand the lowest biological yield (8.47 t ha$^{-1}$) was achieved from the treatment combination of $M_0P_0$ which was statistically similar with $M_0P_1$, $M_0P_2$, $M_1P_0$ and $M_2P_0$.

### 4.3.4 Harvest index

### 4.3.4.1 Effect of manure

Harvest index was significantly affected by different manure under the present experiment (Figure 25). It was expressed that the highest harvest index (44.85%) was obtained from the treatment $M_1$ (cowdung) where the lowest harvest index (43.45%)

was achieved from the treatment $M_0$ (control). The result of the experiment was in coincided with the findings of Arif *et al.* (2014) who reported that 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. Hasanuzzaman *et al.* (2010) revealed that Poultry manure @ 4 t $ha^{-1}$ + 50% of recommended NPK) produced the highest grain yield and harvest index of rice which was statistically identical to $T_{10}$ (100% of recommended NPK) and $T_9$ (Vermicompost @ 8 t $ha^{-1}$ + $N_{40}P_6K_{36}S_{10}$).

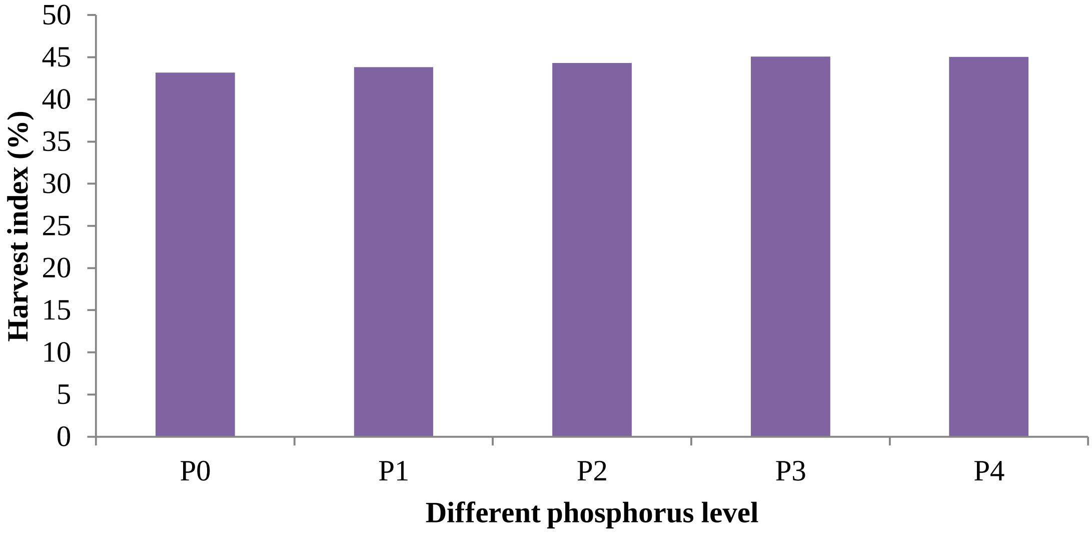



$M_0$= Control, $M_1$= Cowdung @ 10 t $ha^{-1}$ and $M_2$= Poultry manure @ 5 t $ha^{-1}$

**Figure 25. Effect of manure on harvest index (%) of BRRI dhan80** ($LSD_{0.05}$= 0.83).

#### 4.3.4.2 Effect of phosphorus

Significant difference was found in terms of harvest index of rice influenced by different rates of phosphorus (Figure 26). Results showed that the highest harvest index (45.09%) was achieved from the treatment $P_3$ followed by $P_4$ (45.03%) where the lowest harvest index (43.17%) was obtained from the treatment $P_0$ followed by $P_1$ (43.82%). The result of the experiment was in agreement with the findings of Nahar (2018). Khan *et al.* (2007) reported that rice showed positively response to P application and hence both yield and yield parameters were significantly greater in the P than in the check treatment.




