EFFECTS OF INORGANIC PHOSPHORUS AND POTASSIUM ALONG WITH COWDUNG AND VERMICOMPOST ON GROWTH, YIELD AND NUTRIENT CONTENT OF BRRI dhan62

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CERTIFICATE

This is to certify that the thesis entitled **"EFFECTS OF PHOSPHORUS AND POTASSIUM ALONG WITH COWDUNG AND VERMICOMPOST ON GROWTH, YIELD AND NUTRIENT CONTENT OF BRRI dhan62"** *submitted to the DEPARTMENT OF AGRICULTURAL CHEMISTRY, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (M.S.) in AGRICULTURAL CHEMISTRY, embodies the results of a piece of bona fide research work carried out by* **MD.AWLAD HOSSAIN**, *Registration No. 05-01716, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma in any other institution.*

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

Dated: June, 2014
Dhaka, Bangladesh

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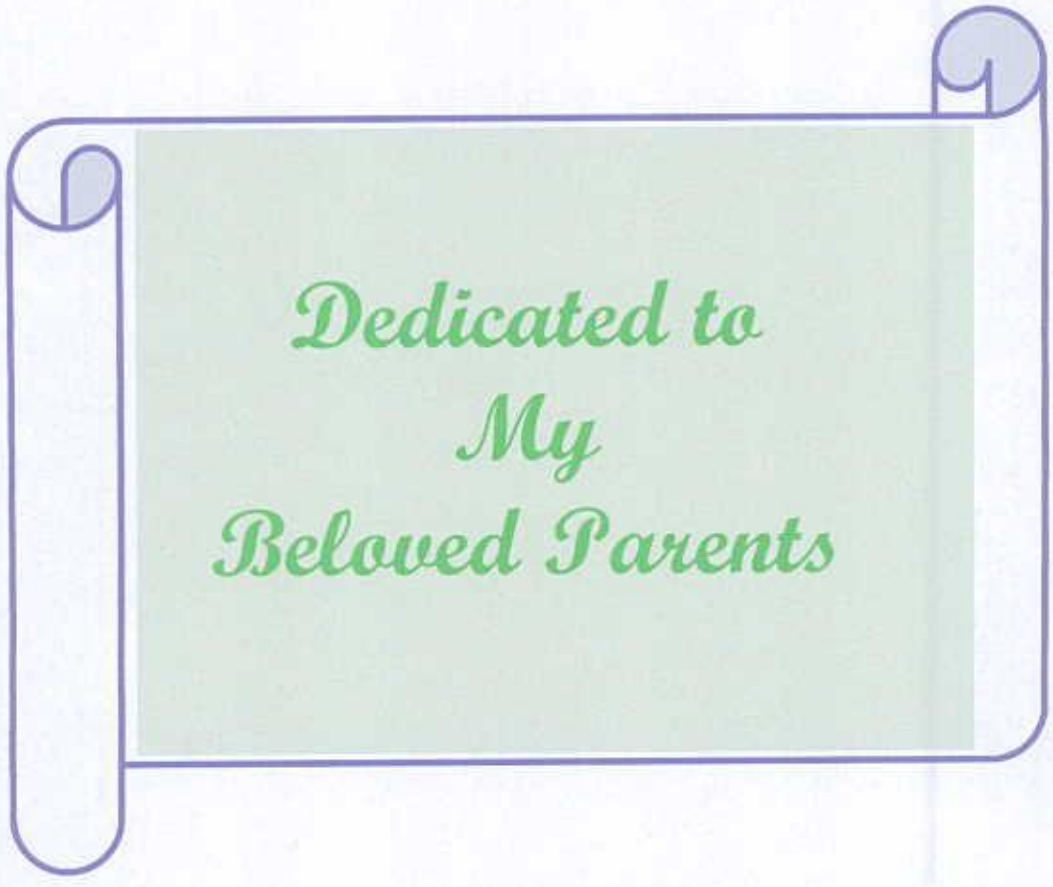
Dedicated to
My
Beloved Parents

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EFFECTS OF PHOSPHORUS AND POTASSIUM ALONG WITH COWDUNG AND VERMICOMPOST ON GROWTH, YIELD AND NUTRIENT CONTENT OF BRRI dhan62

BY

MD. AWLAD HOSSAIN

ABSTRACT

An experiment was conducted at the experimental field of the farm of Sher-e-Bangla Agricultural University during the period from May to October, 2014 to study the effects of different combinations of cowdung (CD) and vermicompost (VC) along with P and K on BRRI dhan62 using RCBD with three replications. The treatments were : T_0 – Control, T_1 – 100% inorganic fertilizer (IF), T_2 – 25 % P from + 75% P from IF, T_3 – 50 % P from CD + 50% P from IF, T_4– 75 % P from CD + 25% P from IF, T_5 – 25 % P from VC + 75% P from IF, T_6 – 50 % P from VC + 50% P from IF, T_7 – 75 % P from VC + 25% P from IF, T_8 – 25 % K from CD + 75% K from IF, T_9 – 50 % K from CD + 50% K from IF, T_{10} – 75 % K from CD + 25% K from IF, T_{11} –25 % K from VC + 75% K from IF, T_{12} – 50 % K from VC + 50% K from IF, T_{13} – 75 % K from VC + 25% K from IF. Most of the growth and yield parameters differed significantly due to the combinations of organic and inorganic sources of P and K. Highest plant height, effective tillers hill^{-1}, total tillers hill^{-1}, longest panicle were produced by 50% K from VC + 50% K from IF while 50% P each from VC and produced the highest number of filled grains panicle^{-1}. The highest grain yield was obtained from 50% K from VC + 50% K from IF which was statistically similar to 50% P from VC + 50% P from IF. The highest straw yield was observed from 50% P from VC + 50% P from IF which was statistically similar to 50% K from VC + 50% K from IF. The highest P and S content in grain was observed from 50% P from VC + 50% P from IF while highest K content in grain was observed from 50% K from VC + 50% K from IF. The overall results suggest that farmers can be advised to use 50% P or K from VC and 50% from IF for better growth and nutrient content of BRRI dhan62 under the agro climatic condition of Sher-e-Bangla Agricultural University.

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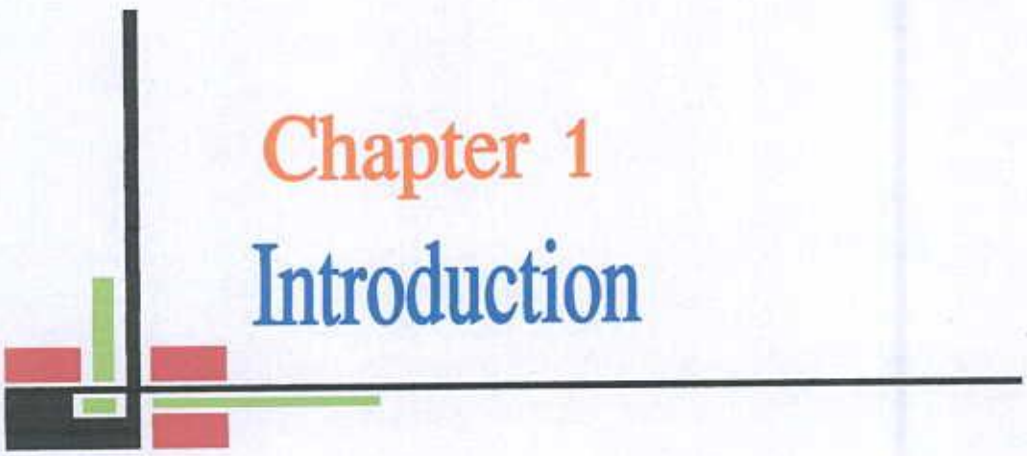
LIST OF ABBREVIATIONS

%	=	Percent
@	=	At the rate
°C	=	Degree Celsius
AEZ	=	Agro Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BAU	=	Bangladesh Agricultural University
BRRI	=	Bangladesh Rice Research Institute
cv.	=	Cultivar (s)
CD	=	Cowdung
DAS	=	Days After Sowing
DMRT	=	Duncan's Multiple Range Test
EC	=	Emulsifiable Concentrate
et al.	=	And Others
FAO	=	Food and Agriculture Organization
g	=	Gram
IRRI	=	International Rice Research Institute
LSD	=	Least Significant Difference
MoP		Muriate of Potash
ppm	=	Parts per million
RCBD	=	Randomized Complete Block Design
SAU	=	Sher-e-Bangla Agricultural University
t/ha	=	Ton per Hectare
Tk./ha	=	Taka per Hectare
TSP	=	Triple Super Phosphate
VC	=	Vermicompost



Chapter 1

Introduction

CHAPTER 1

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important food for the people of Bangladesh and it is the staple food for more than two billion people in Asia (Hien *et al.*, 2006) and it provides 21% and 15% per capita of dietary energy and protein, respectively (Maclean *et al.*, 2002). In Bangladesh, the geographical, climatic and edaphic conditions are favorable for year round rice cultivation. However, the national average rice yield in Bangladesh (4.2 t ha^{-1}) is very low compared to those of other rice growing countries, like China (6.30 t ha^{-1}), Japan (6.60 t ha^{-1}) and Korea (6.30 t ha^{-1}) (FAO, 2009). The population of Bangladesh is increasing at an alarming rate and the cultivable land is reducing due to urbanization and industrialization resulting in more shortage of food. As it is not possible to have horizontal expansion of rice area. So, rice yield $unit^{-1}$ area should be increased to meet this ever-increasing demand of food in the country.

Agriculture in Bangladesh is dominated by intensive rice cultivation covering 80% of arable land and the most dominant cropping pattern is rice. Among the production factors affecting crop yield, essential nutrient is the single most important factor that plays a dominant role in yield increase if other production factors are not limiting. It is reported that chemical fertilizers today hold the key to success of production systems of Bangladesh agriculture being responsible for about 50% of the total crop production (BARC, 1997). Nutrient imbalance can be minimized by judicious application of different fertilizers. There is a need to develop appropriate management technique to assess the nutrient requirement for rice cultivation in the country.

