EFFECT OF DIFFERENT ORGANIC MANURES ON THE MORPHOPHYSIOLOGICAL ATTRIBUTES AND PRODUCTIVITY OF AMAN RICE

BY

SHEYMOL CHANDRA DEV NATH

REGISTRATION No. 08-03143

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APPROVED BY

....	....
Dr. Mirza Hasanuzzaman	**Prof. Dr. Tuhin Suvra Roy**
Supervisor	**Co-supervisor**

....

Prof. Dr. H. M. M. Tariq Hossain
Chairman
Examination Committee

Department of Agronomy

Sher-e Bangla Agricultural University

Sher-e-Bangla Nagar

Dhaka-1207

CERTIFICATE

This is to certify that the thesis entitled, **"EFFECT OF DIFFERENT ORGANIC MANURES ON THE MORPHOPHYSIOLOGICAL ATTRIBUTES AND PRODUCTIVITY OF AMAN RICE"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfilment 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 **SHEYMOL CHANDRA DEV NATH,** Registration No. **08-3143** under my supervision and guidance. No part of the thesis has been submitted for any degree or diploma.

I further certify that such help or source of information, as has been availed during the course of this investigation has been duly acknowledged and style of thesis have been approved and recommended for submission.

....

Dr. Mirza Hasanuzzaman
Associate Professor
Department of Agronomy
Sher-e-Bangla Agricultural University,
Dhaka-1207

Date: 23.11.2015
Place: Dhaka, Bangladesh

DEDICATED TO

MY BELOVED PARENTS

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ABSTRACT

An experiment was conducted at the Sher-e-Bangla Agricultural University during the period from aman season (June-December 2013) with a view to study the effect of different organic manures and chemical fertilizers on the morphophysiological and yield contributing characters of transplant aman rice cv. BRRIdhan54. There were several treatments viz. T_1=Control, T_2=Recommended dose of NPK , T_3=Green manure +1/2 recommended dose of NPK, T_4= Green manure +2/3 recommended dose of NPK, T_5=Poultry manure +1/2 recommended dose of NPK, T_6= Poultry manure +2/3 recommended dose of NPK, T_7=Cowdung +1/2 recommended dose of NPK, T_8= Cowdung +2 /3 recommended dose of NPK, T_9=Quick compost +1/2 recommended dose of NPK, T_{10}= Quick compost +2 /3 recommended dose of NPK, T_{11}=Vermicompost +1/2 recommended dose of NPK, T_{12}= Vermicompost +2/3 recommended dose of NPK, T_{13}= Magic growth +1/2 recommended dose of NPK, T_{14}=Magic growth +2/3 recommended dose of NPK. The experiment was laid out in a RCBD design with three replications. All the plant growth and yield contributing characteristics were affected at different treatments. Maximum plant height was attained in T_{14} treatment (Magic growth +2/3 recommended dose of NPK). T_{12} treatment (Vermicompost +2/3 recommended dose of NPK) produce highest tillers hill^{-1},dry weight, effective tillers hill^{-1}, panicle length, number of filled grain panicle^{-1}, 1000 grain weight, straw yield, grain yield except harvest index, number of unfilled grain panicle^{-1}, and non effective tillers hill^{-1}. Higher harvest index was found in T_7 treatment (Cowdung + 1/2 recommended dose of NPK). Unfilled grain panicle^{-1}, and non effective tillers hill^{-1} were better in untreated plot. Benefit cost ratio was highest in T_2 recommended dose of NPK. Net return was highest in T_{12} .Significantly the highest grain yield was found in (5.95 t ha^{-1}) by the T_{12} treatment (Vermicompost +2/3 recommended dose of NPK) and lowest grain yield was found (3.80 t ha^{-1}) in control or without fertilization. So, T_{12} treatment (Vermicompost +2/3 recommended dose of NPK) is the best treatment with combined application of inorganic fertilizers other than poultry manure, green manure, cowdung, magic growth, quick compost and solitary application of inorganic fertilizer.

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LIST OF ACRONYMS AND ABBREVIATIONS

AEZ	Agro Ecological Zone
BBS	Bangladesh Bureau of Statistics
cv.	Cultivar
Cm	Centi-meter
DAT	Days After Transplanting
Etc	Etcetra
USDA	United States Department of Agriculture
M	Meter
HI	Harvest Index
HYV	High Yielding Variety
Hr	Hour
Kg	Kilogram
G	Gram
m^2	Meter Square
viz.	Namely
CV%	Percentage Coefficient Variance
t ha^{-1}	Ton per hectare
Ppm	Parts per million
LSD	Least Significance Difference
RCBD	Randomized Completely Block Design
L	Liter
EC	Emulsifiable Concentrate
SS	Sewage Sludge
DM	Dry Matter
Et.al	And others
RH	Rice Hull

Chapter 1

INTRODUCTION

Rice (*Oryza sativa* L.) belongs to the Gramineae family and it is dominant over all other crops in respect of economic and social significance in Bangladesh. It is also largest cereal crop in Bangladesh. In worldwide, 474.86 million metric tons of rice was produced from 159.64 million hectares of land with an average yield of 4.43 t ha^{-1} during the year of 2014-15 (USDA, 2015). USDA estimates Bangladesh has to produce around 34.8 million tons of rice in 2014-15 (May - April), up about 1% from an estimated 34.59 million tons in 2013-14. During the year 2013-14, 2.35 t ha^{-1} of aman rice was produced from 55.30 million hectares of land in Bangladesh (BBS, 2013-14). Rice is a staple crop in Bangladesh and its production has to be enhanced to meet the food requirement of an over populated country where the size of the population is still going fast. Due to the extensive and improper use of chemical fertilizers in the soil, our soil is degrading to an alarming level, causing an imbalance in the ecosystem and environmental pollution as well. More recently, attention is being focused on the global environmental problems; utilization of organic wastes, FYM, compost, vermicompost and poultry manures as the most effective measure for the purpose. Organic materials are the safer sources of plant nutrient without any detrimental effect to crops and soil. Cowdung, farm yard manure, poultry manure and also green manure are excellent sources of organic matter as well as primary plant nutrients (Pieters, 2004). However, after the industrial revolution wide spread introduction of inorganic fertilizers led to a decline in the use of organic material in the cropping systems (Rosegrant and Roumasset, 1988). The impact of increased fertilizer use on crop production has been large and important (Hossain and Singh, 2000). It has been estimated that fertilizer use growth contributed to about 25% of the total increase in rice production in Asia between 1965 and 1980 (Barker *et al.*, 1985). However, in recent years there has been serious concern about long term adverse effect of continuous and indiscriminate use of inorganic fertilizers on deterioration of soil structure, soil health and environmental pollution (Ghosh and Bhat, 1998; Shukla *et al.*, 1998; Singh, 2000). The yield of rice has reached a plateau due to declining factor productivity under increasing intensification. Therefore, farmers are compelled to apply increasing rates of fertilizers to maintain current yield levels (Pagiola, 1995). The reasons for low yield of rice are manifold; some are varietals, others are technological and rests are climatic. Undoubtedly, with the introduction of high yielding varieties the yield of rice has been increased, but the trend of increase is not linear. The yield can be increased by using improved cultural practices like use of quality seed, high yielding varieties, adopting plant protection measures, judicious application of fertilizers, etc. Integrated nutrient management for rice can increase the productivity of rice. The long-term research of BARI revealed that the application of cowdung @ 5 t ha^{-1} $year^{-1}$ improved rice productivity as well as prevented the soil resources from degradation (Bhuiyan, 1994). Poultry manure is another good source of nutrients in soil. Meelu and Singh (1991) showed that 4 t ha^{-1} poultry manure along with 60 kg N ha^{-1}as urea produce grain yield of crop similar to that with 120 kg N ha^{-1}as urea alone. Poultry manure is an excellent organic fertilizer, as it contains high nitrogen, phosphorus, potassium and other essential nutrients. It was also indicated that poultry manure more readily supplies P to plants than other organic manure sources (Garg and Bahla, 2008). Use of organic manures alone, as a substitute to chemical inorganic fertilizer is not profitable and will not be enough to maintain the present levels of crop productivity of high yielding varieties (Garrity and Flinn, 1988). Therefore, integrated nutrient management in which both organic manures and inorganic fertilizers are used simultaneously is probably the most effective method to maintain healthy sustainable soil system can improve soil structure, improve nutrient exchange and maintain soil health has again raised interest in organic farming (Becker *et al.*, 1995; Ayoub, 1999). Vermicompost has been shown to have high levels of total and available nitrogen, phosphorous, potassium (NPK) and micro nutrients, microbial and enzyme activities and growth regulators (Parthasarathi and Ranganathan, 1999) and continuous and adequate use with proper management can increase soil organic carbon, soil water retention and transmission and improvement in other physical properties of soil like bulk density, penetration resistance and aggregation (Zebarth *et al.*, 1999) as well as beneficial effect on the growth of a variety of plants (Atiyeh *et al.*, 2002). Plant height increased with the increasing level of nitrogen as magic growth (Singh and Singh 1986). Magic growth increased number of tillers $hill^{-1}$ with increased nitrogen level as USG (Kamal *et al.* 1991).