$P_0$= Control, $P_1$= 25% lower dose of recommended P, $P_2$= Recommended dose of P, $P_3$= 25% higher dose of recommended P and $P_4$= 50% higher dose of recommended P

**Figure 26. Effect of phosphorus on harvest index (%) of BRRI dhan80** ($LSD_{0.05}$= 1.24).

#### 4.3.4.3 Combined effect of manure and phosphorus

Combined effect of manure and different rates of phosphorus showed significant influence on harvest index of aromatic rice (Table 5 and Appendix IX). It was indicated that the highest harvest index (45.81%) was obtained from the treatment combination of $M_1P_3$ followed by $M_1P_4$ and $M_2P_3$ and $M_2P_4$. The lowest harvest index (42.17%) was achieved from the treatment combination of $M_0P_0$ which was statistically similar with $M_0P_1$, $M_0P_2$, $M_1P_0$ and $M_2P_0$.

**Table 5. Combined effect of manure and phosphorus fertilizer on grain yield, straw yield, biological yield and harvest index of BRRI dhan80**

| Treatment combinations | Grain yield (t $ha^{-1}$) | Straw yield (t $ha^{-1}$) | Biological yield (t $ha^{-1}$) | Harvest index (%) |
|---|---|---|---|---|
| **$M_0P_0$** | 3.62 j | 4.85 e | 8.47 h | 42.71 f |
| **$M_0P_1$** | 3.70 ij | 4.91 e | 8.61 gh | 42.95 ef |
| **$M_0P_2$** | 3.81 h-j | 4.95 de | 8.76 f-h | 43.50 c-f |
| **$M_0P_3$** | 3.91 g-i | 5.03 c-e | 8.95 e-h | 43.73 b-f |
| **$M_0P_4$** | 4.11 e-g | 5.15 c-e | 9.26 c-g | 44.38 a-f |
| **$M_1P_0$** | 3.87 g-j | 5.00 c-e | 8.87 e-h | 43.61 b-f |
| **$M_1P_1$** | 4.06 e-h | 5.11 c-e | 9.17 d-g | 44.27 a-f |
| **$M_1P_2$** | 4.27 c-e | 5.25 b-e | 9.52 c-e | 44.85 a-e |
| **$M_1P_3$** | 4.87 a | 5.76 a | 10.63 a | 45.81 a |
| **$M_1P_4$** | 4.73 ab | 5.62 ab | 10.35 ab | 45.70 ab |
| **$M_2P_0$** | 3.77 ij | 4.96 de | 8.73 f-h | 43.18 d-f |
| **$M_2P_1$** | 3.97 f-i | 5.00 c-e | 8.97 e-h | 44.25 a-f |
| **$M_2P_2$** | 4.19 d-f | 5.21 b-e | 9.40 c-f | 44.57 a-f |
| **$M_2P_3$** | 4.51 bc | 5.39 a-c | 9.90 bc | 45.55 a-c |
| **$M_2P_4$** | 4.41 cd | 5.35 a-d | 9.76 b-d | 45.18 a-d |
| **$LSD_{(0.05)}$** | **0.25** | **0.39** | **0.73** | **2.14** |
| **CV(%)** | **3.62** | **4.52** | **4.69** | **2.87** |

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

**Notes *viz:***

$M_0$= Control (no organic manure)
$M_1$= Cowdung (10 t $ha^{-1}$)
$M_2$= Poultry manure (5 t $ha^{-1}$)

$P_0$= Control (no Phosphorus)
$P_1$= 25% lower dose than recommended dose of P
$P_2$= Recommended dose of P
$P_3$= 25% higher dose than recommended dose of P
$P_4$= 50% higher dose than recommended dose of P

# CHAPTER V

# SUMMARY, CONCLUSIONS AND RECOMMENDATION

# CHAPTER V

## SUMMARY, CONCLUSIONS AND RECOMMENDATION

The field experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from July 2019 to November 2019 to find out the effect of manure and phosphorus level on growth and yield of aromatic rice. Two factors were used in the experiment, *viz*. Manure – $M_0$ (control), $M_1$ (10 t $ha^{-1}$ cowdung) and $M_2$ (5 t $ha^{-1}$ poultry manure) and five levels of phosphorus application - $P_0$ (control), $P_1$ (25% lower dose than recommended dose of P), $P_2$ (recommended dose of P), $P_3$ (25% higher dose than recommended dose of P) and $P_4$ (50% higher dose than recommended dose of P). The experiment was laid out in a Split-plot design with three replications. Data on different growth, yield and yield contributing parameters were recorded.