Depleted soil fertility is a major constrain to higher crop production in Bangladesh. The increasing land use intensity has resulted in a great exhaustion of nutrient in soils. The farmers of this country use on an average 102 kg nutrients ha^{-1} annually (70 kg N + 24 kg P + 6 kg K + 2 kg S and Zn) while the crop removal is about 200 kg ha^{-1} (Islam *et al.*, 1994). In Bangladesh, most of the cultivated soils have less than 1.5% organic matter while a good agricultural soil should contain at least 2% organic matter (Ali, 1994). Moreover, this important component of soil is declining with time due to intensive cropping and use of higher dose of chemical fertilizers with little or no

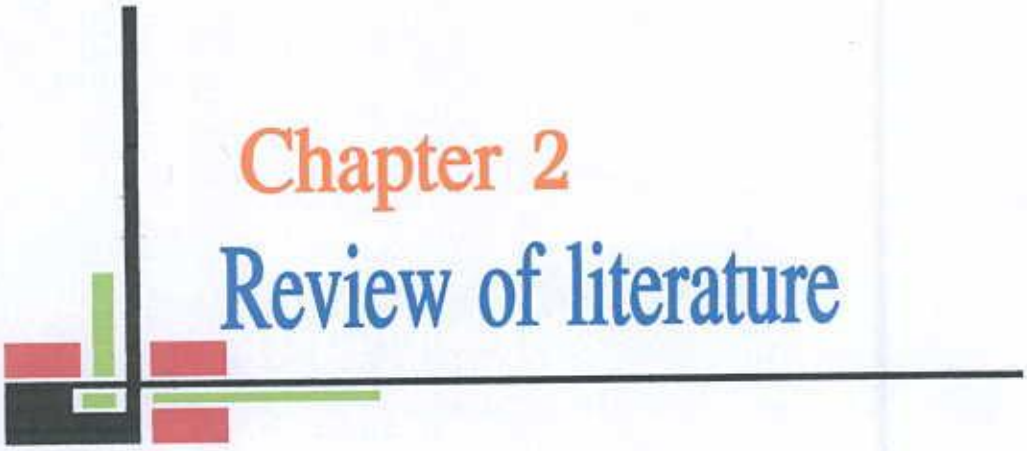
addition of organic manure in the farmer's field. In addition, rapid mineralization of soil organic matter occurs due to humid tropic climatic conditions of Bangladesh. Cowdung can supply a good amount of plant nutrients which can contribute to crop yields. Mineralization and immobilization are biochemical in nature and are mediated through the activities of microorganisms. The rate and extent of mineralization determines crop availability of nutrients. The transformation of N, P and S in soil depends on the quality and quantity of organic matter and cowdung is well known organic manure in our country. The long-term research of Bangladesh Rice Research Institute (BRRI) revealed that the application of cowdung @ 5 t ha^{-1} $year^{-1}$ improved rice productivity as well as prevented the soil resources from degradation. Soil organic matter improves the physicochemical properties of the soil and ultimately promotes crop production. Evidences from different Agro- Ecological Zone (AEZ) of the country have shown a decrease in the content of organic matter by the range of 15 to 30% over the last 20 years (Miah, 1994). Therefore, it would not be wise to depend only on inherent potentials of soils for higher crop production. More recently, attention is focused on the global environmental problems; utilization of organic manures as the most effective measure for the purpose.

Phosphorous (P) is a vital yield determining nutrient in crops. It is an important component of key molecules such as nucleic acids, phospholipids and ATP, and consequently, plants cannot grow without a reliable supply of this nutrient. P is also essential for the seed formation. It is known to stimulate root growth and is associated with early maturity of crops. It not only improves the quality of fruits, forages, vegetables and grains but also play role in disease resistance of plants (Brady and Weil, 1999). Potassium (K) is the third macronutrient required for plant growth, after nitrogen (N) and phosphorus (P). Unlike N and P; K is not a component of cell structure. Instead, it exists in mobile ionic form, and acts primarily as a catalyst (Wallingford, 1980). Potassium has an important osmotic role in plants (Tisdale and Nelson, 1966) and performs important function in arid environments for plants metabolism.

Organic farming relies on large-scale application of animal or farm yard manure (FYM), compost, crop rotation, residues, green manuring, vermicompost, bio-fertilizers and bio-pesticides. But it may not be possible to obtain desired yield from

sole use of organic fertilizers. Balance use of fertilizer is important to obtain maximum seed yield. Therefore, the present study was undertaken –

a. To investigate the effects of P and K along with cowdung and vermicompost on growth and yield of BRRI dhan62.
b. To examine the nutrient content of BRRI dhan62 as affected by the integrated use of organic and inorganic sources of P and K fertilizers.



Chapter 2

Review of literature

CHAPTER 2

REVIEW OF LITERATURE

Among the essential nutrient elements phosphorus and potassium are the important macronutrients and primary elements for the growth and development and better yield of crops. On the other way, use of organic manure is also an essential factor for sustainable soil fertility and crop productivity. The cowdung is the common and well known organic manure in our country. Vermicompost is also becoming more and more popular day by day. Organic fertilizers increase plant growth, yield contributing characters and yield because they are the store house of plant nutrients. The available relevant reviews that are related to the effect of phosphorus and potassium and integrated use of organic and inorganic manure on the yield and yield attributes of rice are reviewed below under the following headings-

2.1 Effect of phosphorus on rice

Plant absorbs phosphorus in the form of $H_2PO_4^-$, HPO_4^{2-} and PO_4^{3-}. Adequate P nutrition enhances many aspects of plant physiology, including the fundamental processes of photosynthesis, N-fixation, flowering fruiting (including seed production) and maturation. It is an essential component of the organic compound often called the energy currency of living cell: adenosine tri phosphate (ATP) (Brady and Weil, 1996). Considerable amounts of works have been done on the effects of phosphorus on rice in different parts of the world. Some of them are cited below:

Zhar *et al.* (2005) conducted an experiment to study the effects of agricultural production on P losses from paddy soils. This implied that runoff P losses would be greatly increased in 10-20 years as a result of the accumulation of soil P if 50 kg P /ha is applied each year.

Xu-Da *et al.* (2005) conducted pot and field experiment to study the effects of N fertilizer application time and N, P, K fertilizer management on grain amylase content and RVA profile parameters in rice cultivars. Result showed that P fertilizer had influenced on the amylase content.

He-Yuan *et al.* (2004) carried out an experiment to study the effects of soil moisture content and phosphorus application on phosphorus nutrition of rice cultivated in different water regime systems. The P application rates had greater effect on the P nutrition of rice than the soil moisture content.

Iqbal (2004) carried out an experiment on interactions of N, P and water application and their combined effects on biomass and yield of rice. It was concluded that the yield of rice increased by 50-60% in response to the application of N and P interaction with H_2O.

Pheav *et al.* (2003) conducted an experiment and seen that freshly applied P increased rice grain yield by 95%. In the first and second crops using residual P fertilizer, yields increased by 62 and 33% relative to the nil-P plot. Grain yields in the third crop using residual P dropped to levels obtained in the nil-P soils.Sharma and Prasad (2003) studied the effect of rock phosphate (RP) and TSP in three cycle of rice-wheat cropping systems. Application of TSP had significant effect on grain and straw yields and P uptake by rice and wheat. They found that the efficiency of RP+TSP was better than that of RP alone in rice wheat cropping system.

Kumar and Singh (2001) observed that the significant response of rice to P was observed only up to 26.2 kg ha^{-1} and application of P in all seasons recorded maximum rice equivalent yield (79.6 q ha^{-1}) which was as per with treatment receiving P in both year rabi (70.8 q ha^{-1}) and treatment receiving P in first *kharif* and *rabi* (70.8 ha^{-1}).

Sahrawat *et al.* (2001) reported that phosphorus deficiency has been identified as a major constant to crop production on highly weathered; low activity clay soils in the humid and sub humid zones of sub Saharan Africa. The main problem concerning is its fixation with soil complex with a very short period of application of inorganic P and relative increase in grain and straw yields.

Chitdeshwari and Savithri (2000) reported that the combined use of organic and inorganic phosphate fertilizer on yield and P status of rice. They obtained highest yield applying 100% of recommended P (SSP) and green manure @ 6.25 t ha^{-1}.

Chowdhury (1996) carried out an experiment in BAU farm to study the effect of different pesticides with recommended doses of NPK (100 kgN/ha, 60 kgP_2O_5/ha and 40 kg K_2O/ha) fertilizers on the growth, yield and mineral composition at tillering and harvesting stages of two varieties of transplanted Aman rice (BR 11 and Nizershall). He reported that nutrients like N, P, K were found to be in higher amount at tillering stage of plant and decreased with the age.

2.2 Effect of Potassium on rice

Dunn and Stevens (2005) found that pre plant and mid season K fertilizer application increased rice yields on soils where K fertilizer application was not previously expected to have that effect.

Arivazhagan *et al.* (2004) carried out a field experiment to investigate the effects of split application of different potassium fertilizers [muriate of potash (MoP) and sulfate of potash (SoP)] on the yield and nutrient uptake by rice (cv. PY). The highest mean grain yield was observed in MoP treated plots in both seasons.

Hong *et al.* (2004) conducted field experiments to investigate the potassium uptake distribution and use efficiency of hybrid and conventional rice under different low K stress conditions. The grain yield and total K uptake by rice increased.

BRRI (1994) reported that applying K rate upto 120 kg/ha that, it failed to increase the straw and grain yield significantly over 30 kg/ha.

Morok and Dhakiwak (1987) reported from replicated field trials enveloping graded doses of K showed that paddy response to the application of K in soils of low to medium K availability. A dose of 30 kg K_2O/ha was optimum that gave unit response of 4.90 kg grain with 1 kg of K_2O dose and also gave a net profit of Rupees 1.88 per Rupee invested on potassium fertilizer.

Purohit *et al.* (1986) conducted two years trails with three varieties of rice and four levels of K_2O (0, 40, 60 and 80 kg/ha) and observed that grain yield and net profit were the highest with 80 kg K_2O/ha.

Uexkull (1984) reported that in traditional rice culture, the negative K balance over a 5 years period was only 169 kg/ha, under intensive HYV culture it increased to about 1200 kg/ha.

2.3 Combined effect of organic and inorganic fertilizer on rice

Kumar and Reddy (2010) conducted an experiment during three consecutive kharif seasons of 2000, 2001 and 2002 at Agricultural Research Station, Neliore in the southern Agro-climatic Zone of Andhra Pradesh to study the effect of organic and inorganic sources of nitrogen on soil fertility, productivity and profitability of lowland rice. Farmyard manure, poultry manure and neem cake were tried as organic sources of nitrogen substituting 25% and 50% of inorganic nitrogen in comparison to 100% inorganic nitrogen. The experiment was laid out in randomized block design, replicated thrice. The combination of 50% N through urea and 50% N through any of the organic sources viz., farmyard manure, poultry manure and neem cake produced significantly higher grain and straw yield, net returns and benefit cost ratio. Integrated supply of N at 50% each through fertilizer and organics recorded higher N uptake than all other combinations. Post harvest soil fertility status viz., organic carbon, available nitrogen, phosphorus and potassium was highest by substituting 50% N fertilizer with any of the organic source compared to recommended dose of N entirely through inorganic source. Lowest soil organic carbon and available nitrogen was registered with control while, lowest available phosphorus and potassium was with 100% N through urea.