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. Evidences from different AEZ of the country have shown a decrease in the content of organic matter by the range of 15 to 30% over the last 20 years (Miah, 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 while increasing crop productivity (Janssen, 1993). Combined applications of both chemical and organic fertilizers need to be applied for the improvement of soil physical properties and supply of essential plant nutrients for high yield. However, it is necessary to carry out studies by using fertilizers and manures in an integrated way in order to obtain sustainable crop yield without affecting soil fertility. In view of limited information on the problems mentioned above, a study was therefore, undertaken with the following objectives:

i. To investigate the effect of organic manures on the performance of aman rice., and

ii. To find out a suitable combination of organic manure and chemical fertilizer for aman rice cultivation.

Chapter 2

REVIEW OF LITERATURE

2.1 Effect of vermicompost on rice

Edward and Burrows (1988) concluded that seedlings emergence of tomato, cabbage, and radish was much better in vermicompost than in thermophilically composted animal waste.

Sylvia *et al.* (1998) estimated that as much as 20% of the total carbon assimilated by the plant may be allocated to mycrorrhizal fungi. Thus, application of composts used in the studies at higher concentrations was antagonistic, rather than synergistic to plant growth. Compost and vermicompost showed improvement in plant growth at concentration of 2.5 and 5 t ha^{-1}.

Nethra *et al.* (1999) observed the increase in stem girth and number of branches in china ester by using vermicompost with recommended NPK in different proportions.

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

which was significantly higher than 100% recommended NPK fertilizers. The study suggests nutrient concentration based application of vermicompost likely to be a more effective proposition than using this material on the basis of total weight, as is generally done for different organic manures.

Atiyeh *et al.* (2001) concluded that vermicomposts, whether used as soil additives or as components of greenhouse bedding plant container media, have improved seed germination, enhanced seedling growth and development and increased overall plant productivity.

Cavender *et al.* (2003) showed that nutrients present in vermicomposts stimulated the fungal colonization, but at the expense of plant growth.

Hashemimajd *et al.* (2004) reported that vermicomposting and composting are efficient methods for converting solid wastes to useful products. Incorporation of composts and vermicomposts into potting and container media is a potential use for these materials. So, they conducted an experiment on green house to assess the effects of a vermicompost produced from raw dairy manure (RDM) along with some other composts produced from tobacco residue (TR), yard leaf (YL), sewage sludge + rice hull (SS + RH), sewage sludge + yard leaf (SS + YL), and RDM. The mixing proportions of vermicomposts and composts were 0, 15, 30, and 45% of pot volume and tomato seedlings were grown in pots. All potting mixtures produced significantly higher biomass than the control (soil + sand) and RDM. Shoot and root dry matters (DM) were greatest in VC and SS + RH. Rates of composts in potting mixture did not generally affect DM, although a decrease in DM was observed in pots containing 45% of SS + YL. TR and YL produced lower DM in comparison with VC, SS + RH, and SS + YL.

Suthar *et al.* (2005) reported a hormone like effect of earthworm body fluid on seedling growth of some legumes.

Hameeda *et al.* (2006) found that RSC or RSVC applied at 2.5 t ha^{-1} showed significant improvement in shoot length (1-12%), leaf area (20-34%), plant biomass (9-27%), root volume and mycorrhizal colonization. When RSC or RSVC were applied at concentrations of 5 t ha^{-1}, there was decrease in plant biomass with RSC+AM and RSVC+AM, when compared to the application of RSC and RSVC alone.

Suthar (2006) demonstrated that during the vermicomposting of some crop residues mixed with cattle dung resulted in an increase in total N (91–144%), available P (63–105%), and exchangeable K (45–90 %) content of it.

Basnet (2006) found that vermicompost sample of cowdung contain organic matter (50.25%), nitrogen (1.96%), phosphorus (2.33%) and potassium (4.99%). The vermicompost sample contained several times more nitrogen, phosphorus and potassium than the soil sample. These added mineral nutrients may be the factors responsible for the enhanced growth of the vermicompost treated plants.

Prajapati *et al.* (2008) showed that the manure effects on shoot length, root length, fresh shoot and root weight, dry shoot and root weight, and panicle number on 45th day and 90th day were investigated. In both the stages these parameters of all the treated plants were significantly ($P<0.05$) greater than the un inoculated control. Dual inoculated plants in presence of vermicompost gave better positive effects on both 45th day and 90th day, in comparison to single inoculation of *A. chroococcum*, *P.indica* and vermicompost. However, *A. chroococcum* treated plants showed significant decrease in dry root weight as compared to control plants on 90th day observation. This suggested that dual inoculation of *A. chroococcum* and *P. indica* had beneficiary response on growth of rice plant.

Singh *et al.* (2008) investigate that vermicompost is made up primarily of C, H and O, and contains nutrients such as NO_3, PO_4, Ca, K, Mg, S and micronutrients which exhibit similar effects on plant growth and yield as inorganic fertilizers applied to soil.

2.2 Effect of cowdung on rice

Abe *et al.* (1995) reported that Cattle manure applied to the rice crop increased root density and enhanced root growth to deeper soil layers.

Mannan *et al.* (2000) showed that straw yield was highest from BR23 and lowest from BR11for cowdung application. Grain protein content was similar and higher in BR11 and BR23 than the other varieties. Among the fertilizer application treatments, F_5 and F_3 produced the highest and $F_1$the lowest grain and straw yields. Grain protein content was higher in F_5, F_4 and F_3treatments receiving 5 or 10 t ha^{-1} cow dung and late N application. Manu ring with cow dung up to 10 t ha^{-1} in addition to recommended inorganic fertilizers with late N application improved grain and straw yields and quality of transplant autumn rice over inorganic fertilizers alone.

Glaser *et al.* (2001) found that Losses of soil organic matter can only be replenished in the short term by application of organic matter such as manure.

Bhuiyan, (1994) implied that application of cowdung @ 5 t ha^{-1} yr^{-1} improved rice productivity as well as prevented the soil resources from degradation.

Parham *et al.* (2002) observed that cattle manure-P is relatively more mobile than inorganic fertilizer-P and promotes microbiological activities and P cycling.

Adeoye *et al.* (2004) demonstrated that cow dung has a reasonably high content of N, K and fibrous materials that favorably regulates soil moisture, temperature and even prevents multiplication effects of weeds on soil surfaces.

Solaiman *et al.* (2006) found that the highest plant height and dry weight of shoot, the maximum number of clusters of flowers and fruits $plant^{-1}$ as well as the greatest fruit size and fruit yield/plant, fruit yield/ha were obtained from the application of the recommended dose of nutrients viz. 200 kg N + 35 kg P + 80 kg K + 15 kg S ha^{-1}, but similar results were obtained from the treatment receiving 5 t ha^{-1} cowdung along with half of the recommended doses of nutrients (100 kg N+ 17.5 kg P + 40 kg K + 7.5 kg S ha^{-1}). The effect of 10t cow dung per ha, along with one third of the recommended dose of nutrients, was also comparable to the effect of employing the recommended dose of nutrients. It was further observed, from an economic standpoint, that the combination of 5 t ha^{-1} cowdung along with half of the recommended doses of nutrients appeared to be a viable treatment which would offer the maximum benefit concerning cost ratio (4.38) for tomato production in the shallow red-brown terrace soil (AEZ-28) of Bangladesh.

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

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

2.3 Effect of poultry manure on rice

Dick *et al.* (1995) investigate that poultry litter can play a vital role for maintaining soil fertility. Because the application of manure increased total C and total N in soil, while the application of nitrogen fertilizer (inorganic) increased neither carbon nor nitrogen in soil.

Khanam *et al.* (2001) the result demonstrated that all the treatment had positive effect on the yield components and yields of BRRIdhan30. Grain and straw yields of Brridhan 30 were significantly increased due to different treatment and the highest value was recorded with the application of poultry manure@10 t ha^{-1}

Miah *et al.* (2006) viewed that application of PL as preserved by farmers produced lower yield than the others, but still this yield was significantly higher than that of control plot (no PL). The yield obtained with 50% STB (4.04 t ha^{-1}) was lower compared to these PL treated plots showing a beneficial effect of PL on rice production.

Li-Mingly *et al.* (2007) found that poultry litter improves the quality of cereal crops, fruits and fibre crops. Poultry litter with inorganic fertilizer promoted the quality of soybean.

Agbede *et al.* (2008) reported that poultry litter improved soil physical properties significantly, by increasing total porosity and moisture content.

Sarker *et al.* (2009) found that poultry droppings could be used as organic manure for crops, vegetables and psciculture.

Hossain *et al.* (2010) reported that all PL treatments received poultry litter 3 t ha^{-1} and 50% of STB chemical fertilizers. In both years, 30 days old PL produced significantly higher rice yield with higher nutrient uptake.

Hossaen *et al.* (2011) reported that the maximum number of effective tillers per hill (13.52), the longest panicle (24.59 cm), maximum number of total grain per plant (97.45), the highest weight of 1000 seeds (21.80 g), the maximum grain yield (7.30 t ha^{-1}) and straw yield (7.64 t ha^{-1}) was recorded from T_5 treatment (70% NPKS +2.4 t ha^{-1} poultry manure).

Masarirambi *et al. (2012)* showed that chicken manure levels significantly ($P < 0.05$) affected growth, yield and nutritional quality of lettuce. A trend of superiority of the different level of chicken manure application was observed as lettuce provided with 60 t ha^{-1} exhibited higher values in number of leaves, plant height, marketable yield and mean leaf dry mass. The second best results were obtained from plants supplied with 40 t ha^{-1} followed by plants previously fertilized with 20 t ha^{-1} and the lowest from those provided with inorganic fertilizer.