Different manure had significant influence on growth, yield and yield contributing parameters of aromatic rice. Considering the growth, yield and yield contributing parameters, the tallest plant (115.55 cm at harvest), maximum number of tillers $hill^{-1}$ (11.57 at harvest), effective tillers $hill^{-1}$ (10.68), panicle length (27.52 cm), filled grains $panicle^{-1}$ (172.21), total grains $panicle^{-1}$ (193.89), 1000 grains weight (26.28 g), grain yield (4.36 t $ha^{-1}$), straw yield (5.35 t $ha^{-1}$), biological yield (9.71 t $ha^{-1}$) and harvest index (44.85%) were achieved from the treatment $M_1$ (10 t cowdung $ha^{-1}$). But the maximum number of non-effective tillers $hill^{-1}$ (1.27) and unfilled grains $panicle^{-1}$ (25.32) were obtained from the treatment $M_0$ (control). On the other hand, the shortest plant (110.87 cm at harvest), minimum number of tillers $hill^{-1}$ (9.67), effective tillers $hill^{-1}$ (8.40), panicle length (23.97 cm), filled grains $panicle^{-1}$ (153.07), total grains $panicle^{-1}$ (178.58), 1000 grains weight (24.35 g), grain yield (3.83 t $ha^{-1}$), straw yield (4.97 t $ha^{-1}$), biological yield (8.81 t $ha^{-1}$) and harvest index (43.45%) were achieved from the treatment $M_0$ (control) but the lowest number of non-effective tillers $hill^{-1}$ (0.89) and unfilled grains $panicle^{-1}$ (21.48) were observed from the treatment $M_1$ (10 t cowdung $ha^{-1}$).

Different rates of phosphorus application had significant influence on growth, yield and yield contributing parameters of aromatic rice. Considering the growth, yield and yield contributing parameters, the tallest plant (123.27 cm at harvest), maximum number of tillers $hill^{-1}$ (11.87 at harvest), effective tillers $hill^{-1}$ (11.02), panicle length

(28.30 cm), filled grains panicle$^{-1}$ (175.08), total grains panicle$^{-1}$ (196.15), weight of 1000 grains (26.55 g), grain yield (4.43 t ha$^{-1}$), straw yield (5.39 t ha$^{-1}$), biological yield (9.83 t ha$^{-1}$) and harvest index (45.09%) were noted from the treatment $P_3$ (25% higher dose than recommended dose of P). But the maximum number of non-effective tillers hill$^{-1}$ (1.35) was obtained from the treatment $P_0$ (control) and unfilled grains panicle$^{-1}$ (25.09) was obtained from the treatment $P_1$ (25% lower dose than recommended dose of P). On the other hand, the shortest plant (102.53 cm at harvest), minimum number of tillers hill$^{-1}$ (9.39), effective tillers hill$^{-1}$ (8.04), panicle length (23.38 cm), filled grains panicle$^{-1}$ (150.05), total grains panicle$^{-1}$ (175.03), 1000 grains weight (23.83 g), grain yield (3.75 t ha$^{-1}$), straw yield (4.94 t ha$^{-1}$), biological yield (8.69 t ha$^{-1}$) and harvest index (43.17%) were achieved from the treatment $P_0$ (control) but the lowest number of non-effective tillers hill$^{-1}$ (0.83) was obtained from the treatment $P_4$ and unfilled grains panicle$^{-1}$ (20.41) was noted from the treatment $P_3$ (25% higher dose than recommended dose of P).