Myint *et al.* (2010) conducted an experiment on rice cultivation at Kyushu University farm. Cow manure (CM), poultry manure (PM), rice straw + urea mix-application (SU), urea (UF) and M-coat, a slow released compound fertilizer (M-coat) were used as the N sources by comparing with no application (Control). Treatments were made with two levels application of each N source at 40 (level I) and 80 kg N ha^{-1} (level II) excluding M-coat. In all urea treatments, three split applications were made. A study of soil incubation was conducted for 2 weeks to investigate the mineralized N of applied mineral and organic fertilizer. Plant growth characters, dry matter, yield and plant nutrient accumulations were higher in mineral fertilization than organic. Mineral fertilization was observed in correlation with the larger crop removal. PM-II as an organic matter provided comparatively higher nutrient accumulations which in turn

enhanced the growth and yield of rice. CM and SU gave the lower plant growth, yield and nutrient accumulation. Mineralized N was higher in sole mineral N applications. Organic matter with high C/N ratio provided very low mineralized N and its net N mineralization percentage. Negative values of net N mineralization percentage were observed in SU due to N immobilization.

Nyalemegbe *et al.* (2010) studied at the Agricultural Research Centre, Kpong, of the University of Ghana, to find solution to the problem of low rice yields on the Vertisols of the Accra Plains. Rice yields from continuously cropped fields have been observed to decline with time, even with the application of recommended levels of inorganic fertilizers. The decline in yield has been attributed to low inherent soil fertility, which is partly the result of low levels of soil organic matter (OM). As part of the study, cow dung (CD) and poultry manure (PM) were separately applied to the soil at 20 t ha^{-1} solely and also 5, 10 and 15 t ha^{-1}, in combination with urea fertilizer at 90, 60 and 30 kg N ha^{-1}, respectively. Other treatments included a control and urea fertilizer at 30, 60, 90 and 120 kg N ha^{-1}. There was a basal application of phosphorus and potassium to all plots at 45 kg P_2O_5 ha^{-1} and 35 kg K_2O ha^{-1}, respectively, based on the recommended fertilizer rate of 90 kg N ha-1, 45 kg P_2O_5 ha^{-1} and 35 kg K_2O ha^{-1}, on the Vertisols of the Accra Plains. Studies were also conducted on the redox potential of CD, PM and rice straw (RS). The application of 10 t ha^{-1} CD and urea fertilizer (at 45 kg N ha^{-1}) and 10 t ha^{-1} PM and urea (at 60 kg N ha^{-1}) both gave paddy yields of 4.7 t ha^{-1}, which did not differ significantly from the yield of 5.3 t ha^{-1}, obtained under the recommended inorganic nitrogen fertilizer application of 90 kg N ha^{-1}. This indicates a synergistic effect of OM and urea on soil fertility. The redox potential studies showed that RS had greater propensity to bring about reduced soil condition in paddy fields than CD and PM, while PM brought about greater reduction than CD.

Yadav *et al.* (2009) studied at Kumarganj, Faizabad to assess the impact of organic manures on performance of (*Oryza sativa* L.)-wheat (*Triticum aestivum* (L.) Fiori & Paol.) system. Among different organic farming treatments, incorporation of crop residues in both the crops+green manuring+phosphorus solubilising microbes (PSM)+poultry manure (PM) 5 t/ha+neem cake 0.2 t/ha, resulted in highest values of growth and yield components, yield and net return. This treatment gave 16.1, 16.6,

13.1, 13.1 and 44.5% higher yield of rice and 19.7, 17.0, 14.5, 7.5 and 26.8% higher yield of wheat over T_1, T_2, T_3, T_4 (organics) and T_6 (inorganics) respectively. Maximum amount of balance or un-utilized NPK was computed with inorganics treatment (T_6). All the organic farming treatments improved soil health as evident by increased organic carbon and reduction in soil pH. Highest values of organic carbon (0.64%) after 5 years of experimentation was recorded with wheat residues + FYM 10 t/ha + 0.2 t/ha neem cake in rice and rice residue + press mud 10 t/ha in wheat (T_3). Treatment with crop residue + green manuring + poultry manure 5 t/ha + PSM + neem-cake 0.2 t/ha also proved most remunerative and gave 15.46, 16.08, 14.17, 8.87 and 36.48 x 103 Rs/ha higher net return over T_1, T_2, T_3, T_4 and T_6, respectively. Highest benefit: cost ratio (1.60) was also recorded with this treatment.

Reddy and Kumar (2007) conducted an experiment during 1999, 2000 and 2001 kharif seasons in Andhra Pradesh, India, to study the relative efficiency of organic and inorganics sources of N on the growth, yield and N uptake of lowland rice. The combination of 50 percent N through urea and 50 percent N through different organic sources (farmyard manure, poultry manure and neem cake) produced significantly taller plants, more number of tillers, higher quantity of dry matter, more number of panicles m^{-2}, longer panicles, greater number of grains $panicle^{-1}$ and higher test weight than all other combinations. The conjunctive use of 50 percent N fertilizer as urea along with 50 percent N as farmyard manure, poultry manure or neem cake produced significantly higher grain as well as straw yields of rice during all the three years. Integrated supply of N at 50 percent each through fertilizer and organics recorded higher N uptake than all the other combinations.

Mahavishnan *et al.* (2004) conducted a field study on the effect of nutrient management through organic and inorganic sources on the yield of rice. They found that the yield and yield contributing components were higher with the application of 125% recommended doses of fertilizer RDF + poultry manure (PM) compared to other treatments.

Singh *et al.* (2004) conducted a field experiment during boro and kharif seasons of 2001-2002 and 2002 respectively in a randomized block design in West Bengal, India with seven treatment combinations (T_1=control, T_2= 100% recommended dose of N

through straight fertilizer, T_3=100% N through IFFCO-NPK + urea, T_4=25% of N as FYM +75%N as straight fertilizer, T_5= 25% N as FYM + 75% N as IFFCO NPK + urea, T_6= 50% of N as FYM + 50% N as straight fertilizer and T_7=50% as FYM + 50% N as IFFCO-NPK+ urea) to study the effect of organic and inorganic manuring on growth and yield of high yielding rice cv. IET 1786 (shatabdi) grown under rice-rice crop sequence. 100% recommended dose of N through IFFCO-NPK and urea produced higher number of panicle/m^2, number of filled grains/panicle, 1000 grain weight and ultimately grain yield by 17.9, 4.6, 0.5 and 20.7% over the control treatment in boro season. This was closely followed by 100% recommended doses of N through straight fertilizer or 25% N through FYM + 75% N through IFFCO-NPK, while in kharif season all the yield components responded well with either 25% N as FYM + 75% N as IFFCO-NPK + urea of 100% recommended dose of N through IFFCO-NPK + urea. Under rice-rice cropping sequence maximum grain yield, total nutrient uptake, net return per rupee invested were recorded when the crop received 100% recommended doses of N through IFFCO-NPK + urea, fertility status of soil declined in all the treatment combination as compared to initial status after harvesting of the first and second season rice crop.

Rahman (2001) reported that in rice-rice cropping pattern, the highest grain yield of boro rice was recorded in the soil test basis (STB) NPKSZn fertilizers treatment while in T. Aman rice the 75% or 100% of NPKSZn (STB) fertilizers plus cowdung gave the highest or a comparable yield.

Sengar *et al.* (2000) stated that the application of chemical fertilizers in combination with manures improved the fertility status of the soil. They evaluated the efficiency of different fertilizers in rainfed lowlands at the Zonal Agricultural Research Station, Jagdalpur, Madhya Pradesh, India and found that application of N fertilizer and manure significantly increased the yield and NPK uptake by rice compared with the control and NPK treatment.

Liang *et al.* (1999) observed that the results from long term experiment in rice based cropping system where high crop yields were sustainable over period of 12-16 years through the continuous application of inorganic NPK fertilizers and yields were mainly restricted by insufficient N nutrient supplementing NPK fertilization with

organic manure could further increase rice yield. Soil physical and chemical properties were either unaltered or improved soil physical condition.

Sarker and Singh (1997) reported that soil pH was decreased to 6.5-6.6 by application of organic fertilizers alone compared with the pH 6.7. However a combination of organic plus inorganic fertilizers increased soil pH to 6.6-6.8. Organic fertilizers alone or in combination with inorganic fertilizers increased the level of organic carbon in the soil as the total N, P and K content of soil.

Sanzo *et al.* (1997) observed that application of standard rates of 200 kg N, 80 kg P and 90 kg K/ha or 15, 30 or 45 cattle manure (t/ha) with or without 50% or 100% of the standard rate of application N. Yield generally increased with increasing rates of manures with better result in combination with NPK with 45 t manure there was no significant difference in yield between N rates.

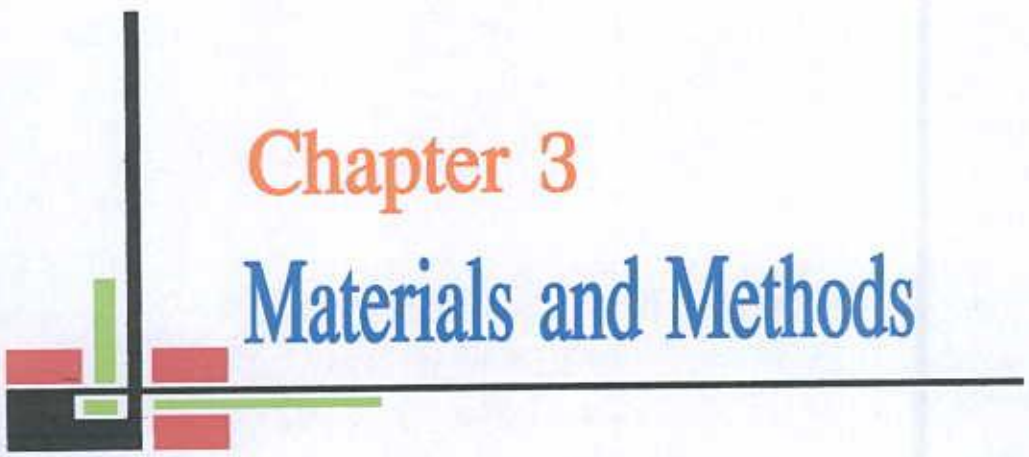
Zhang and Peng (1996) showed that the content of soil organic matter and total N, P and K were raised, soil nutrients were activated, soil fertilizers were enhanced, nutrient absorption by rice was increased and rice yields were heightened by combined application of organic and inorganic fertilizers.