Saha *et al.* (2013) reported that the application of different treatments showed positive trend in all the parameters of BRRI dhan39. The highest grain yield (4.07 t ha^{-1}) was recorded by the application of 6 L ha^{-1} humic acid along with 3 t ha^{-1} poultry manure which was identical with the application of 6 L ha^{-1} humic acid along with 6 t ha^{-1} poultry manure but was different from other treatment combinations.

2.4 Effect of green manure on rice

Reddy *et al.* (1972) found that application of gliricidia green manure @ 7.5 or 15 t ha^{-1} + 120 kg N, 60 kg P_2O_5 and 60 kg K_2O ha^{-1} significantly increased plant height, number of tillers, filled grains per panicle of rice over control. The response to the addition of green leaf manure was quadratic.

Jaggi and Russel (1973) observed that green manure significantly influenced the number of tillers per hill and leaf area index; however, it did not affect the height of main shoot significantly.

Stangel (1979)reported that crop yield is *Ca.* 2 t ha^{-1} $crop^{-1}$, which means that N_2 fixation in the related rice field is *Ca.* 40 kg N ha^{-1} $crop^{-1}$, if we assume that to produce 100 kg of grain, the rice plant, regardless of soil type or time of transplanting, requires *ca.* 2.0 kg of N.

Jha *et al.* (1980) noted that application of green manure @ 5-10 ṭ ha^{-1} was very useful for improving the growth rate. They reported that application of green manure (*Ipomea cornea*) was very useful for improving the grain and straw yields of rice through increased number of ear bearing tillers m^{-2}.

Tiwari *et al.* (1980) opined that application of green manure was very useful for improving the grain and straw yield through increased number of ear bearing tillers.

Dreyfus *et al.* (1981) have found that *Sesbania rostrata,* a tropical legume which colonizes waterlogged soils in the Sénégal Valley, forms N-fixing nodules with *Rhizobiurn* on both the roots and the stem.

Bhardwaj *et al.* (1981) showed that green manuring of sunnhemp, dhaincha and *Ipomea carnea* @ 15 t ha^{-1} in combination with 0, 30, 60, 90 kg N ha^{-1} increased the number of tillers m^{-2} and dry matter accumulation. They also marked that the incorporation of *Crotalaria juncea* and *Sesbania canabina* significantly increased the grain yield of rice on irrigated land. The prediction equation perceived that there was saving of 49.9 and 23.3 kg N ha^{-1} by green manure with *Crotalaria juncea* and *Sesbania canabina*, respectively.

Khind *et al.* (1983) spotted that, when 30, 45 and 60 days old crop with dhaincha (*Sesbania aculeata*) incorporated one day before transplanting of rice the amount of green matter, dry matter accumulation and nitrogen added increased progressively with the increase in age of Dhaincha. The increase in the yield with the incorporation of 60 days old dhaincha was equivalent to those obtained with application of 120 kg N ha^{-1} through urea.

Rinaud *et al.* (1983) reports that application of chemical N fertilizer (treatment **3)** increased the grain yield by 169 g m^{-1} (1.69 t ha^{-1}), whereas incorporating ***S.*** *rostrata* as green manure resulted in a grain yield increase of 372 g m^{-2} (3.72 t ha^{-1}). N2 fixed by *S. rostrata* was estimated to be at least 26.7 g m^{-2} (267 kg N ha^{-1}), one third being transferred to the crop and two thirds to the soil.

Jamdade and Ramteke (1986) monitored that incorporation of dhaincha and gliricidia increased the number of tillers, dry matter accumulation, number of panicles, thousand grain weight, number of filled grains per panicle as compared to no green manure, which in turn produced the highest grain yield of 52.12 and 52.09 q ha^{-1}, respectively.

Antil *et al.* (1988) studied that the grain and straw yield of rice were significantly higher after application of green manure of dhaincha and moong compared to fallow and maize. The beneficial effect of green manure was mainly due to steady release of nitrogen during crop season.

Kolar and Grewal (1988) examined that burying sesbania, cowpea and sunnhemp resulted in significant increase in grain and straw yield of rice.

Ghai and Thomas.(1989) showed that green manure (Sesbania aculeate) are fast growing leguminous plants cultivated annually and can accumulate more than 80 kg N ha^{-1} when grown as green manures.

Yadvinder-Singh *et al.* (1991) observed green manures are the crops which are returned into the soil in order to improve the growth of subsequent crops. Green manures offer considerable potential as a source of plant nutrients and organic matter.

Yakardi *et al.* (1992) reported positive response for number of pods per plant and 100 kernel weight by application of potassium.

Shivkant and Rajkumar (1992) concluded that application of FYM and green manure to rice increased the grain yield by 11 to 26% as compared to control.

Bal *et al.* (1993) registered that all the yield contributing characters *viz.*, number of panicles per hill, length of panicle, number of filled grains per panicle, thousand grain weight were significantly influenced by the application of gliricidia and FYM @ 5 t ha^{-1} as compared to control ultimately resulting in increased grain and straw yield of rice. They further observed that incorporation of gliricidia green leaves 5 t ha^{-1} at the time of puddling resulted in 50% saving in recommended dose of fertilizer nitrogen and also increased organic carbon content of lateritic soils of Konkan compared to the application of FYM @ 5 t ha^{-1} and no organic manures. The superiority of gliricidia over FYM was mainly due to low C: N ratio i.e. 15:1 of gliricidia as compared to FYM (20:1).

Dekamedhi *et al.* (2000) reported that grain yield of rice was significantly increased due to application of green manure in combination with N fertilizer.

Talathi (2001) observed that the height of rice plant, number of leaves, number of tillers and dry matter accumulation per hill was significantly higher with application of 50% recommended NPK through fertilizers + 50% N through gliricidia, which was closely followed by 50% recommended NPK through fertilizers + 50% N through FYM. Rice supplied with 50% recommended NPK through fertilizers + 50% N through gliricidia produced higher number of panicles per hill, length of panicles, number of grains and weight of grains per panicle. They also observed that Application of 50% recommended NPK through fertilizers + 50% N through gliricidia, 50% recommended NPK through fertilizers + 50% N through FYM to rice recorded 105.41 and 103.33% higher grain yield compared to that of 100% recommended NPK, respectively, while 50% recommended NPK through fertilizers + 50% N through gliricidia produced higher straw yield of rice followed by 50% FYM substitution.

Duhan *et al.* (2002) who found increased N uptake of rice with application of green manure along with N fertilizer.

Sarrantonio *et al.* (2003) found that green manure or cover crops have been shown to improve soil chemical and physical properties.

Mishra *et al.* (2006) are strongly supported by finding of other studies that GM legumes increased crop yields and improved soil organic fertility.

Shah *et al.* (2011) found that grain and straw yields of both rice and wheat crops have shown strong relationship with the total biomass of GM legumes. The improvement gained in crop yields from GM legumes could be attributed to improvement in the soil conditions and nutrient status of the soil. It is therefore recommended that green manure legumes should be encouraged for sustainable soil and crop productivity in rice-wheat system.

Deshpande *et al.* (2011) found that combined application of *Sesbania* green manure and nitrogen fertilizer increased the plant height.

Salahin *et al.* (2013) found that incorporation of *S. aculeata* and deep tillage practice gives the highest yield of agronomic crops (T. aman and maize).

Islam *et al.* (2014) found that application of Sesbania green manure incorporated at 50DAS in combination with 75% recommended dose of nitrogen could be considered more effective for BINA dhan7 production

2.5 Effect of magic growth on rice

Crasswell and De Datta (1980) broadcast application of urea on the surface soil causes losses up to 50% but application of magic growth solution in leaf may result in negligible loss.

Singh and Singh (1986) found that adequacy of nitrogen as magic growth probably favoured the cellular activities during panicle formation and development which led to increased number of roductive tillers $hill^{-1}$.

Singh and Singh (1986) showed that plant height increased with the increasing level of nitrogen as magic growth.

Singh and Mohapatra (1989) effect of magic growth level was significant in respect of grain yield. The highest grain yield (3.42 t ha^{-1}) was obtained from T_3 treatment which was statistically identical with T_4, T_5 and T_2 treatments. The lowest grain yield (2.54 t ha^{-1}) was obtained from T_0 (control) treatment.

Kamal *et al.* (1991) recorded increased number of tillers $hill^{-1}$ with increased nitrogen level as USG.

Quayum and Prasad (1994) who stated that grain yield increased upto 112.5 kg N ha^{-1} as USG. Alam (2002) recorded a positive effect of USG level on plant height.

Panir *et al.* (2014) showed that effect of magic growth solution exerted significant influence on all the yield attributes except 1000-grain weight. Grain and straw yields were highest (3.42 t ha^{-1}, 4.52 t ha^{-1}, respectively) in the treatment T_3. The highest grain yield of BRRI dhan37 was mostly the resultant effect of highest number of effective tillers $hill^{-1}$, highest number of grains $panicle^{-1}$ and lowest number of sterile spikelets $panicle^{-1}$. The lowest grain yield (2.54 t ha^{-1}) was produced in T_0 which was the consequence of lowest number of effective tillers $hill^{-1}$, lowest number of grains $panicle^{-1}$ and highest number of sterile spikelets $panicle^{-1}$. Grain and straw yields were found to be highest in treatment T_3, where N, K and magic growth solution were applied. This highest grain yield was statistically identical with T_4. From the result of the study it may be concluded that T_3 treatment produced the highest grain yield of transplant *aman* rice CV BRRI dhan37.