Combined effect of manure and phosphorus had also significant influence on growth, yield and yield contributing parameters of aromatic rice. Considering the growth yield and yield contributing parameters, the tallest plant (125.15 cm at harvest), maximum number of tillers hill$^{-1}$ (13.06 at harvest), effective tillers hill$^{-1}$ (12.41), panicle length (30.85 cm), filled grains panicle$^{-1}$ (188.40), total grains panicle$^{-1}$ (204.93), 1000 grains weight (27.72 g), grain yield (4.87 t ha$^{-1}$), straw yield (5.76 t ha$^{-1}$), biological yield (10.63 t ha$^{-1}$) and harvest index (45.81%) were achieved from $M_1P_3$ treatment combination (10 t cowdung ha$^{-1}$ + 25% higher dose than recommended dose of P). But the maximum number of non-effective tillers hill$^{-1}$ (1.52) and unfilled grains panicle$^{-1}$ (28.13) were obtained from the treatment combination of $M_0P_0$ (control). On the other hand, the shortest plant (99.26 cm at harvest), minimum number of tillers hill$^{-1}$ (8.75), effective tillers hill$^{-1}$ (7.23), panicle length (22.71 cm), filled grains panicle$^{-1}$ (142.07), total grains panicle$^{-1}$ (170.20), weight of 1000 grains (22.97 g), grain yield (3.62 t ha$^{-1}$), straw yield (4.85 t ha$^{-1}$), biological yield (8.47 t ha$^{-1}$) and harvest index (42.71%) were achieved from the treatment combination of $M_0P_0$ (control) but the lowest number of non-effective tillers hill$^{-1}$ (0.65) and unfilled grains panicle$^{-1}$ (16.53) were observed from the treatment combination of $M_1P_3$ (10 t cowdung ha$^{-1}$ + 25% higher dose than recommended dose of P).

## CONCLUSIONS

From the above findings, it may be concluded that-

- The treatment manure, $M_1$ (cowdung @10 t $ha^{-1}$) performed the best results in case of growth and grain yield.
- In case of phosphorus treatment, $P_3$ (25% higher dose than recommended dose of P) performed the best results.
- The treatment combination of $M_1P_3$ (10 t cowdung $ha^{-1}$ + 25% higher dose than recommended dose of P) is the superior combination compared to other treatment combinations for aromatic rice production.

## RECOMMENDATION

- Although the treatment combination of manure, $M_1$ (10 t cowdung $ha^{-1}$) with phosphorus treatment, $P_4$ (50% higher dose than recommended dose of P) gave similar result with treatment combination of manure $M_1$ (10 t cowdung $ha^{-1}$) with phosphorus treatment $P_3$ (25% higher dose than recommended dose of P) may be recommended for aromatic rice cultivation as this combination required lower dose of phosphorus.