Gupta (1995) conducted a field trial on different organic manure in India and reported that the application of field manure (10 t/ha) produced the highest grain yield (4.5 t/ha) followed by PM and FYM which produced yield of S.

Singh *et al.* (1995) reported that cattle manure significantly improves rice yield but was less efficient than urea. The combination of cattle manure and urea showed no positive interaction effects. Total N uptake by rice was also significantly higher from urea than manure. P and K uptake by rice increased in response to N application from urea and cattle manures.

Ahmed and Rahman (1991) reported that the application of organic matter and chemical fertilizers increased tiller number, panicle length, grain and straw yields of rice.

The literature review discussed above indicates that organic manure can supply a good amount of plant nutrients and thus can contribute to crop yields. The properties of soils are also influenced by the inclusion of organic manure and crop residues in the soil fertility management system either directly or through residual action.



Chapter 3

Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from May to October 2014 to study the effect of inorganic phosphorus and potassium incorporated with cowdung and vermicompost on growth, yield and nutrient content of grain of BRRI dhan62. This chapter includes materials and methods that were used in conducting the experiment. The details are presented below under the following headings –

3.1 Experimental site and soil

The experiment was conducted in typical rice growing silty clay soil at the Sher-e-Bangla Agricultural University Farm, Dhaka. The morphological, physical and chemical characteristics of the soil are shown in Appendix I.

3.2 Climate

The climate of the experimental area is characterized by high temperature, high humidity and medium rainfall with occasional gusty winds during the *kharif* season (March-September) and a scanty rainfall associated with moderately low temperature in the *rabi* season (October-February). The weather information regarding temperature, rainfall, relative humidity and sunshine hours prevailed at the experimental site during the cropping season June to November 2014 have been presented in Appendix II.

3.3 Planting material

BRRI dhan62 was used as the test crop in this experiment. This variety was developed at the Bangladesh Rice Research Institute from the cross between Jirakateri and BRRI dhan39 followed by two times Rapid Generation Advance (RGA) and then pedigree selection in 2013. It is recommended for early *Aman* season. Average plant height of the variety is 100 cm at the ripening stage. The grains are small, fine and white. It requires about 100 days completing its life cycle with an average grain yield is 4.2 t ha^{-1} (BRRI, 2014).

3.4 Land preparation

The land was first opened on 20 June, 2014 by a tractor and prepared thoroughly by ploughing and cross ploughing with a power tiller followed by country plough. Laddering helped breaking the clods and leveling the land followed every ploughing. Before transplanting each unit of plot was cleaned by removing the weeds, stubbles and crop residues. Finally each plot was prepared by puddling for transplanting seedlings.

3.5 Experimental design and layout

The experiment was laid out in a randomized complete block design (RCBD) with three replications, where the experimental area was divided into three blocks representing the replications to reduce soil heterogenic effects. Each block was divided into 14 unit plots as treatments with raised bunds around. Thus the total numbers of plots were 42. The unit plot size was 2 m × 2 m and was separated from each other by 0.5 m ails. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m respectively. The layout of the experiment is shown in Appendix III.

3.6 Raising of seedlings

The seedlings of rice were raised wet-bed methods. Seeds (95% germination) @ 25 kg ha^{-1} were soaked and incubated for 48 hour and sown on a well-prepared seedbed. During seedling growing, no fertilizers were used. Proper water and pest management practices were followed whenever required.

3.7 Treatments

The experiment was designed to study the effect of inorganic phosphorus and potassium incorporated with cowdung and vermicompost on growth, yield and nutrient content of aman rice BRRI dhan62. Details were presented below:

T_0 - Control

T_1 – 100% inorganic fertilizer

T_2 –25% P of recommended dose from Cowdung+75% P from Inorganic fertilizer (IF)

T_3 –50 % P of recommended dose from Cowdung + 50% P from IF

T_4– 75 % P of recommended dose from Cowdung + 25% P from IF

T_5 –25 % P of recommended dose from Vermicompost + 75% P from IF

T_6 –50 % P of recommended dose from Vermicompost + 50% P from IF

T_7 –75 % P of recommended dose from Vermicompost + 25% P from IF

T_8 –25 % K of recommended dose from Cowdung + 75% K from IF

T_9 –50 % K of recommended dose from Cowdung + 50% K from IF

T_{10} –75 % K of recommended dose from Cowdung + 25% K from IF

T_{11} –25 % K of recommended dose from Vermicompost + 75% K from IF

T_{12} –50 % K of recommended dose from Vermicompost + 50% K from IF

T_{13} –75 % K of recommended dose from Vermicompost + 25% K from IF

3.8 Fertilizers and manure application

The fertilizers in the form of urea, TSP, MOP, Gypsum, zinc sulphate and borax, respectively were applied for N, P, K, S, Zn and B respectively. The one third amount of urea and entire amount of gypsum, zinc sulphate and borax were applied during the final preparation of land. On the other hand entire TSP, MOP as well as cowdung and vermicompost were applied according to the treatments into the plots. Rest urea was applied in two equal installments at tillering and panicle initiation stages. Cowdung and vermicompost were applied according to the treatments and the dose of urea was adjusted with their N content.

3.9 Cowdung and vermicompost incorporation

Cowdung and vermicompost were used as organic manure and applied before four days of final land preparation. Chemical compositions of cowdung have been presented below-

Chemical compositions of cowdung and vermicompost (dry basis)

Sources of organic manure	Nutrient content				
	C (%)	N (%)	P (%)	K (%)	C:N
Cowdung	34	1.48	0.45	0.53	2.4
Vermicompost	28	1.66	1.25	0.254	9.60

3.10 Transplanting

Thirty days old seedlings of BRRI dhan62 were carefully uprooted from the seedling nursery and transplanted on 03 July, 2014 in well puddled plot. Three seedlings $hill^{-1}$

were used following a spacing of 20 cm × 20 cm. After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings whenever required.

3.11 Intercultural operations

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

3.11.1 Irrigation

Necessary irrigations were provided to the plots as and when required during the growing period of rice crop.

3.11.2 Weeding

The plots were infested with some common weeds, which were removed by uprooting them from the field three times during the period of the cropping season.

3.11.3 Insect and pest control

There was no infection of diseases in the field but leaf roller (*Chaphalocrosis medinalis*) was observed in the field and used Malathion @ 1.12 L ha^{-1}.

3.12 Crop harvest

The crop was harvested at full maturity when 80-90% of the grains were turned into straw colored. The crop was cut at the ground level and plot wise crop was bundled separately and brought to the threshing floor.

3.13 Data collection on yield components and yield

3.13.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of harvesting stage. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the panicle/flag leaf.

3.13.2 Number of leaves

The number of leaves hill^{-1} was counted from the selected plants.

3.13.2 Effective tillers

The total number of effective tillers hill^{-1} was counted as the number of panicle bearing tiller during harvesting. Data on effective tillers hill^{-1} were counted from 10 selected hills and average value was recorded.

3.13.3 Non-effective tillers

The total number of non-effective tiller hill^{-1} was counted as the number of non-panicle bearing tiller during harvesting. Data on non effective tiller hill^{-1} were counted from 10 selected hills and average value was recorded.

3.13.4 Total tillers

The total number of tiller hill^{-1} was counted as the number of effective tillers hill^{-1} and non-effective tillers hill^{-1}. Data on total tillers hill^{-1} were counted from 10 selected hills and average value was recorded.

3.13.5 Length of panicle

The length (cm) of panicle was measured with a meter scale from 10 selected plants and the average value was recorded as per plant.

3.13.6 Filled grains

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

3.13.7 Unfilled grains

The total numbers of unfilled grain was collected randomly from selected 10 panicles of a plot on the basis of not grain in the spikelet and then average numbers of unfilled grains panicle^{-1} was recorded.

3.13.8 Total spikelet

The total numbers of spikelet panicle^{-1} was collected randomly from selected 10 plants of a plot by adding filled and unfilled grains and then average number of grains panicle^{-1} was recorded.

3.13.9 Grain yield

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of the respective unit plot to record the final grain yield plot^{-1} (g).

3.13.10 Straw yield

Straw obtained from each unit plot were sun-dried and weighed carefully. The dry weight of straw of central 1 m^2 area respective unit plot yield to record the final straw yield plot^{-1} (g).

3.14 Chemical analysis of grain samples

3.14.1 Digestion of grain samples with nitric-perchloric acid for P, K, S

A sub sample weighing 0.5 g was transferred into a dry, clean 100 ml digestion vessel. Ten ml of di-acid (HNO_3: $HClO_4$ in the ratio 2:1) mixture was added to the flask. After leaving for a while, the flasks were heated at a temperature slowly raised to 200^{0}C. Heating were stopped when the dense white fumes of $HClO_4$ occurred. The content of the flask were boiled until they were became clean and colorless. After cooling, the content was taken into a 100 ml volumetric flask and the volume was made up to the mark with de-ionized water. P, K, S and Zn were determined from this digest.

3.14.2 Determination of P, K, S from grain samples

Phosphorus

Phosphorus in the grain was determined by using 1 mL grain sample from 100 mL extract. Then blue color was developed with reduction of phosphomolybdate complex using ascorbic acid and the color intensity was measured colorimetrically at 660 nm wavelength. The readings were calibrated with the standard P curve (Page *et al.*, 1982).

Potassium

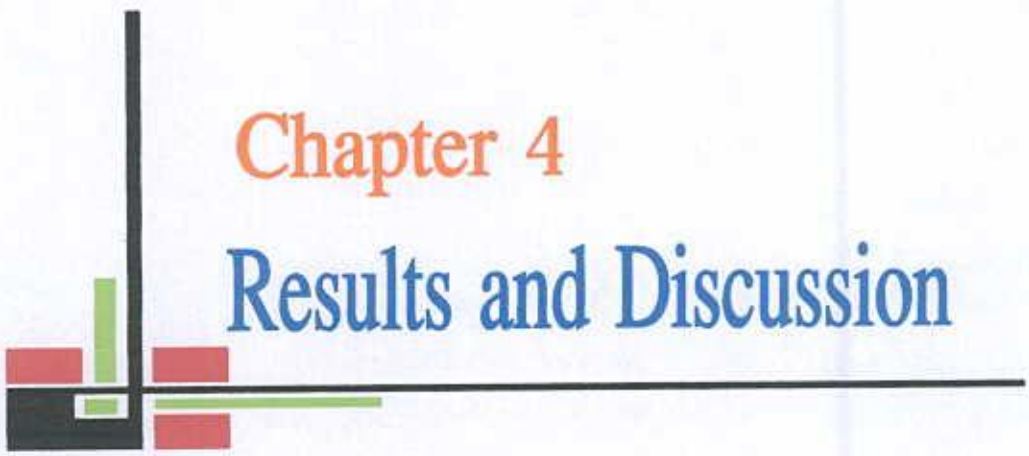
Five mL of digested sample of the grain were taken and diluted to 50 mL volume to make desired concentration. Afterwards the emissions of K of the samples were measured within the range of standard solutions using flame photometer (Page *et al.*, 1982).