2.6 Effect of compost on rice

Zaka *et al.* (2003) claimed increased yields of rice as well as wheat crops with the use of different organic materials alone and in combination with mineral fertilizer.

Khan *et al.* (2004) found compost had been shown to act as a good soil conditioner by improving crop rhizopheres for better growth and development.

Vijaya Krishna (2007) observed that the increase in dry matter yield with coffee pulp compost and rice hull ash treatments may be attributed to the positive effect of these components on soil properties and consequently reflected on yield components. Many research workers have reported the advantage of using high quality organic manure for better crop growth and biomass accumulation.

Buresh et.al (2008) observed superior performance of upland rice cultivars at 8 t ha^{-1} compost rate means that this quantity of compost will supply nutrients needed for optimal growth performance of upland rice. Applying beyond this rate might create imbalance and affect crop growth negatively. Irrespective of cultivar type, applying 8 tha^{-1} compost appeared to have promoted better growth and development

Echarte*et et al.* (2008) shown biomass yield by the three cultivars was not significantly different during the first growing cycle. This suggests that compost supplied adequate nutrients necessary for abundant production of plant canopy factors like leaf length, leaf breadth, specific leaf area, tillering ability needed to enhance better radiation use efficiency by these cultivars.

Akanbi *et al.* (2009) viewed that compost application helped in improving fertility status of Alfisol in this region as the performance of the crop improved significantly on compost augmented soil far better than the unfertilized control plots.

Myint *et al.* (2010) stated that the response of the crop on compost augmented plots suggests that applied compost contains growth promoting substances with the attribute to promote better growth and development of the three upland cultivars.

2.7 Effect of inorganic fertilizers on rice

Yoshida *et al.* (1972) viewed that as the amount of nitrogen absorbed by the crop increases, there is an increase in the number of tillers per square meter.

Singh *et al.* (1981) reported that surface application of gypsum @ 25 or 50% GR before transplanting of rice gave higher grain yield.

Tandon (1987) stated that phosphorus is the second key nutrient element and plays a critical role in the life cycle of plants. It is needed greatly by young, fast growing tissue and performs a number of functions related to growth, development, photosynthesis and utilization of carbohydrate.

BRRI (1990) reported that nitrogen has a positive influence on the production of effective tillers.

Saharawat *et al.* (1994) showed that grain yields increased with increasing application of triple superphosphate (TSP).

Donahue (1997) found that phosphorous is an essential component of deoxyribonucleic acid (DNA), the inheritance characteristics of living organisms.

Raju *et al.* (1997) found that phosphorus has marked beneficial impact on seedling establishment, root biomass production, flowering and maturity of the crop.

Ahsan *et al.* (1997) observed the negative K balance was observed even up to 60 $kgha^{-1}$ of the applied K level with diminishing magnitude and suggested that an amount of about 61 kg Kha^{-1} would be required to sustain soil native K for rice cropping.

Stewart *et al.* (1997) observed that plants grown as green manures that are capable of extracting P from rock phosphate have the potential to supply P to a subsequent crop through organic P mineralization.

Zakir *et al.* (1997) was noted that application of FYM with Gypsum was the best in obtaining highest number of filled grains which might be occurred by the reduction of sodium ion concentration in these treatment over control.

Singh *et al.* (1999) conducted a field experiment to study the effect of sources of phosphorus (0, 30 and 60 kg P_2O_5 ha^{-1}) on growth, grain yield and phosphorus use-efficiency of rice and residual effects which revealed that the grain yield of rice increased with up to 30 kg P_2O_5 ha^{-1}.

Dobermann *et al.* (1998) found that increase in soil available K due to straw application.

Thakur *et al.* (1999) found that potassium performs many functions in plant metabolism, promoting photosynthesis, harnessing the interaction of K with N, and hence could have increased the nutrient uptake.

Chopra *et al.* (2000) reported that effective tillers $hill^{-1}$ N ha^{-1} increased with the application of 80 or 120 kg.

Peng *et al.* (2000) claimed that higher level of nitrogen through effect on yield components specifically the number of panicle and the number of seed per panicle and also effect on traits such as panicle length and increase in flag leaf area causes more increment in total dry matter accumulation.

Hassan *et al.* (2001) found that the pH of the leachates collected from control pots did not show any significant decrease even after ninth collection, however by adding and increasing the level of gypsum, the average value of pH decreased moderately i.e. from 9.07 (control) to 8.18 (T6, 200% yield of 25.3 gm pot-1 was produced by the treatment No. 6 which had received 200% gypsum of the soil requirement. It was followed by the treatment No.5 that had received 100 % gypsum of the soil requirement. The grain yield in this treatment was recorded 24.70 gm pot^{-1}. The percent increase over control for T_5 and T_6 were noted as 44.2 and 47.7 respectively.

Ali *et al.* (2001) stated that addition of gypsum initially increases the EC of the soil, they recommended that either extra irrigation should be applied or high delta crop should be grown.

Haq *et al.* (2001) Various amendments like gypsum, sulphur, acids, press mud and farm yard manure (FYM) may be used for reclamation of these soils.

Sudhakar *et al.* (2001) found that there was a significant increase grain yield, straw yield, net return and B:C ratio with each increment of nitrogen application up to 125 kg ha^{-1}.

Kumar *et al.* (2001) during their study mentioned that using of phosphate fertilizer increased grain yield.

Bayan *et al.* (2002) claimed that tillers $hill^{-1}$ increased with the application of nitrogen fertilizer.

Ahmed *et al.* (2002) stated that USG was most efficient form of nitrogen in producing all yield components and in turn, grain and straw yields.

Singh *et al.* (2002) reported that increasing levels of nitrogen significantly increased total tiller $hill^{-1}$ up to a certain stage.

Akhtar *et al.* (2003) found that one of the reasons of low efficiency of fertilizer for enhancing crop productivity is imbalance use of applied nutrients. The ratio of potassium and nitrogen fertilizer used in Pakistan (0.02:1) is far below than that used in other countries of the world i.e. Japan (3.99:1), UK (0.37:1), Netherlands (0.30:1), China (0.15:1) and India (0.14:1).

Samrathlal *et al.* (2003) showed that longest panicle (28.74cm) along with highest 1000 grain weight (20.91 gm) were obtained from the treatment where potash was applied in two equal splits ½ at 25 DAT and ½ at 45 DAT (T_5) which was statistically at par with the treatment where whole of potash was applied at 25 DAT (T_2) and were significantly different from other treatments. The smallest panicles having length 27.97 and least 1000 grain weights 19.86 gm were obtained from T_1 where whole potash was applied as basal. This increase in panicle length and in 1000 grain weight may be due to continuous supply of K to the crop during crop growth stages. The efficient potash uptake by rice plant results in better growth and development when applied at maximum tillering stage (25 DAT) and at panicle initiation stage (45 DAT).

Gupta *et al.* (2003) mentioned that in tomato plant increasing vegetative growth is due to increasing potassium fertilizer levels.

Fageria *et al.* (2003) reported that use of adequate N rate is important not only for obtaining maximum economic return, but also to reduce environmental pollution.

Meena *et al.* (2003) recorded the highest grain yield of rice hybrid with the application 200 kg N ha^{-1}. However, the information on nitrogen requirement and neem bitter-coated urea for optimum yield of newly-released aromatic hybrid ('PRH 10') and an aromatic high yielding variety ('Pusa 1121') is limited. Harneet-Kaur *et al.* (2003) reported that the total yield, marketable yield and total average yield per plant were increased by increasing application rates of potassium.

Pal *et al.* (2000) showed among the sources of fertilizer tried, the highest mean grain and straw yield was observed in muriate of potash treated plots than in sulphate of potash treated plots. Application of potassium in proper time (split doses) enhanced the enzymatic activities, probably caused higher mobilization of nutrients in soil and plant and translocation of photosynthetics in plant system, which ultimately resulted in higher grain and straw yields.

Singh *et al.* (2004) found that among these practices, application of nitrogen is the important factor to achieve higher yield from different rice varieties.

Rehman (2004) showed that available phosphorus in plants was affected by three factors: plant available phosphorus concentration in soil solution, the amount of exchangeable phosphorus and the amount of phosphorus relative uptake in soils. Chemical fertilizers are one of the major sources of providing phosphorus in plants, but the high costs of chemical fertilizers, and environmental problems that caused by their overuse have led that researchers seek ways to reduce chemical fertilizers.

Grag *et al.* (2005) showed in their studies that adding nutrients such as phosphorus (fertile-2 phosphate) to the soil would lead to the increase of the rate of photosynthesis and its efficiency and finally the increase of grain yield and growth in sesame.

Hussain *et al.* (2005) carried out a study to assess the effects of nitrogen (30, 60, 90 and 120 kg N ha^{-1}) and phosphorus (20, 40 and 60 kg P_20_5 ha^{-1}) on the growth and yield of rice/sorghum inter-crop. Application of nitrogen up to 90 kg ha^{-1}enhanced the growth and yield of rice crop and application of phosphorus @ 40kg P_2O_5 ha^{-1} resulted in higher growth and yield of rice crop.