# REFERENCES

## REFERENCES

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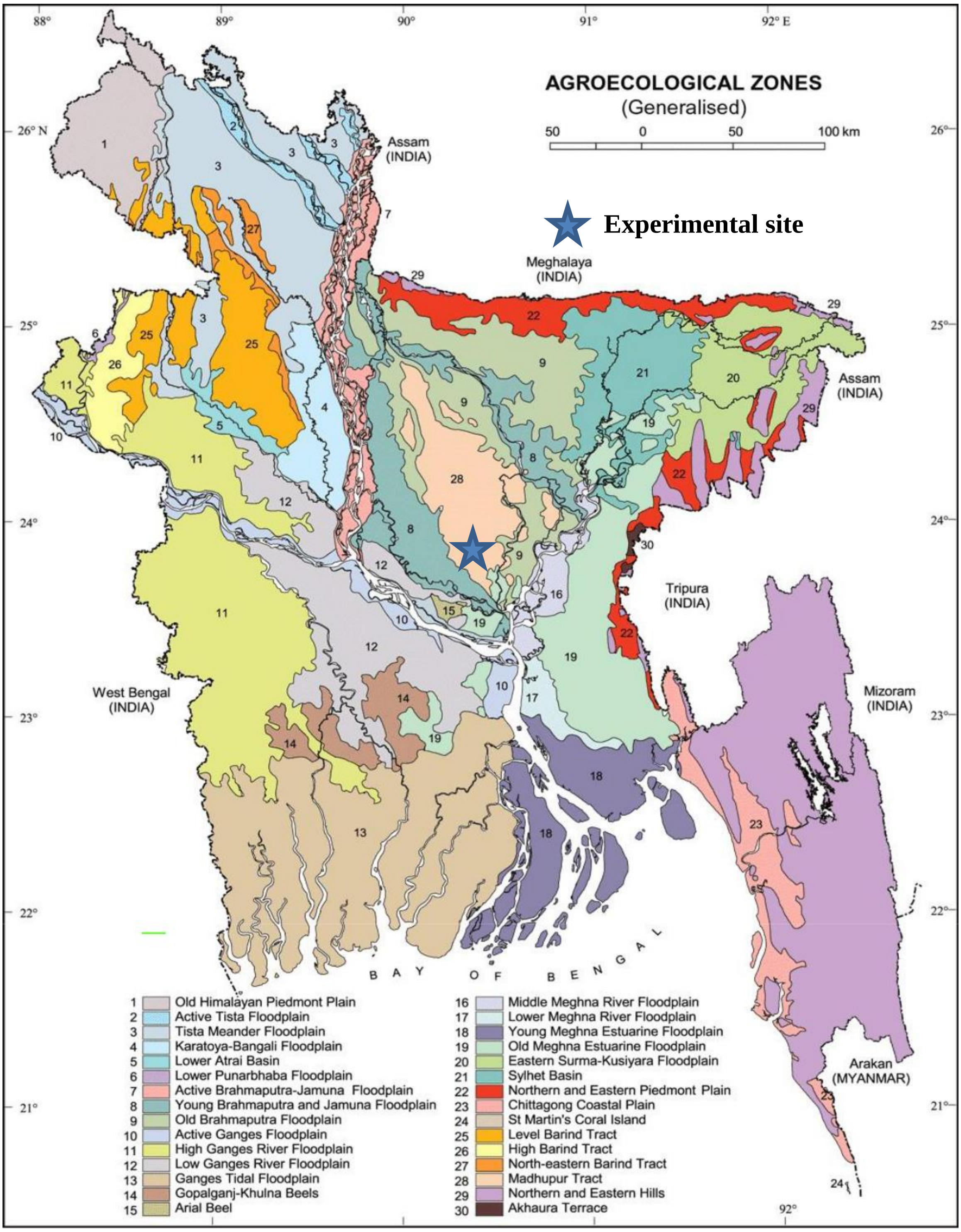
# APPENDICES

# APPENDICES

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



**Appendix II. Monthly records of air temperature, relative humidity and total rainfall during the period from July 2019 to December 2019**

| Year | Month | Air temperature ($^{0}C$) | | Relative humidity (%) | Total rainfall (mm) |
|---|---|---|---|---|---|
| | | Maximum | Minimum | | |
| 2019 | July | 32.6 | 26.8 | 81 | 114 |
| | August | 32.6 | 26.5 | 80 | 106 |
| | September | 32.4 | 25.7 | 80 | 86 |
| | October | 31.2 | 23.9 | 76 | 52 |
| | November | 29.6 | 19.8 | 53 | 00 |
| | December | 28.8 | 19.1 | 47 | 00 |

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212

**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 | Sher-e-Bangla Agricultural University, 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 |