Sulphur

Sulphur content was determined from the digest of the grain samples with $BaCl_2$ solution as described by Page *et al.*, 1982. The S of digested samples were determined by developing turbidity by adding $BaCl_2$ solution. The intensity of turbidity was measured by spectrophotometer at 420 nm wavelengths (Hunter, 1984).

3.15 Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference of different treatments on growth, yield and nutrient content of transplanted aman rice BRRI dhan62. The mean values of all the characters were calculated and analysis of variance were performed by the 'F' (variance ratio) test. The significance of the differences among the treatment means were adjudged by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).



Chapter 4

Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

The present experiment was conducted at farm of Sher-e-Bangla Agricultural University. The results have been presented and discussed, and possible interpretations have been given under the following headings:

4.1 Plant height

Plant height differed significantly due to various combinations of inorganic phosphorus and potassium with organic cowdung and Vermicompost. The treatment T_{12} (50% K from Vermicompost + 50% K from Inorganic source) showed the highest plant height (99.00 cm) which was statistically similar to T_1 (100% inorganic fertilizer) (98.67 cm) and T_{10} (75 % K from Cowdung + 25% K from Inorganic source) (98.33 cm). The treatments T_6 (96.33 cm), T_7 (97.33 cm), T_8 (96.67 cm) and T_9 (97.67 cm) also significantly produced taller plants compare to other treatments. The control treatment T_0 (no fertilizer) gave the lowest plant height (92.67 cm) among the treatments (Table 1).

It seems from the results that combination of organic and inorganic fertilizers significantly increased the plant height than sole use of inorganic fertilizer. Actually organic fertilizers help to increase the organic matter content of soil, thus reducing the bulk density and decreasing compaction. Thus plants get a suitable growing environment which promotes better growth and development. Similar sort of findings were found by many scientists while experimenting with various crops. Combination of organic and inorganic fertilizers was found better by Ahmed and Rahman (1991) in rice than only inorganic fertilizers.

4.2 Number of leaves

Due to various combinations of inorganic phosphorus and potassium with organic cowdung and vermicompost number of leaves $hill^{-1}$ differed significantly. The highest number of leaves $hill^{-1}$ (51.67) was observed from T_6 (50 % P from Vermicompost + 50% P from Inorganic source) which was statistically similar to T_{12} (50 % K from Vermicompost + 50% K from Inorganic source) (49.00) and the lowest number of

leaves hill^{-1} (27.67) was observed from T_0 (Control) which was statistically similar to T_{13} (75 % K from Vermicompost + 25% K from Inorganic source) (29.00) (Table 1).

Table 1: Effect of inorganic phosphorus and potassium incorporated with organic manure on plant height and number of leaves hill^{-1} of BRRI dhan62

Treatment	Plant height (cm)	Number of leaves/hill
T_0	92.67 e	27.67 g
T_1	98.67 ab	31.00 ef
T_2	97.00 a-d	35.67 d
T_3	94.00 de	33.67 de
T_4	94.67 c-e	40.00 c
T_5	94.00 de	40.00 c
T_6	96.33 a-d	51.67 a
T_7	97.33 a-c	36.67 d
T_8	96.67 a-d	36.00 d
T_9	97.67 a-c	35.33 d
T_{10}	98.33 ab	48.00 b
T_{11}	95.67 b-d	37.00 cd
T_{12}	99.00 a	49.00 ab
T_{13}	95.00 c-e	29.00 fg
Level of significance	*	**
LSD	**2.693**	**3.062**
CV %	**1.12**	**4.48**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 (*) or 0.01 (**) level of probability

T_0 – Control, T_1 –100% inorganic fertilizer (IF), T_2 –25% of recommended dose (RD) of P from Cowdung(CD) + 75% P from IF, T_3 –50% of RD of P from CD + 50% P from IF, T_4–75% of RD of P from CD + 25% P from IF, T_5 –25% of RD of P from Vermicompost (VC) + 75% P from IF, T_6 – 50% of RD of P from VC + 50% P from IF, T_7 – 75% of RD of P from VC + 25% P from IF, T_8 – 25% of RD of K from CD + 75% K from IF, T_9 – 50% of RD of K from CD + 50% K from IF, T_{10} –75% of RD of K from CD + 25% K from IF, T_{11} –25% of RD of K from VC + 75% K from IF, T_{12} – 50% of RD of K from VC + 50% K from IF, T_{13} – 75% of RD of K from VC + 25% K from IF.

Results showed that the combination of organic and inorganic fertilizers significantly increased the number of leaves hill^{-1} than sole use of inorganic fertilizer. As organic fertilizers help to improve the soil condition and inorganic fertilizers assure quick availability of essential nutrients, the combination of two proved better than single use of the each. Ahmed and Rahman (1991) found better growth by using combination of organic and inorganic fertilizers than only inorganic fertilizers in groundnut and in green gram respectively.

4.3 Number of effective tiller

Number of effective tiller hill^{-1} also showed significant variation among the various combinations of inorganic phosphorus and potassium with organic cowdung and vermicompost. The highest number of effective tillers hill^{-1} (25.33) was observed from T_{12} (50 % K from Vermicompost + 50% K from Inorganic source) and it was statistically similar to T_6 (50 % P from Vermicompost + 50% P from Inorganic source) (24.67), T_7 (75 % P from Vermicompost + 25% P from Inorganic source) (23.00) and T_{13} (75 % K from Vermicompost + 25% K from Inorganic source) (23.00) whereas, the lowest number of effective tillers hill^{-1} (17.67) was observed from T_0 (control) (Table 2).

Combination of organic and inorganic fertilizers significantly increased the number of effective tillers hill^{-1} than sole use of inorganic fertilizer. Mahavishnan *et al.* (2004) conducted a field study on the effect of nutrient management through organic and inorganic sources on the yield of rice. They found that the yield and yield contributing components were higher with the application of 125% recommended doses of fertilizer RDF + poultry manure (PM) compared to other treatments.

Table 2: Effect of inorganic phosphorus and potassium incorporated with organic manure on effective tiller hill^{-1} of BRRI dhan62

Treatment	Number of effective tillers hill^{-1}
T_0	17.67 g
T_1	22.00 b-d
T_2	21.00 b-e
T_3	18.33 fg
T_4	18.67 e-g
T_5	20.67 b-f
T_6	24.67 a
T_7	23.00 ab
T_8	18.33 fg
T_9	19.67 d-g
T_{10}	20.33 c-f
T_{11}	22.33 bc
T_{12}	25.33 a
T_{13}	23.00 ab
Level of significance	**
LSD	**2.21**
CV %	**1.65**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.01 (**) level of probability

T_0 – Control, T_1 –100% inorganic fertilizer (IF), T_2 –25% of recommended dose (RD) of P from Cowdung(CD) + 75% P from IF, T_3 –50% of RD of P from CD + 50% P from IF, T_4–75% of RD of P from CD + 25% P from IF, T_5 –25% of RD of P from Vermicompost (VC) + 75% P from IF, T_6 – 50% of RD of P from VC + 50% P from IF, T_7 – 75% of RD of P from VC + 25% P from IF, T_8 – 25% of RD of K from CD + 75% K from IF, T_9 – 50% of RD of K from CD + 50% K from IF, T_{10} –75% of RD of K from CD + 25% K from IF, T_{11} –25% of RD of K from VC + 75% K from IF, T_{12} – 50% of RD of K from VC + 50% K from IF, T_{13} – 75% of RD of K from VC + 25% K from IF.

4.4 Number of non-effective tiller

Different combinations of inorganic phosphorus and potassium with organic cowdung and vermicompost showed significant variation for number of non-effective tillers hill^{-1} (Table 3). The highest number of non-effective tiller hill^{-1} (5.00) was observed from T_0 whereas, the lowest number of non-effective tiller hill^{-1} (2.00) was observed from T_9 (50 % K from Cowdung + 50% K from Inorganic source) which was statistically similar to T_1 (100% inorganic fertilizer) (2.33) (Table 3).

4.5 Number of total tiller

Total number of tillers hill^{-1} differed significantly due to various combinations of organic and inorganic source of phosphorus and potassium. The highest total tillers hill^{-1} (29.00) was observed from T_{12} (50 % K from Vermicompost + 50% K from Inorganic source) which was statistically similar to T_6 (50 % P from Vermicompost + 50% P from Inorganic source) (28.00) whereas, the lowest total number of tillers hill^{-1} (21.67) was observed from T_9 (50 % K from Cowdung + 50% K from Inorganic source) which was statistically similar to T_0 (control) (22.67) (Table 4).

Combination of organic and inorganic source of phosphorus and potassium significantly increased the number of total tillers hill^{-1} than sole use of inorganic fertilizer. Mahavishnan *et al.* (2004) conducted a field study on the effect of nutrient management through organic and inorganic sources on the yield of rice. They found that the yield and yield contributing components were higher with the application of 125% recommended doses of fertilizer RDF + poultry manure (PM) compared to other treatments. Reddy and Kumar (2007) conducted an experiment and found that the combination of 50 percent N through urea and 50 percent N through different organic sources (farmyard manure, poultry manure and neem cake) produced significantly taller plants, more number of tillers, higher quantity of dry matter, more number of panicles m^{-2}, longer panicles, greater number of grains panicle^{-1} and higher test weight than all other combinations.

Table 3: Effect of inorganic phosphorus and potassium incorporated with organic manure on non-effective tiller hill^{-1} of BRRI dhan62

Treatment	Non-effective tiller hill^{-1}
T_0	5.000 a
T_1	2.330 ef
T_2	4.000 c
T_3	4.670 ab
T_4	4.000 c
T_5	4.000 c
T_6	3.330 d
T_7	2.670 e
T_8	4.000 c
T_9	2.000 f
T_{10}	4.330 bc
T_{11}	2.670 e
T_{12}	3.670 cd
T_{13}	4.000 c
Level of significance	*
LSD	**0.593**
CV %	**8.91**

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

T_0 – Control, T_1 –100% inorganic fertilizer (IF), T_2 –25% of recommended dose (RD) of P from Cowdung(CD) + 75% P from IF, T_3 –50% of RD of P from CD + 50% P from IF, T_4–75% of RD of P from CD + 25% P from IF, T_5 –25% of RD of P from Vermicompost (VC) + 75% P from IF, T_6 – 50% of RD of P from VC + 50% P from IF, T_7 – 75% of RD of P from VC + 25% P from IF, T_8 – 25% of RD of K from CD + 75% K from IF, T_9 – 50% of RD of K from CD + 50% K from IF, T_{10} –75% of RD of K from CD + 25% K from IF, T_{11} –25% of RD of K from VC + 75% K from IF, T_{12} – 50% of RD of K from VC + 50% K from IF, T_{13} – 75% of RD of K from VC + 25% K from IF.