Ali *et al.* (2005) reported that significant increase in paddy yield was recorded when potash was applied in splits at different growth stages over a single application as basal.

Fawzy *et al.* (2005) showed that potassium fertilizer had a significant effect on the fresh weights of leaves and stems, early and total yield of sweet pepper plants. Fresh weight of leaves showed significant difference among treatments.

Eftekhari *et al.* (2006) found that by using phosphate bio fertilizer and phosphate solubilizing bacteria on rice, phosphate bio fertilizer has caused the highest increase of grain yield ($7593.7 kg.ha^{-1}$).

El-Desuki *et al.* (2006) reported that mean dry weight of the pods ranged from 10.41 (in T_2) to 17.93 (in T_5). T_5 showed a significant difference from T_2. This simulative effect may be due to the role of potassium on production of enzyme activity and enhanced translocation of assimilative and photosynthesis .

Turk *et al.* (2006) reported that most of the measured traits like seed yield, seed weight per plant, 100 seed weight, seeds pod^{-1}, plant height, pod length, pods $plant^{-1}$ and branches $plant^{-1}$ were significantly affected by phosphorus application as compared with control.

Jamal *et al.* (2006) found that many cases aerial spray of nutrients is preferred and gives quicker and better results than the soil application.

Anonymous (2006-07a) reported in Pakistan, rice is grown on an area of 2.58 million hectares, with an annual production of 5.438 million tons having average yield of 2107 kg ha^{-1}

Awan *et al.* (2007) showed that intensive cultivation, the need of K will increase.

Rasipour *et al.* (2007) found that phosphorous has a defined role in plant metabolisms such as root development, photosynthesis, nutrient transport within the plant, Meiosis, phospholipid in cell walls, reproductive parts of plant.

Joachim *et al.* (2007) attributed the beneficial effect of combined use of farm yard manure and Gypsum on the reclamation of sodic soils.

Ojaghloo (2007) stated that the superiority bio fertilizer treatments in comparison with control treatment can be because of increase and speed of higher uptake in some mineral nutrient specially phosphorus that produce with effect of phosphate souloblizing bio fertilizer on phosphate less dissolved compounds and supplying plant available phosphorus causes to increase yield components and finally grain yield.

Das *et al.* (2007) showed phosphate bio fertilizer with higher uptake of phosphorus and increase photosynthesis caused to develop biological yield. Darzi (2007) showed that application of phosphate bio fertilizer in fennel has positive effect on biological yield.

Maheswari *et al.* (2007) found that applications of higher N (240 and 180 kg N ha^{-1}) have produced more dry matter that could produce additional photosynthates for the development of root system.
Singh *et al.* (2007) viewed that supplying adequate nutrients for plant such as phosphorus is one of the most important aspects of agriculture management and can play an important role in increasing production and improving the yield.

Abro *et al.* (2007) showed that mean effect of different FYM and gypsum combinations showed significant results on plant height, number of effective tiller $hill^{-1}$, number of grains $panicle^{-1}$, grain and straw yield of rice. The tallest plant (105.50cm) was observed from the treatment S_2, where the plant received FYM 5 tha^{-1} + Gypsum 210 $kgha^{-1}$ and the shortest plant of 97.00cm height was found in control treatment.

Ullah *et al.* (2007) found that combined application of inorganic, for instance gypsum, and organic amendments, like farm manure and humic acid, improves their effectiveness for increasing soil properties.

Manzoor *et al.* (2008) stated that increased grain yield of rice with split applying of potash in T5 may be due to continuous supply of K to crop during crop growth stages. The efficient potash uptake by rice plant results in better growth and development when applied at maximum tillering stage (25 DAT) and at panicle initiation stage (45 DAT).

Hasanuzzaman *et al.* (2009) reported that application of USG @ 75 kg N ha G_1 gave the highest thousand grain weight and straw yield.

Ghasem *et al.* (2009) investigated the effect of biological phosphate fertilizer (fertile 2) on the yield of tomato and showed that the treatment with consumption of 200 g ha^{-1} phosphate (fertile 2) had a higher yield than the treatment with consumption of 100 g/ha phosphate (fertile 2).

Hao *et al.* (2009) conducted an experiment on the effects of P fertilizer level on distribution of Fe, Mn, Cu and Zn and brown rice qualities in rice (*Oryza sativa* L.) observed that the protein content of brown rice increased, amylose content decreased, gel consistency elongated, and the nutritional quality improved if additional P fertilizer was applied.

Zhang *et al.* (2009) reported that with even high nitrogen applications in aerobic rice, grain filling may be limited by a low contribution of post-anthesis assimilates. Lampayan *et al.* (2010) found that nitrogen fertilization and proper time of its application is the major agronomic practice that affects the yield and quality of rice crop, which requires as much as possible at an early and mid tillering stages to maximize panicle numbers and during reproductive stages to produce more number of spikelets per panicle and percentage filled spikelets. Lafayette *et al.* (2009) reported that gypsum did not cause any significant change on the soil pH in acidic soils.

Thind *et al.* (2010) found nitrogen absorption and its subsequent utilization in plants with neem cake coated urea resulted in to higher growth, yield of transplanted rice over prilled urea and other slow release modified urea fertilizers.

Bera *et al.* (2010) showed that the number of effective tillers hill^{-1} increased gradually due to increasing level of nitrogen application up to N_{150}. The maximum number of effective tillers hill^{-1} (20.03 and 22.14) was recorded in crop receiving nitrogen 150 kg ha^{-1} as compared to 0, 50, 100 and 200 kg ha^{-1} respectively.

Shibu *et al.* (2010) reported that with increasing nitrogen fertilizer in rice, total dry weight was raised.

Masum *et al.* (2010) reported that placement of N fertilizer in the form of USG @ 58 kg N ha G1 produced the highest filled grains panicle^{-1}, grain yield and straw yield.

Ghorbani (2010) stated that the use of biological phosphate fertilizer (fertile 2) increased the number of grains per row in different maize cultivars which was consistent with the findings of the research.

Zafarian *et al.* (2011) stated that application of triple superphosphate in safflower (Goldasht cultivar) allocated 36 grains per boll to the plant.

Cha-um *et al.* (2011) found that in addition, the low sodium ion accumulation in gypsum and FYM treated rice was positively related to water use efficiency and pigment stabilization, leading to high efficiency of photosystem II (ΦPSII), and net-photosynthetic rate (Pn). The sugar content in the flag leaf of rice cultivated with gypsum and FYM treatment was enriched, leading to high productivity.

Devi and Sumathi (2011) reported that application of optimum nitrogen within the time interval of 20 days during grand vegetative stage might have induced the more number of tillers m^{-2}.

Reddy *et al.* (2012) found that nitrogen is associated with protoplasm synthesis and vigorous vegetative growth due to increased cell division and cell elongation. Hence application of nitrogen resulted in the significant increase in plant height at early stage of crop growth.

Parhizkar *et al.* (2012) reported in a research that the effect of triple superphosphate on the number of grains per capsule was significant at 1% level which was consistent with the results of the research. The highest number of grains per capsule belonged to the treatment with application of 40 kg/ha phosphorus which was different from the results of the research that referred to the increasing trend of the number of grains per capsule influenced by the increase of triple superphosphate fertilizer.

Verma *et al.* (2012) stated that the combined application of farm manure and mineral fertilizer could induce an increase in the humus content, nitrogen, and available phosphorus and potassium levels.

Rosen's Inc (2012) stated that P_2O_5-Max® increases P uptake and improves root surface area resulting in better nutrient absorption and higher yields.

Hasanuzzaman *et al.* (2012) reported the response of hybrid rice to different levels of nitrogen and phosphorus. There were six nitrogen fertilizer levels viz., 0,80, 120, 160, 200 kg N ha^{-1},urea super granules @ 75 kg N ha^{-1} and four phosphorus fertilizer levels viz., 0, 30, 50 and 70 kg P_2O_5 ha^{-1}. Results indicated that the effect of nitrogen and phosphorus showed significant variation in respect of yield contributing characters and yield. Phosphorus at 50 kg P_2O_5 gave the highest grain yield (7.85 t ha^{-1}).

Yosef Tabar (2012) reported that application nitrogen and phosphorus fertilizer on growth and yield resulted showed tiller number, fertile filler, total grain, 1000 grain weight and yield increase by application of N-fertilizer.

Zhang *et al.* (2012) investigated how upland and paddy japonica rice responded to phosphorous (P) fertilizer under two cultivation methods. The upland rice Zhonghan 3 and the paddy rice Yangfujing 8 were both grown under moist cultivation (MC, control) and bare dry cultivation (DC) with three P levels, low (LP, 45 kg m-^{2}), normal (NP, 90 kg m^{-2}) and high (HP, 135 kg m^{-2}). As P level increased, grain yields of both upland and paddy rice increased under DC. DC head milled rice rate and appearance quality of both upland and paddy rice, and cooking and nutrient qualities of paddy rice. With paddy rice, upland rice had better processing, nutrient and eating qualities. The results suggest that upland and paddy rice respond differently to cultivation method and phosphorus level.

Rahmatullah *et al.* (2007) conducted an experiment to evaluate the effect of phosphorus application on wheat and rice yield under wheat- rice system. The basal dose of N at 120 kg and K_2O at 60 kg ha^{-1} was applied with P levels (0, 45and 90 kg P_2O_5 ha^{-1}) to both wheat and rice crops. 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.