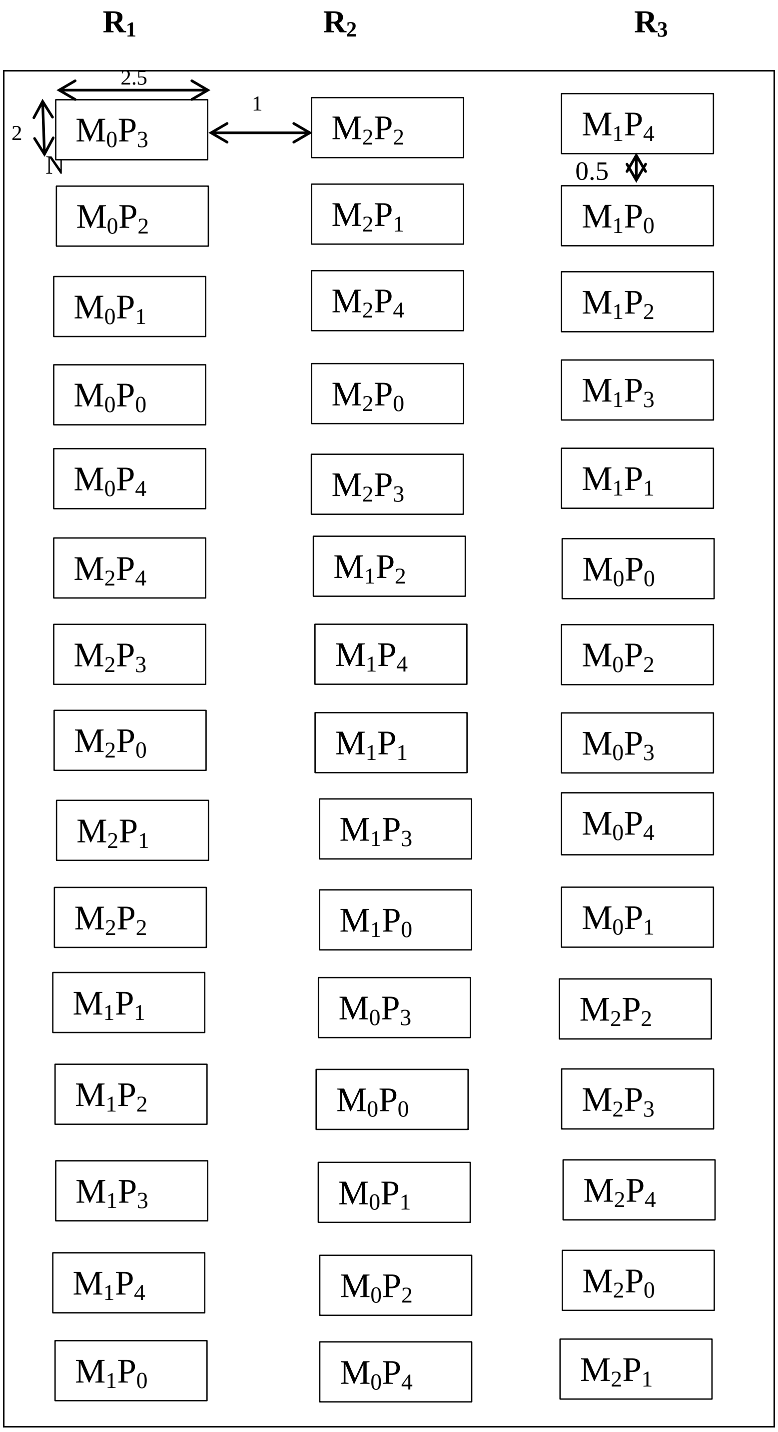
Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

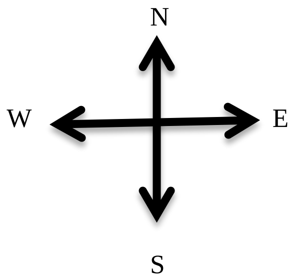
| Characteristics | Value |
|---|---|
| Partical size analysis % Sand | 27 |
| %Silt | 43 |
| % Clay | 30 |
| Textural class | Silty Clay Loam |
| pH | 6.2 |
| Organic carbon (%) | 0.45 |
| Organic matter (%) | 0.78 |
| Total N (%) | 0.03 |
| Available P (ppm) | 20 |
| Exchangeable K ( me/100 g soil) | 0.1 |
| Available S (ppm) | 45 |

Source: Soil Resource Development Institute (SRDI)

## Appendix IV: Layout of the experimental field




**LEGENDS**




**Factor A: Manure (3)**

$M_0$= Control
$M_1$= Cowdung @10 t $ha^{-1}$
$M_2$= Poultry manure @5 t $ha^{-1}$

**Factor B: Phosphorus level (5)**

$P_0$= Control
$P_1$= 25% lower dose of P
$P_2$= Recommended dose of P
$P_3$= 25% higher dose of P
$P_4$= 50% higher dose of P

**Length of plot:** 2.5 m
**Width of plot:** 2 m
**Replication to replication distance**: 1 m
**Plot to plot distance**: 0.5 m
**Unit plot size**: 2.5 m × 2 m (5 $m^2$)