Table 4: Effect of inorganic phosphorus and potassium incorporated with organic manure on total tiller hill^{-1} of BRRI dhan62

Treatment	Total tiller hill^{-1}
T_0	22.67 ef
T_1	24.33 de
T_2	25 c-e
T_3	23 ef
T_4	22.67 ef
T_5	24.67 c-e
T_6	28 ab
T_7	25.67 c-e
T_8	22.33 ef
T_9	21.67 f
T_{10}	24.66 c-e
T_{11}	25 c-e
T_{12}	29 a
T_{13}	27.00 a-c
Level of significance	*
LSD	**2.224**
CV %	**1.41**

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

T_0 – Control, T_1 –100% inorganic fertilizer (IF), T_2 –25% of recommended dose (RD) of P from Cowdung(CD) + 75% P from IF, T_3 –50% of RD of P from CD + 50% P from IF, T_4–75% of RD of P from CD + 25% P from IF, T_5 –25% of RD of P from Vermicompost (VC) + 75% P from IF, T_6 – 50% of RD of P from VC + 50% P from IF, T_7 – 75% of RD of P from VC + 25% P from IF, T_8 – 25% of RD of K from CD + 75% K from IF, T_9 – 50% of RD of K from CD + 50% K from IF, T_{10} –75% of RD of K from CD + 25% K from IF, T_{11} –25% of RD of K from VC + 75% K from IF, T_{12} – 50% of RD of K from VC + 50% K from IF, T_{13} – 75% of RD of K from VC + 25% K from IF.

4.6 Panicle length

Panicle length (cm) differed significantly due to various combinations of organic and inorganic source of phosphorus and potassium. The treatments T_6 (50 % P from Vermicompost + 50% P from Inorganic source) and T_{12} (50 % K from Vermicompost + 50% K from Inorganic source) produced the longest panicle (26.50 cm) which was statistically similar to T_7 (75 % P from Vermicompost + 25% P from Inorganic source) (25.63 cm), T_8 (25 % K from Cowdung + 75% K from Inorganic source) (25.77 cm) and T_{10} (75 % K from Cowdung + 25% K from Inorganic source) (26.07 cm) whereas, T_0 (17.65 cm) showed the lowest panicle length (Table 5).

Combination of organic and inorganic source of phosphorus and potassium significantly increased the panicle length than sole use of inorganic fertilizer. Reddy and Kumar (2007) conducted an experiment and found that the combination of 50 percent N through urea and 50 percent N through different organic sources (farmyard manure, poultry manure and neem cake) produced significantly taller plants, more number of tillers, higher quantity of dry matter, more number of panicles m^{-2}, longer panicles, greater number of grains $panicle^{-1}$ and higher test weight than all other combinations.

4.7 Number of filled grain

Number of filled grains $panicle^{-1}$ differed significantly due to various combinations of inorganic phosphorus and potassium with organic cowdung and Vermicompost. The treatment T_6 (50 % P from Vermicompost + 50% P from Inorganic source) showed the highest number of filled grains $panicle^{-1}$ (96.33) which was statistically similar to T_{12} (50 % K from Vermicompost + 50% K from Inorganic source) (94.33), T_5 (25 % P from Vermicompost + 75% P from Inorganic source) (92.67) or T_{13} (75 % K from Vermicompost + 25% K from Inorganic source) (93.33) and T_{11} (25 % K from Vermicompost + 75% K from Inorganic source) (92.33) whereas T_0 (72.00) showed the lowest number of filled grains $panicle^{-1}$ (Table 6).

Table 5: Effect of inorganic phosphorus and potassium incorporated with organic manure on panicle length of BRRI dhan62

Treatment	Panicle length (cm)
T_0	17.65 d
T_1	23.97 a-c
T_2	24.43 a-c
T_3	24.63 ab
T_4	24.17 a-c
T_5	24.00 a-c
T_6	26.50 a
T_7	25.63 a
T_8	25.77 a
T_9	21.80 c
T_{10}	26.07 a
T_{11}	22.70 bc
T_{12}	26.50 a
T_{13}	24.83 ab
Level of significance	*
LSD	**2.499**
CV %	**4.45**

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

T_0 – Control, T_1 –100% inorganic fertilizer (IF), T_2 –25% of recommended dose (RD) of P from Cowdung(CD) + 75% P from IF, T_3 –50% of RD of P from CD + 50% P from IF, T_4–75% of RD of P from CD + 25% P from IF, T_5 –25% of RD of P from Vermicompost (VC) + 75% P from IF, T_6 – 50% of RD of P from VC + 50% P from IF, T_7 – 75% of RD of P from VC + 25% P from IF, T_8 – 25% of RD of K from CD + 75% K from IF, T_9 – 50% of RD of K from CD + 50% K from IF, T_{10} –75% of RD of K from CD + 25% K from IF, T_{11} –25% of RD of K from VC + 75% K from IF, T_{12} – 50% of RD of K from VC + 50% K from IF, T_{13} – 75% of RD of K from VC + 25% K from IF.

Table 6: Effect of inorganic phosphorus and potassium incorporated with organic manure on filled grain panicle^{-1} of BRRI dhan62

Treatment	Filled grain panicle^{-1}
T_0	72.00 f
T_1	82.33 d
T_2	88.33 b
T_3	80.67 d
T_4	84.33 b-d
T_5	92.67 a
T_6	96.33 a
T_7	83.67 cd
T_8	76.67 e
T_9	87.00 bc
T_{10}	83.00 cd
T_{11}	92.33 a
T_{12}	94.33 a
T_{13}	93.33 a
Level of significance	*
LSD	**3.94**
CV %	**1.26**

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

T_0 – Control, T_1 –100% inorganic fertilizer (IF), T_2 –25% of recommended dose (RD) of P from Cowdung(CD) + 75% P from IF, T_3 –50% of RD of P from CD + 50% P from IF, T_4–75% of RD of P from CD + 25% P from IF, T_5 –25% of RD of P from Vermicompost (VC) + 75% P from IF, T_6 – 50% of RD of P from VC + 50% P from IF, T_7 – 75% of RD of P from VC + 25% P from IF, T_8 – 25% of RD of K from CD + 75% K from IF, T_9 – 50% of RD of K from CD + 50% K from IF, T_{10} –75% of RD of K from CD + 25% K from IF, T_{11} –25% of RD of K from VC + 75% K from IF, T_{12} – 50% of RD of K from VC + 50% K from IF, T_{13} – 75% of RD of K from VC + 25% K from IF.

As organic fertilizers help to improve the soil condition and inorganic fertilizers assure quick availability of essential nutrients, the combination of two proved better than single use of the each. Patil (1998) reported that in groundnut the maximum pod yield (30.04 q/ha) was recorded with the application of vermicompost @ 2.50 t per ha + fly ash @ 30 t per ha + RDF, whereas, the lowest pod yield (20.66 q/ha) was recorded with the application of RDF alone. Abbas *et al.* (2011) found that application of DAP at 124 kg along with 10 tons ha^{-1} of poultry litter yielded maximum number of pods $plant^{-1}$.

4.8 Number of unfilled grain

Number of unfilled grains $panicle^{-1}$ differed significantly due to various combinations of inorganic phosphorus and potassium with organic cowdung and Vermicompost. The control treatment T_0 produced the highest number of unfilled grains $panicle^{-1}$ (14.67) which was statistically similar to T_1 (100% inorganic fertilizer) (13.67) whereas T_6 (50 % P from Vermicompost + 50% P from Inorganic source) (5.670) produced the lowest number of unfilled grains $panicle^{-1}$ (Table 7).

4.9 Total number of spikelet

Total number of spikelet $panicle^{-1}$ differed non-significantly due to various combinations of inorganic phosphorus and potassium with organic cowdung and Vermicompost. Though numerically T_{11} (25 % K from Vermicompost + 75% K from Inorganic source) showed the highest total number of grains $panicle^{-1}$ (101.66) which was closely followed by T_6 (50 % P from Vermicompost + 50% P from Inorganic source) (102.0) whereas T_{12} (50 % K from Vermicompost + 50% K from Inorganic source) (100.33) while T_0 showed the lowest total number of grains $panicle^{-1}$ (86.67) (Table 7).

Combination of organic and inorganic fertilizers increased the number of total spikelets $panicle^{-1}$ than use of inorganic fertilizer alone. This may be because combination of organic and inorganic fertilizers improves soil physical properties, which provide health and favourable soil conditions to enhance nutrient use efficiency. Similar results were reported by Channaveerswami (2005) in groundnut and Rajkhowa *et al.* (2002) in green gram.

Table 7: Effect of inorganic phosphorus and potassium incorporated with organic manure on unfilled grain panicle^{-1} and total spikelet panicle^{-1} of BRRI dhan62

Treatment	Unfilled grain panicle^{-1}	Total spikelet panicle^{-1}
T_0	14.67 a	86.67
T_1	13.67 ab	96
T_2	12.00 a-c	100.33
T_3	9.000 c-e	89.67
T_4	9.000 c-e	93.33
T_5	6.000 de	98.67
T_6	5.670 e	102
T_7	11.33 a-c	95
T_8	10.00 c	86.67
T_9	9.670 c	96.67
T_{10}	10.00 c	93
T_{11}	9.330 cd	101.66
T_{12}	6.000 de	100.33
T_{13}	6.000 de	99.33
Level of significance	**	Ns
LSD	**3.111**	**15.21**
CV %	**7.72**	**1.36**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.01 (**) level of probability. ns = Non-significant

T_0 – Control, T_1 –100% inorganic fertilizer (IF), T_2 –25% of recommended dose (RD) of P from Cowdung(CD) + 75% P from IF, T_3 –50% of RD of P from CD + 50% P from IF, T_4–75% of RD of P from CD + 25% P from IF, T_5 –25% of RD of P from Vermicompost (VC) + 75% P from IF, T_6 – 50% of RD of P from VC + 50% P from IF, T_7 – 75% of RD of P from VC + 25% P from IF, T_8 – 25% of RD of K from CD + 75% K from IF, T_9 – 50% of RD of K from CD + 50% K from IF, T_{10} –75% of RD of K from CD + 25% K from IF, T_{11} –25% of RD of K from VC + 75% K from IF, T_{12} – 50% of RD of K from VC + 50% K from IF, T_{13} – 75% of RD of K from VC + 25% K from IF.