Haque *et al.* (2015) found that due to the interaction effect of both FYM and gypsum combinations and N levels, the maximum grain yield of rice was found as 4.39 t ha^{-1} under the treatment combination of $S_2 N_4$, i.e., FYM @ 5 tha^{-1} and gypsum 210 $kgha^{-1}$along with 125 kg Nha^{-1}.

Chapter 3

MATERIALS AND METHODS

This chapter presents a brief description about experimental period, site description, climatic condition, crop or planting materials, treatments, experimental design and layout, crop growing procedure, fertilizer application, uprooting of seedlings, intercultural operations, data collection and statistical analysis. The details of the materials and methods have presented below:

3.1 Description of the experimental site

3.1.1 Location

The field experiment was conducted at the Agronomy field laboratory, Sher-e-Bangla Agricultural University, Dhaka during the period from July to December, 2013. The location of the experimental site has been shown in Appendix I

3.1.2 Soil

The soil of the experimental area belonged to the Modhupur tract (AEZ No. 28). It was a medium high land with non-calcarious dark grey soil. The pH value of the soil was 5.6. The physical and chemical properties of the experimental soil have been shown in Appendix III

3.1.3 Climate

The experimental area was under the subtropical climate and was characterized by high temperature, high humidity and heavy precipitation with occasional gusty winds during the period from April to September, but scanty rainfall associated with moderately low temperature prevailed during the period from October to March. The detailed meteorological data in respect of air temperature, relative humidity, rainfall and sunshine hour recorded by the meteorology center, Dhaka for the period of experimentation have been presented in Appendix II

3.1.4 Physical and Chemical properties of initial soil (0 to 15 cm depth)

Characteristics	Value
Partical size analysis	
% 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 (Soil Resource Development Institute), Farmgate, Dhaka.

3.2 Variety used

Transplant aman rice cultivars viz., BRRI dhan54 is used as experimental crop.

Its salient feature is stated below:

BRRI dhan54 is generally grown in aman season in saline prone areas. It is an advance line and salt tolerant. This variety was released in 2010.This variety matures at 135 days of transplanting. It attains a plant height of 115 cm. The variety gives an average yield of 5.5 t ha^{-1}. It protein and amylase contents are 7 and 24.7 respectively. It can tolerate 8-10 ds m^{-1} salt. Its grain size medium coarse.

3.3 Experiment details

3.3.1 Treatments

i. T_1= Control
ii. T_2= Recommended Dose of NPK
iii. T_3= Green manure +1/2 Recommended Dose of NPK
iv. T_4= Green manure +2/3 Recommended Dose of NPK
v. T_5= Poultry manure +1/2 Recommended Dose of NPK
vi. T_6= Poultry manure +2/3 Recommended Dose of NPK
vii. T_7= Cowdung +1/2 Recommended Dose of NPK
viii. T_8= Cow dung +2/3 Recommended Dose of NPK
ix. T_9= Quick compost +1/2 Recommended Dose of NPK
x. T_{10}= Quick compost +2/3 Recommended Dose of NPK
xi. T_{11}= Vermi compost +1/2 Recommended Dose of NPK
xii. T_{12}= Vermi compost +2/3 Recommended Dose of NPK
xiii. T_{13}= Magic growth +1/2 Recommended Dose of NPK
xiv. T_{14}= Magic growth +2/3 Recommended Dose of NPK

3.4 Design and layout

The experiment was laid out in a RCBD (Randomized Completely Block Design) with three replications. The size of the individual plot was 4m×4m and total numbers of plot were 42. There were 14 treatment combinations. Each block was divided 14 unit plots. The layout of the experiment was done keeping inter block and inter plot spacing of 1m and 1m, respectively.

3.5 Crop cultivation

3.5.1 Seedling raising

Rice seeds BRRI dhan54 was collected from the Bangladesh Rice Research Institute, Joydebpur, Gazipur. Seeds were soaked in water for 24 hours and then incubated for 48 hours. Nursery bed was prepared and sprouted seeds were sown in the wet nursery bed on 7 July 2013. Proper care was taken to raise the seedlings in the nursery bed. No manuring and fertilization was done, but irrigation was done and weeds were removed from the nursery bed as and when necessary.

3.5.2 Land preparation

The experimental field was first opened on 26 June 2013, by a tractor drawn disc plough. First Ploughing was done on 1 July 2013 and another was done in 14 July 2013.The land was irrigated on 7 July 2013. Later on, the land was puddle thoroughly by ploughing and cross ploughing for 3 times with a country plough followed by laddering to level the land. Weeds and stubble were removed from the land and thus the land was made ready for transplanting. Field layout was done on 7 July 2013.

3.5.3 Application of fertilizer and manures

Recommended dose of NPK (Urea 149kg, TSP 52 kg Mop 82 kg, Gypsum 59 kg ha^{-1} were applied two days before transplanting. Urea was applied in three split dose at 7, 28, days after transplanting and before panicle initiation. Daincha (15t ha^{-1}) was incorporate before 10 days before transplanting and allow them rotten. Quick compost (0.7t ha^{-1}), Vermicompost (4t ha^{-1}), Cow dung (10t ha^{-1}), Poultry manure (5t ha^{-1}) was applied 5 days before transplanting. Magic Growth was applied 1.6 L $decimal^{-1}$ in the evening, three times and 15 days interval.

3.5.4 The uprooting and transplantation of seedlings

Seedlings were raised on nursery bed and 27 days old seedlings were transplanted on 4 August in 2013 by maintaining a space of 15cm between hills and 25 cm between rows. Necessary gap filling was done at 7 days after transplanting

3.5.5 Intercultural operations

The crops were kept under constant observations from transplanting to harvesting. Intercultural operations such as weeding, irrigation, pest management and other necessary cultural operations were done for proper growth and development of the crops. Three weeding done on 10, 30, 45 days after transplanting to keep the crops free from weeds. Irrigation was as per crop need. The crop was infested with leaf roller at 60 days after transplanting and was controlled by spraying Malathion 57 EC @ 1L ha^{-1}. The crop also infested with stem borer at 75 days after transplanting and was controlled by spraying Diazinon 60EC @ 1L ha^{-1} successive two sprays at seven day intervals were required to control them.

3.6 Harvesting, processing and data collection

3.6.1 Growth data

Five sample plants were selected at random from each plot and tagged them for taking growth data. Following data were recorded

1. Plant height (cm)

2. Tillers number hill^{-1}

3. Dry weight hill^{-1} (g)

4. Leaf number and leaf length

3.6.2 Yield contributing characters and yield data

Five hills from each plot were collected prior to harvesting and taken out for studying yield attributes. The crop was harvested plot wise on the basis of their maturity. The crop was harvested when 80% spikelets were matured. An area of 1m^2 was harvested for measurements of gain and straw yields. The harvested crops were threshed, cleaned, dried, weighed and necessary data were collected on various crop characters. The following data were recorded

1. Effective tiller hill^{-1}
2. Non effective tiller hill^{-1}
3. Panicle length
4. Filled grain panicle^{-1}
5. Unfilled grain panicle^{-1}
6. 1000 grain weight

3.6.3 Yield and harvest index data

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

3. Biological yield (t ha^{-1})

4. Harvest index (%)

3.7 Procedures of data collection

3.7.1 Plant height

The height of the plant was taken from the five selected hills at the time of 15, 30, 45, 60, 75, 90 and at harvest. Plant height was measured from the ground level to the top of the leaf of plant. The average height of five hills was considered the height of the plant for each plot. The height was expressed in (cm).

3.7.2 Tillers number $hill^{-1}$

Total numbers of tillers were counted from the selected hills at the time 15, 30, 45, 60, 75, 90 and at harvest. The tillers obtained from five hills were averaged to have tillers $hill^{-1}$.

3.7.3 Dry weight $hill^{-1}$

Three sample hills uprooted from each plot unbiasly wash them in water and then dried them in an electric oven maintaining 90 C for 72 hours. Then the hills were weighed in an electric balance and averaged them to have dry weight $hill^{-1}$.

3.7.4 Effective and non effective tillers $hill^{-1}$

The numbers of tillers from the five sample hills were counted. The tillers having panicles with at least one grain were considered as effective tillers. On the other hand, tillers having no panicle were regarded as non effective tillers.

3.7.5 Panicle length

Panicle length was recorded from the basal nodes of the rachis to apex of each panicle.

3.7.6 Filled grain $panicle^{-1}$ and unfilled grain $panicle^{-1}$

Presence of any food material in the spikelet was considered as grain. On the other hand lack of food material in the spikelet is considered as unfilled grain.

3.7.7 1000 grain weight

One thousand grains were randomly collected from the seed stock obtained from plants of each plot and were dried in air weigh them in electric balance. The weight was adjusted at 14% moisture content and expressed in grams (gm).

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

Plants of central $1m^2$ area were harvested and grains were separated from the plant. The grains were cleaned and dried properly in the sun. After drying the weight of the grain was measured and the weight was converted as t ha^{-1}. The grain weight was adjusted at 14% moisture content and expressed in t ha^{-1}.

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

Straw from $1m^2$ areas of each plot was weighed after repeated drying and expressed in t ha^{-1}.

3.7.10 Biological yield (t ha^{-1})

Grain yield and straw yield were altogether regarded as biological yield and expressed in t ha^{-1}. The biological yield was calculated with the following formula:

Biological yield = Grain yield + straw yield.