**Appendix V. Mean square values of plant height at different days after transplanting of aromatic rice growing under the experiment**

| Sources of variation | Df | Mean square of plant height at different days after transplanting (DAT) | | | | |
|---|---|---|---|---|---|---|
| | | 30 | 50 | 70 | 90 | At harvest |
| Replication | 2 | 108.703 | 581.820 | 540.022 | 666.667 | 621.089 |
| Factor A | 2 | 106.228** | 175.616** | 70.110* | 67.175* | 82.388* |
| Error | 4 | 0.850 | 0.545 | 7.422 | 11.667 | 17.389 |
| Factor B | 4 | 298.138** | 395.702** | 754.790** | 736.865** | 771.064** |
| A × B | 8 | 1.153* | 3.454* | 2.471* | 2.240* | 1.236 |
| Error | 24 | 1.900 | 4.500 | 13.122 | 27.000 | 5.956 |

* significant at 5% level of significance
** significant at 1% level of significance

**Appendix VI. Mean square values of number of tillers hill$^{-1}$ at different days after transplanting of aromatic rice growing under the experiment**

| Sources of variation | Df | Mean square of number of tillers hill$^{-1}$ at different days after transplanting (DAT) | | | | |
|---|---|---|---|---|---|---|
| | | 30 | 50 | 70 | 90 | At harvest |
| Replication | 2 | 20.184 | 47.242 | 29.009 | 67.586 | 77.429 |
| Factor A | 2 | 6.892** | 6.168** | 11.405** | 16.293** | 14.628** |
| Error | 4 | 0.237 | 0.020 | 0.183 | 0.141 | 0.544 |
| Factor B | 4 | 18.622** | 4.924** | 8.838** | 12.750** | 11.333** |
| A × B | 8 | 0.547** | 0.224* | 0.351* | 0.842* | 0.529* |
| Error | 24 | 0.166 | 0.168 | 0.148 | 0.275 | 0.391 |

* significant at 5% level of significance
** significant at 1% level of significance

**Appendix VII. Mean square values of number of effective tillers hill$^{-1}$ and non-effective tillers hill$^{-1}$ of aromatic rice growing during experimentation**

| Sources of variation | Df | Mean square of | |
|---|---|---|---|
| | | Effective tillers hill$^{-1}$ | Non-effective tillers hill$^{-1}$ |
| Replication | 2 | 42.605 | 0.232 |
| Factor A | 2 | 21.133** | 0.591** |
| Error | 4 | 0.015 | 0.026 |
| Factor B | 4 | 16.165** | 0.436 |
| A × B | 8 | 0.656* | 0.011* |
| Error | 24 | 0.256 | 0.014 |

* significant at 5% level of significance
** significant at 1% level of significance

**Appendix VIII. Mean square values of panicle length, number of filled grains panicle$^{-1}$, number of unfilled grains panicle$^{-1}$, number of total grains panicle$^{-1}$ and weight of 1000 grains of aromatic rice growing during experimentation**

| Sources of variation | Df | Mean square of number of tillers plant$^{-1}$ at | | | | |
|---|---|---|---|---|---|---|
| | | Panicle length | Filled grains panicle$^{-1}$ | Unfilled grains panicle$^{-1}$ | Total grains panicle$^{-1}$ | Weight of 1000 grains |
| Replication | 2 | 143.731 | 2831.950 | 221.645 | 4439.880 | 116.149 |
| Factor A | 2 | 50.802** | 1441.400** | 55.705** | 984.310** | 14.667** |
| Error | 4 | 0.277 | 48.220 | 3.777 | 14.800 | 0.463 |
| Factor B | 4 | 42.726** | 1016.610** | 34.057** | 731.390** | 12.238** |
| A × B | 8 | 4.689* | 32.650* | 11.905* | 38.140* | 0.297* |
| Error | 24 | 1.756 | 53.280 | 4.737 | 65.870 | 0.649 |

* significant at 5% level of significance
** significant at 1% level of significance