4.10 Grain yield

Grain yield m^{-2} (g) differed significantly due to various combinations of inorganic phosphorus and potassium with organic cowdung and Vermicompost. The highest grain yield m^{-2} (g) was observed from T_{12} (50 % K from Vermicompost + 50% K from Inorganic source) (420.7g) which was statistically similar to T_6 (50 % P from Vermicompost + 50% P from Inorganic source) (417.3g), T_1 (100% inorganic fertilizer) (414.0 g) and T_{11} (25 % K from Vermicompost + 75% K from Inorganic source) (412.7g) whereas T_0 (290.4 g) produced the lowest grain yield m^{-2} (Table 8).

Reddy and Kumar (2007) conducted an experiment during 1999, 2000 and 2001 kharif seasons in Andhra Pradesh, India, to study the relative efficiency of organic and inorganics sources of N on the growth, yield and N uptake of lowland rice. The combination of 50 percent N through urea and 50 percent N through different organic sources (farmyard manure, poultry manure and neem cake) produced significantly taller plants, more number of tillers, higher quantity of dry matter, more number of panicles m^{-2}, longer panicles, greater number of grains $panicle^{-1}$ and higher test weight than all other combinations. Liang *et al.* (1999) observed that the results from long term experiment in rice based cropping system where high crop yields were sustainable over period of 12-16 years through the continuous application of inorganic NPK fertilizers and yields were mainly restricted by insufficient N nutrient supplementing NPK fertilization with organic manure could further increase rice yield.

4.11 Straw yield

Straw yield m^{-2}(g) differs significantly due to various combinations of organic and inorganic fertilizers. The highest straw yield m^{-2} (g) was observed from T_6 (50 % P from Vermicompost + 50% P from Inorganic source) (640.3g) which was statistically similar to T_{12} (50 % K from Vermicompost + 50% K from Inorganic source) (631.0 g) whereas T_0 (415.7 g) produced the lowest straw yield m^{-2} (Table 8).

Ahmed and Rahman (1991) reported that the application of organic matter and chemical fertilizers increased tiller number, panicle length, grain and straw yields of rice.

Table 8: Effect of inorganic phosphorus and potassium incorporated with organic manure on grain yield and straw yield of BRRI dhan62

Treatment	Grain yield/ m^2(g)	Straw yield / m^2 (g)
T_0	290.4 f	415.7 i
T_1	414.0 a	598.7 de
T_2	339.0 d	534.0 h
T_3	382.0 c	597.0 e
T_4	396.0 b	606.0 de
T_5	338.7 d	609.7 c-e
T_6	417.3 a	640.3 a
T_7	323.3 e	599.3 de
T_8	379.4 c	535.0 h
T_9	327.3 e	580.3 f
T_{10}	398.0 b	579.7 f
T_{11}	412.7 a	622.0 bc
T_{12}	420.7 a	631.0 ab
T_{13}	386.0 c	549.0 g
Level of significance	**	**
LSD	**8.821**	**11.88**
CV %	**2.12**	**3.87**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.01 (**) level of probability

T_0 – Control, T_1 –100% inorganic fertilizer (IF), T_2 –25% of recommended dose (RD) of P from Cowdung(CD) + 75% P from IF, T_3 –50% of RD of P from CD + 50% P from IF, T_4–75% of RD of P from CD + 25% P from IF, T_5 –25% of RD of P from Vermicompost (VC) + 75% P from IF, T_6 – 50% of RD of P from VC + 50% P from IF, T_7 – 75% of RD of P from VC + 25% P from IF, T_8 – 25% of RD of K from CD + 75% K from IF, T_9 – 50% of RD of K from CD + 50% K from IF, T_{10} – 75% of RD of K from CD + 25% K from IF, T_{11} –25% of RD of K from VC + 75% K from IF, T_{12} – 50% of RD of K from VC + 50% K from IF, T_{13} – 75% of RD of K from VC + 25% K from IF.

4.12 P content in grain

P content in grain (%) differed significantly due to various combinations of inorganic phosphorus and potassium with organic cowdung and vermicompost. The highest P content in grain was observed from T_6 (50 % P from Vermicompost + 50% P from Inorganic source) (0.381%) which was statistically similar to T_{12} (50 % K from Vermicompost + 50% K from Inorganic source) (0.372%) whereas, lowest P content in grain was observed from T_0 (0.317%) (Table 9).

4.13 K content in grain

K content in grain (%) differed significantly due to various combinations of inorganic phosphorus and potassium with organic cowdung and vermicompost. The highest K content in grain was observed from T_{12} (50 % K from Vermicompost + 50% K from Inorganic source) (0.647%) which was statistically similar to T_{13} (75 % K from Vermicompost + 25% K from Inorganic source) (0.644%) and T_{11} (25 % K from Vermicompost + 75% K from Inorganic source) (0.635%) whereas, lowest K content in grain was observed from T_0 (0.508%) (Table 9).

4.14 S content in grain

S content in grain (%) differed significantly due to various combinations of inorganic phosphorus and potassium with organic cowdung and vermicompost. The highest S content in grain was observed from T_6 (50 % P from Vermicompost + 50% P from Inorganic source) (0.439%) which was statistically similar to T_{12} (50 % K from Vermicompost + 50% K from Inorganic source) (0.409%) whereas, lowest S content in grain was observed from T_0 (0.239%) (Table 9).

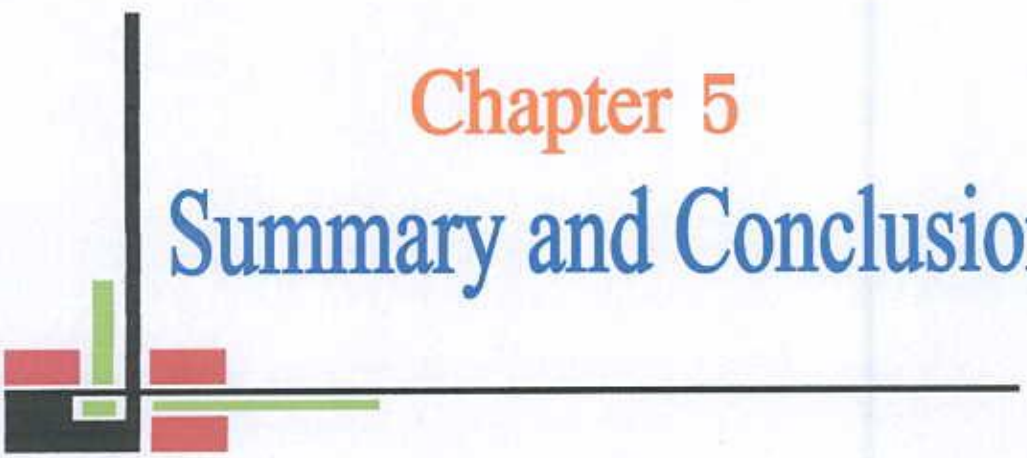
Sengar *et al.* (2000) stated that the application of chemical fertilizers in combination with manures improved the fertility status of the soil. Zhang and Peng (1996) showed that the content of soil organic matter and total N, P and K were raised, soil nutrients were activated, soil fertilizers were enhanced, nutrient absorption by rice was increased and rice yields were heightened by combined application of organic and inorganic fertilizers. Singh *et al.* (1995) reported that P and K uptake by rice increased in response to N application from urea and cattle manures.

Table 9: Effect of inorganic phosphorus and potassium incorporated with organic manure on P, K and S content in grain of BRRI dhan62

Treatment	P in grain (%)	K in grain (%)	S in grain (%)
T_0	0.317 g	0.508 d	0.239 g
T_1	0.332 fg	0.594 c	0.289 fg
T_2	0.347 d-f	0.599 bc	0.309 ef
T_3	0.357 b-e	0.619 a-c	0.349 c-e
T_4	0.365 a-d	0.621 a-c	0.379 b-d
T_5	0.343 e-f	0.604 bc	0.399 a-c
T_6	0.381 a	0.632 a-c	0.439 a
T_7	0.375 ab	0.62 a-c	0.309 ef
T_8	0.363 a-e	0.593 c	0.329 d-f
T_9	0.334 fg	0.603 bc	0.319 ef
T_{10}	0.349 c-f	0.618 a-c	0.329 d-f
T_{11}	0.369 a-c	0.635 ab	0.349 c-e
T_{12}	0.372 ab	0.647 a	0.409 ab
T_{13}	0.361 a-e	0.644 a	0.359 b-e
Level of significance	**	**	**
LSD	**0.0185**	**0.03528**	**0.0502**
CV %	**8.77**	**5.97**	**12.6**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.01 (**) level of probability

T_0 – Control, T_1 –100% inorganic fertilizer (IF), T_2 –25% of recommended dose (RD) of P from Cowdung(CD) + 75% P from IF, T_3 –50% of RD of P from CD + 50% P from IF, T_4–75% of RD of P from CD + 25% P from IF, T_5 –25% of RD of P from Vermicompost (VC) + 75% P from IF, T_6 – 50% of RD of P from VC + 50% P from IF, T_7 – 75% of RD of P from VC + 25% P from IF, T_8 – 25% of RD of K from CD + 75% K from IF, T_9 – 50% of RD of K from CD + 50% K from IF, T_{10} –75% of RD of K from CD + 25% K from IF, T_{11} –25% of RD of K from VC + 75% K from IF, T_{12} – 50% of RD of K from VC + 50% K from IF, T_{13} – 75% of RD of K from VC + 25% K from IF.