3.7.11 Harvest Index (%)

Harvest index was calculated from the Grain yield and straw yield and expressed in percentage (%) using the following formula:

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

3.8 Economic analysis

From beginning to ending of the experiment, individual cost data on all the heads of expenditure in each treatment were recorded carefully and classified under different head cost of production. The rates of different items in transplanted aman rice were given in Appendix

3.8.1 Input cost

Input costs were divided into two parts. These are as follows:

3.8.1.2 A. Non-material cost (labor)

The human labor was obtained from adult male laborers. Eight working hours of a laborer was considered as a man day. The mechanical labor came from tractor. Eight working hours of a tractor was considered as a tractor day.

3.8.1.3 B. Material cost

The seed of aman rice BRRIdhan54 was purchased from BRRI headquarter @ 100 per kg. Urea, TSP, MP, Gypsum, Zinc sulphate, pesticide were collected from authorized dealer. Irrigation was done at SAU irrigation channel facilities.

3.8.1.4 Overhead cost

The interest on input cost was calculated for 6 months @Tk. 12.5% per year based on the interest rate of the Bangladesh Krishi Bank. The value of land was vary from place to place and year to year. In the study the value of land was taken Tk.200000 per hectare. The interest on the value of land was calculated @ 12.5% per year for 2 months for nursery and 4 months for main field.

3.8.1.5 Miscellaneous overhead cost

It was arbitrarily taken to be 5% of the total running capital.

3.8.1.6 Gross return

Gross return from transplanted *aman* rice cultivation (Tk.ha^{-1}) = value of grains (Tk.ha^{-1}) +Value of straw (Tk.ha^{-1}).

3.8.1.7 Net return

Net return was calculated by using the following formula:

Net return (Tk.ha^{-1}) =Gross return (Tk.ha^{-1}) – Total cost of production (Tk.ha^{-1})

3.8.1.8 Benefit cost ratio (BCR)

Benefit cost ratio indicated whether the cultivation is profited or not which was calculated as follows:

$$\text{Benefit cost ratio (BCR)} = \frac{Gross\ return\ (Tk.perha)}{Cost\ of\ production\ \ (Tk.per\ ha)}$$

3.9 Statistical analysis

The data were compiled and tabulated in proper form for statistical analysis. Analysis of variance was done following the experimental design with the help of computer package program XLSTAT 2014 (Addin Soft, 2014). The mean differences among the treatments were adjusted by Least Significance Difference (LSD).

Chapter 4

RESULT AND DISCUSSION

The experiment was conducted to find out a suitable combination of organic manure and chemical fertilizer for aman rice cultivation. The results of the present investigation have been presented, discussed and compared as far as possible with the results of the researchers.

4.1 Plant height (cm)

From the study it was observed that plant height of rice cv. BRRI dhan54 was significantly affected by the manure treatments regardless the crop duration (Table 1). At 75 DAT plant attained maximum height (122.65cm) with T_{14} treatment (magic growth +2/3 recommended dose of NPK) and minimum plant height was observed (91 cm) in untreated treatment. However, the expansion rate of plant height was more between 60 DAT and 75 DAT as it was the maximum vegetative stage in rice plant. Therefore, it was clear that plant height at 75 DAT was highest, after that it was gradually decreasing because of leaf senescence, dry matter partitioning in grain. The variation in plant height due to nutrient sources was considered to be due to variation in the availability of major nutrients. Chemical fertilizer offers nutrients which are readily soluble in soil solution and thereby instantaneously available to plants. Nutrient availability from organic sources is due to microbial action and improved physical condition of soil. These results were supported by Sarker *et al.* (2004). Magic growth is liquid nitrogenous fertilizer and helps to increase plant height (Singh and Singh 1986). Alam (2002) reported that the positive effect of USG level on plant height in rice.

Table 1. Effect of treatment on Plant height (cm) of T.aman rice. Values in a column with different letters are significantly different at $p \leq 0.05$ applying LSD.

Treatment	Plant height(cm)					
	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	Harvest
T_1	53.00 d	62.50g	83.67f	91.00f	85.00d	80.00e
T_2	58.77ab	89.67bc	116.33bc	119.67b	109.50b	106.00b
T_3	57.00abc	81.83f	110.67e	116.50cde	106.17c	101.00d
T_4	56.90abc	87.00cde	113.13de	115.83e	106.67bc	99.67d
T_5	56.13bc	90.67ab	113.67cd	118.17bcde	108.33bc	101.83cd
T_6	57.33abc	86.17de	115.83bcd	117.87bcde	107.17bc	101.13d
T_7	58.00abc	89.67bc	116.00bcd	117.17bcde	108.00bc	101.17d
T_8	55.67cd	84.50ef	116.33bc	115.67e	108.33bc	102.33bcd
T_9	57.67abc	90.33ab	115.00bcd	118.67bcd	107.00bc	101.67cd
T_{10}	58.83ab	85.17e	117.83b	116.33de	108.83bc	102.67bcd
T_{11}	58.17abc	89.00bcd	116.33bc	119.33b	109.17b	102.67bcd
T_{12}	58.33abc	87.33cde	117.67b	119.17bc	106.17c	103.00bcd
T_{13}	59.20a	87.17cde	117.33b	119bc	108.67bc	105.670bc
T_{14}	59.53a	92.97a	121.83a	122.67a	117.00a	115.17a
LSD(0.05)	2.76	2.88	2.90	2.74	2.98	4.07
CV (%)	6.4	7.00	7.5	6.8	5.5	6.00

T_1=Control
T_2=Recommended Dose of NPK
T_3=Green manure + 1/2 recommended dose of NPK
T_4= Green manure + 2/3 recommended dose of NPK
T_5=Poultry manure + 1/2 recommended dose of NPK
T_6= Poultry manure + 2/3 recommended dose of NPK
T_7=Cowdung + 1/2 recommended dose of NPK
T_8= Cowdung + 2/3 recommended dose of NPK
T_9=Quick compost + 1/2 recommended dose of NPK
T_{10}= Quick compost + 2/3 recommended dose of NPK
T_{11}=Vermicompost + 1/2 recommended dose of NPK
T_{12}= Vermicompost + 2/3 recommended dose of NPK
T_{13}= Magic growth + 1/2 recommended dose of NPK
T_{14}== Magic growth + 2/3 recommended dose of NPK

4.2 Tillers number hill^{-1}

There were significant differences among the treatment on the probability level of 5% (Table 2). At 75 DAT highest number of tillers hill^{-1} (14.93) was counted from T_{12} treatment (vermicompost +2/3 recommended dose of NPK) and the minimum number of tillers hill^{-1} (10.16) was counted by control . At initial stages tiller number was not remarkably influenced by the treatments because of the slower activity of nutrients. After that 30 DAT tiller numbers were linearly increased up to 75 DAT. Number of total tillers hill^{-1} varied significantly due to fertilizers and manures treatment throughout the growing season. In general, fertilizers and manures applied plot increased the number of total tillers hill^{-1} over control (without fertilizer). But after the counting from 75 DAT tiller number was found decreased. It was due to the tiller mortality and the senescence of plants. Miller (2007) mentioned that organic sources offer more balanced nutrition to the plants, especially micro nutrients which has caused better affectivity of tiller in plants grown with poultry manure and vermicompost. This result was partially supported by Rakshit *et al.* (2008). The gradual betterment in the formation of tillers with different fertilization might be due to increased nutrients uptake which enhanced tillering. Ahmed and Rahman (1991) reported that combined application of organic manure and chemical fertilizers increased the tiller of rice plant

Table 2. Effect of treatment on Tiller number $hill^{-1}$ of T.aman rice. Values in a column with different letters are significantly different at $p \leq 0.05$ applying LSD.

Treatment	Tiller number $hill^{-1}$					
	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	Harvest
T_1	5.07g	7.27i	9.27f	10.17g	8.33i	6.83g
T_2	7.40b	9.40b	11.40b	14.20b	12.30b	9.83a
T_3	6.67d	8.73cde	10.73cd	13.07d	11.00cdef	8.80cd
T_4	6.80cd	8.77cde	10.77cd	13.47c	11.40c	9.33b
T_5	6.83cd	8.03gh	10.03e	12.33f	10.43gh	7.77f
T_6	6.13f	8.27fg	9.93e	12.57ef	10.63fgh	8.50de
T_7	6.57de	8.43ef	10.43d	13.00d	10.77efg	8.23ef
T_8	7.10bc	8.80cd	10.80cd	13.50c	11.33cd	9.00bc
T_9	6.47def	8.03gh	10.03e	12.40f	10.73efg	8.60cde
T_{10}	6.27ef	8.60cdef	10.60cd	12.90de	11.23cd	8.47de
T_{11}	6.83cd	8.93c	10.93c	13.43c	10.93def	8.53cde
T_{12}	7.93a	10.07a	12.20a	14.93a	12.93a	10.17a
T_{13}	6.13f	7.83h	9.83e	12.27f	10.27h	8.17ef
T_{14}	6.53de	8.57def	10.57cd	12.93d	11.10cde	8.83cd
LSD(0.05)	0.37	0.35	0.37	0.35	0.42	0.47
CV (%)	5.65	6.80	7.5	6.5	6.00	7.3