**Appendix IX. Mean square values of grain yield, straw yield, biological yield and harvest index of aromatic rice growing during experimentation**

| Sources of variation | Df | Mean square of | | | |
|---|---|---|---|---|---|
| | | Grain yield | Straw yield | Biological yield | Harvest index |
| Replication | 2 | 3.285 | 14.046 | 31.263 | 369.026 |
| Factor A | 2 | 1.082** | 0.515* | 3.067** | 8.067* |
| Error | 4 | 0.025 | 0.057 | 0.003 | 0.665 |
| Factor B | 4 | 0.818** | 0.390** | 2.343** | 5.989* |
| A × B | 8 | 0.062* | 0.045* | 0.205* | 0.240* |
| Error | 24 | 0.022 | 0.55 | 0.189 | 1.619 |

* significant at 5% level of significance
** significant at 1% level of significance

**SOME PICTORIAL VIEW DURING EXPERIMENT**


Plate 1. Photograph during transplanting


Plate 2. Photograph during vegetative stage


Plate 3. Photograph during panicle initiation stage

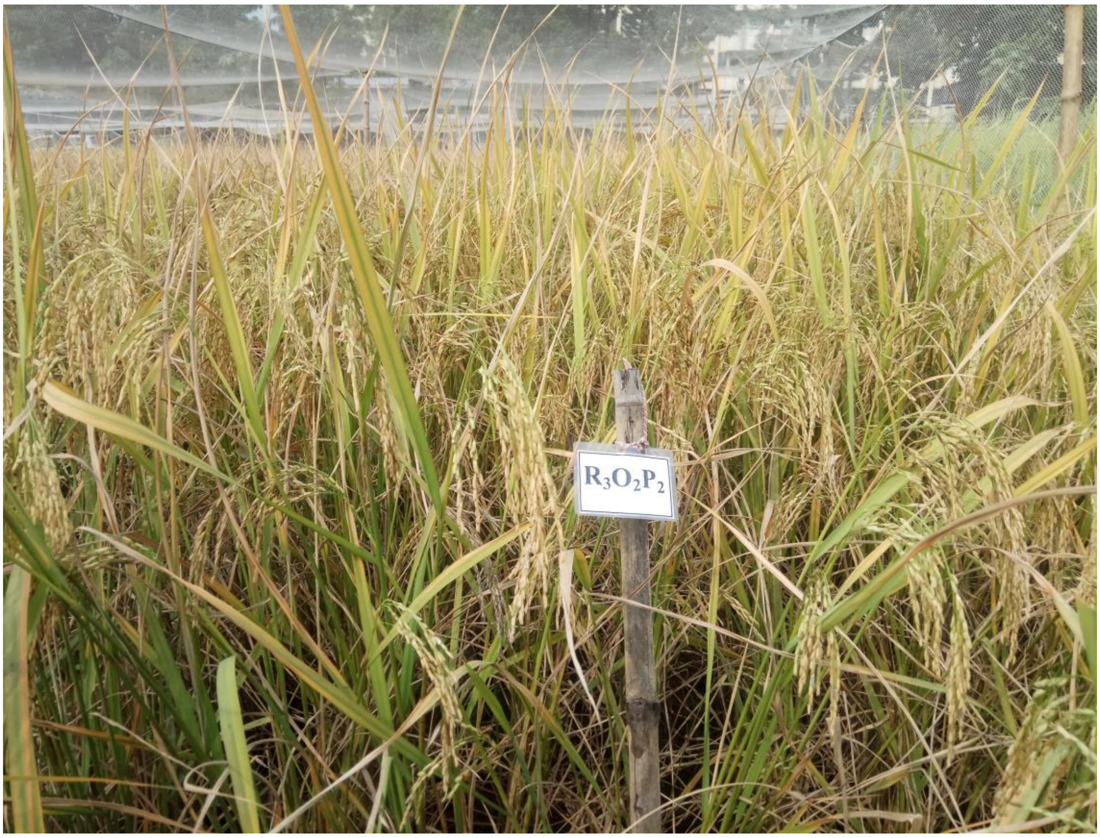



Plate 4. Photograph during ripening stage