Chapter 5

Summary and Conclusion

CHAPTER 5
SUMMARY AND CONCLUSION

A field experiment was carried out during Kharif-I season of 2014 at Sher-e-Bangla Agricultural University (SAU) Farm in the Madhupur Tract (AEZ 28, Paleaustult) of Bangladesh with an objective of finding out effect of different combinations of organic and inorganic source of phosphorus and potassium fertilizers on growth and yield of a rice cultivar. The experiment was designed with 14 treatments, laid out in a randomized complete block design (RCBD) with three replications. The treatments were : T_0 – Control, T_1 – 100% inorganic fertilizer, T_2 –25% of recommended dose (RD) of P from Cowdung + 75% P from Inorganic source, T_3 – 50% of RD of P from Cowdung + 50% P from Inorganic source, T_4– 75% of RD of P from Cowdung + 25% P from Inorganic source, T_5– 25% of RD of P from Vermicompost + 75% P from Inorganic source, T_6 – 50% of RD of P from Vermicompost + 50% P from Inorganic source, T_7 – 75% of RD of P from Vermicompost + 25% P from Inorganic source, T_8 – 25% of RD of K from Cowdung + 75% K from Inorganic source, T_9 – 50% of RD of K from Cowdung + 50% K from Inorganic source, T_{10} – 75% of RD of K from Cowdung + 25% K from Inorganic source, T_{11} –25% of RD of K from Vermicompost + 75% K from Inorganic source, T_{12} – 50% of RD of K from Vermicompost + 50% K from Inorganic source, T_{13} – 75% K from Vermicompost + 25% K from Inorganic source. Each plot size was 2 m x 2 m. BRRI dhan62 was used as planting material in the experiment.

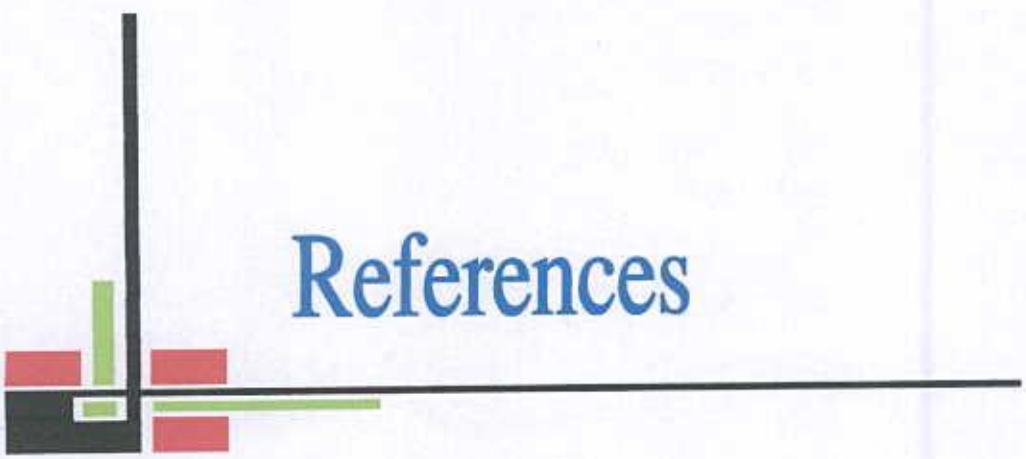
Most of the growth and yield parameters differed significantly due to the combinations of organic and inorganic source of phosphorus and potassium fertilizers. 50% of RD of K from Vermicompost + 50% K from Inorganic source showed the highest plant height which was statistically similar to the results given by 100% inorganic fertilizer and 75% of RD of K from Cowdung + 25% K from Inorganic source. The highest number of leaves $hill^{-1}$ was observed from 50% of RD of P from Vermicompost + 50% P from Inorganic source which was statistically similar to 50% of RD of K from Vermicompost + 50% K from Inorganic source. The highest number of effective tillers $hill^{-1}$ was observed from 50% of RD of K from Vermicompost + 50% K from Inorganic source and it was statistically similar to 50% of RD of P from Vermicompost + 50% P from Inorganic source, 75% of RD of P from Vermicompost

+ 25% P from Inorganic source and 75% of RD of K from Vermicompost + 25% K from Inorganic source. The lowest number of non-effective tiller $hill^{-1}$ was observed from 50% of RD of K from Cowdung + 50% K from Inorganic source which was statistically similar to 100% inorganic fertilizer. The highest total tillers $hill^{-1}$ was observed from 50% of RD of K from Vermicompost + 50% K from Inorganic source which was statistically similar to 50% of RD of P from Vermicompost + 50% P from Inorganic source and 75% of RD of K from Vermicompost + 25% K from Inorganic source. In case of panicle, 50% of RD of P from Vermicompost + 50% P from Inorganic source and 50% of RD of K from Vermicompost + 50% K from Inorganic source produced the longest panicle (26.50 cm) which was statistically similar to 75% of RD of P from Vermicompost + 25% P from Inorganic source, 25% of RD of K from Cowdung + 75% K from Inorganic source, 75% of RD of K from Cowdung + 25% K from Inorganic source, 50% of RD of P from Cowdung + 50% P from Inorganic source and 75% of RD of K from Vermicompost + 25% K from Inorganic source. 50% of RD of P from Vermicompost + 50% P from Inorganic source produced the highest number of filled grains $panicle^{-1}$ as well as the lowest number of unfilled grains $panicle^{-1}$. The highest grain yield m^{-2} (g) was observed from 50% of RD of K from Vermicompost + 50% K from Inorganic source which was statistically similar to 50% of RD of P from Vermicompost + 50% P from Inorganic source, 100% inorganic fertilizer and 25% of RD of K from Vermicompost + 75% K from Inorganic source. The highest straw yield m^{-2} (g) was observed from 50% of RD of P from Vermicompost + 50% P from Inorganic source which was statistically similar to 50% of RD of K from Vermicompost + 50% K from Inorganic source. The highest P and S content in grain was observed from 50% of RD of P from Vermicompost + 50% P from Inorganic source, highest K content in grain was observed from 50% of RD of K from Vermicompost + 50% K from Inorganic source.

From the above results it can be concluded that combinations of organic and inorganic source of phosphorus and potassium fertilizers performed better for growth, yield and grain nutrient content of BRRI dhan62. In specific 50% of recommended dose of P from Vermicompost + 50% P from Inorganic source and 50% of recommended dose of K from Vermicompost + 50% K from Inorganic source can be beneficial for farmers than sole use of inorganic fertilizers.

Recommendations for further researches:

- Research works may be initiated on the long term effects of organic fertilizers on soil quality.
- Other improved cultivars may be tested under such fertilizer combinations.
- Such studies should be conducted under different AEZs.



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Appendices

APPENDICES

Appendix I. Characteristics of experimental field soil as analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Exprimental field, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

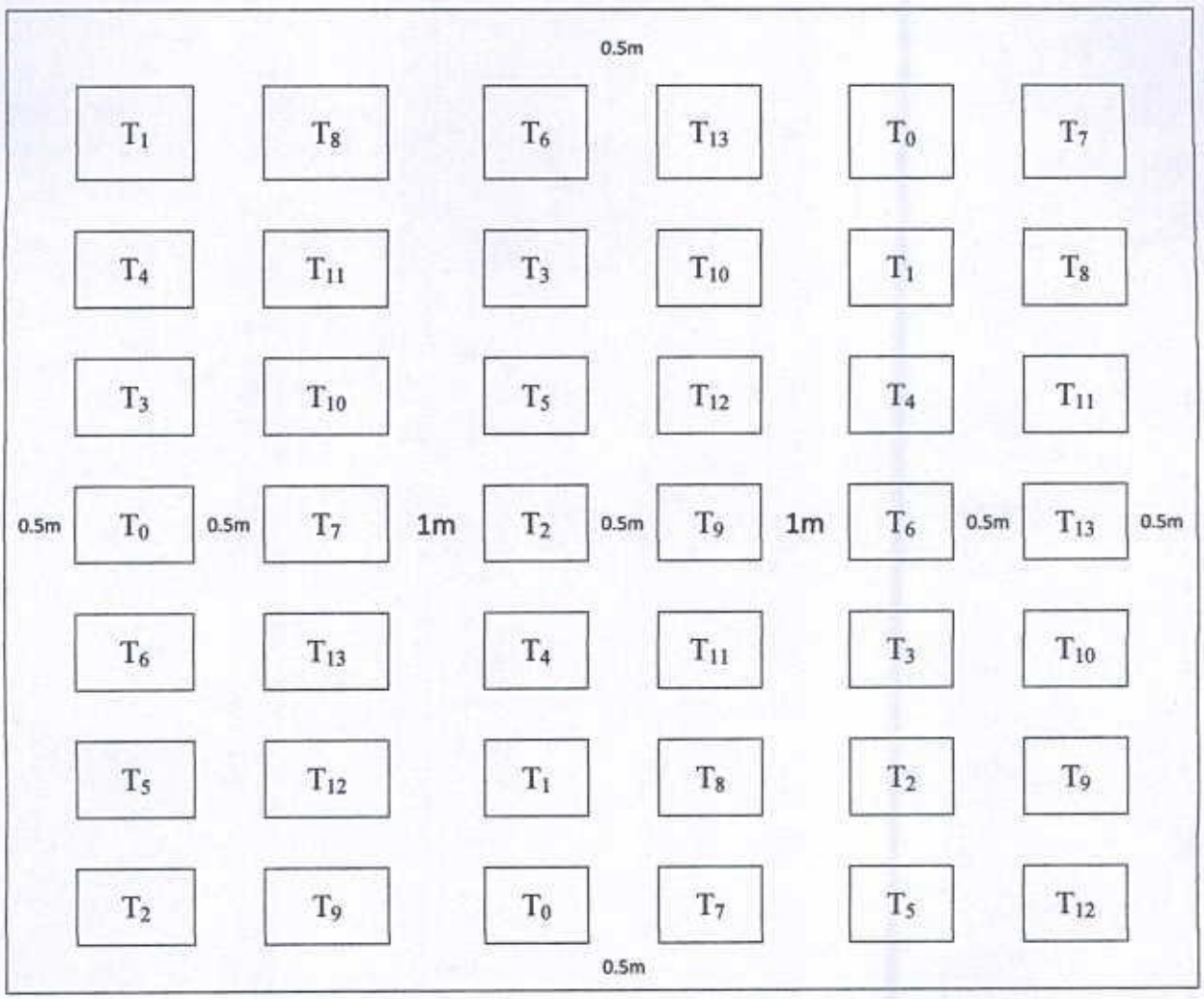
Source: SRDI

Appendix II. Monthly record of air temperature, relative humidity, rainfall, and sunshine (average) of the experimental site during the period from June to Novenber 2014

Month	Air temperature (^{0}c)		Relative humidity (%)	Rainfall (mm)	Sunshine (hr)
	Maximum	Minimum			
June, 2014	35.4	27.5	80	577	4.2
July. 2014	36.0	27.6	83	563	3.1
August, 2014	34.0	25.6	81	319	4.0
September, 2014	32.8	23.4	81	279	4.4
October, 2014	26.5	19.4	81	22	6.9
November, 2014	25.8	16.0	78	00	6.8

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka–1212*

Appendix III. Field layout of the experiment in Randomized Complete Block Design (RCBD)



Length	18 m
Width	16.5 m
Total Area	297 sq. m
Plot Size	2m×2m