T_1=Control
T_2=Recommended Dose of NPK
T_3=Green manure + 1/2 recommended dose of NPK
T_4= Green manure + 2/3 recommended dose of NPK
T_5=Poultry manure + 1/2 recommended dose of NPK
T_6= Poultry manure + 2/3 recommended dose of NPK
T_7=Cowdung + 1/2 recommended dose of NPK
T_8= Cowdung + 2/3 recommended dose of NPK
T_9=Quick compost + 1/2 recommended dose of NPK
T_{10}= Quick compost + 2/3 recommended dose of NPK
T_{11}=Vermicompost + 1/2 recommended dose of NPK
T_{12}= Vermicompost + 2/3 recommended dose of NPK
T_{13}= Magic growth + 1/2 recommended dose of NPK
T_{14}== Magic growth + 2/3 recommended dose of NPK

4.3 Total dry matter production

Dry matter is the material which was dried to a constant weight. Total dry matter production indicates the production potential of a crop. A high dry matter production is the prerequisite for high yield. At initial stages the differences of dry weight of plant was significant. However, the treatments T_{12} produced the highest dry weight in rice plant compared to other treatments at any growth stages. At 90 DAT T_{12} treatment (vermicompost +2/3 recommended dose of NPK) was attained highest dry matter (48.76) compare to the other treatment, but lowest dry matter was attained (35.60) by control. The rapid increase of dry matter was observed between 75 DAT and 90 DAT (Table 3). It was due to the maximum growth and tillering of plant. After 75 DAT although tillers mortality and senescence occurred but reproductive parts contributed a considerable amount of dry matter in plant. Rahman *et al.* (2007) expressed the production of maximum dry matter with proper manuring might be accounted for the luxuriant growth of plant as well as higher number of tillers plant^{-1}

Table 3. Effect of treatment on Dry weight (gm) of T.aman rice. Values in a column with different letters are significantly different at $p \leq 0.05$ applying LSD.

Treatment	**Dry weight (gm)**				
	30 DAT	**45 DAT**	**60 DAT**	**75 DAT**	**90 DAT**
T_1	3.78i	11.52g	18.50i	28.92f	35.60g
T_2	6.13b	18.99b	26.30b	36.17bc	42.50bc
T_3	5.14def	13.77f	23.57efg	34.48de	40.13cdef
T_4	6.13b	14.11f	21.00h	34.75de	41.50bcde
T_5	5.32de	18.63bc	22.67g	35.64bcd	42.33bc
T_6	5.48cd	17.03d	23.00fg	34.70de	41.83bcd
T_7	4.39h	19.10b	25.30bcd	35.57bcd	39.30def
T_8	4.91efg	18.35bc	24.83cde	34.03e	41.83bcd
T_9	6.24ab	15.77e	23.13fg	35.33cde	41.67bcde
T_{10}	4.61gh	17.50cd	25.47bc	36.50abc	41.83bc
T_{11}	6.19b	18.70b	26.50b	36.83ab	43.83b
T_{12}	6.66a	20.67a	28.83a	37.83a	48.77a
T_{13}	4.73fgh	16.72de	24.17def	36.83ab	38.67f
T_{14}	5.92bc	18.93b	25.90bc	37.67a	39.00ef
$LSD_{(0.05)}$	0.46	1.13	1.29	1.41	2.75
CV (%)	6.5	7.7	8.4	7.5	5.45

T_1=Control
T_2=Recommended Dose of NPK
T_3=Green manure + 1/2 recommended dose of NPK
T_4= Green manure + 2/3 recommended dose of NPK
T_5=Poultry manure + 1/2 recommended dose of NPK
T_6= Poultry manure + 2/3 recommended dose of NPK
T_7=Cowdung + 1/2 recommended dose of NPK
T_8= Cowdung + 2/3 recommended dose of NPK
T_9=Quick compost + 1/2 recommended dose of NPK
T_{10}= Quick compost + 2/3 recommended dose of NPK
T_{11}=Vermicompost + 1/2 recommended dose of NPK
T_{12}= Vermicompost + 2/3 recommended dose of NPK
T_{13}= Magic growth + 1/2 recommended dose of NPK
T_{14}== Magic growth + 2/3 recommended dose of NPK

4.4 Effective tillers $hill^{-1}$

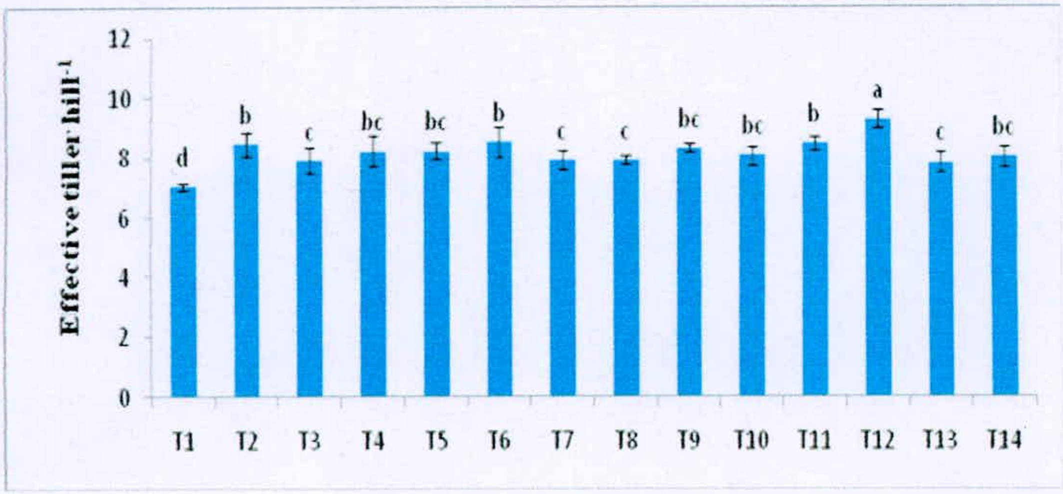

Figure 1. Effect of treatment on effective tiller $hill^{-1}$ of T. aman rice. Bars with different letters are significantly different at $p \leq 0.05$ applying LSD.

T_1=Control
T_2=Recommended Dose of NPK
T_3=Green manure + 1/2 recommended dose of NPK
T_4= Green manure + 2/3 recommended dose of NPK
T_5=Poultry manure + 1/2 recommended dose of NPK
T_6= Poultry manure + 2/3 recommended dose of NPK
T_7=Cowdung + 1/2 recommended dose of NPK
T_8= Cowdung + 2/3 recommended dose of NPK
T_9=Quick compost + 1/2 recommended dose of NPK
T_{10}= Quick compost + 2/3 recommended dose of NPK
T_{11}=Vermicompost + 1/2 recommended dose of NPK
T_{12}= Vermicompost + 2/3 recommended dose of NPK
T_{13}= Magic growth + 1/2 recommended dose of NPK
T_{14}== Magic growth + 2/3 recommended dose of NPK

Results reveals that the effective tillers varied significantly because of fertilizers and manures treatment. It was observed from the (Fig 1) that highest effective tiller was produced (9.26) by the T_{12} treatment (vermicompost +2/3 recommended dose of NPK) and the lowest effective tiller was produced (7.06) by the T_1 treatment (control). In case of control treatment there was deficiency of N and other essential nutrients which was required for tiller production while the other treatments supplied it which rendering the higher number of tillers.

Similar findings were reported by Tanaka (1968). The productivity of rice plant is greatly dependent on the number of productive tiller (tillers which bears panicle) rather than the total tiller numbers.

4.5 Non effective tillers hill^{-1}

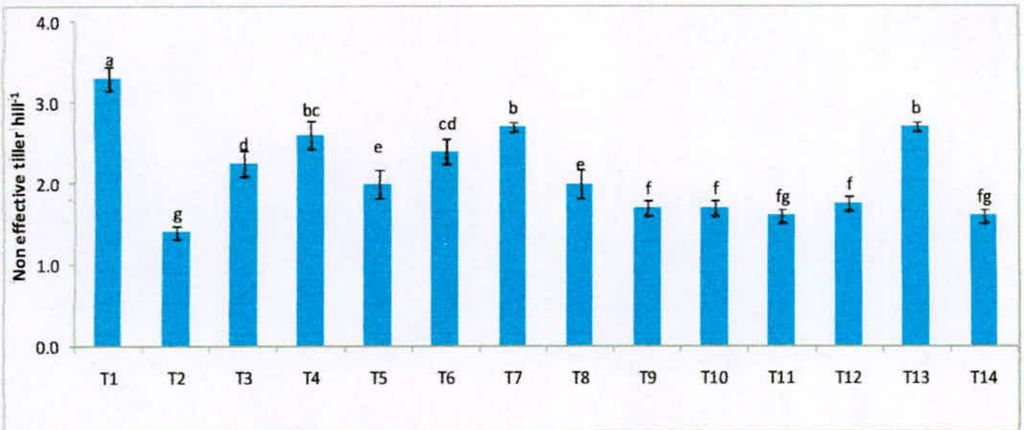

Figure 2. Effect of treatment on non effective tiller hill^{-1} of T. aman rice. Bars with different letters are significantly different at $p \leq 0.05$ applying LSD.

T_1=Control
T_2=Recommended Dose of NPK
T_3=Green manure + 1/2 recommended dose of NPK
T_4= Green manure + 2/3 recommended dose of NPK
T_5=Poultry manure + 1/2 recommended dose of NPK
T_6= Poultry manure + 2/3 recommended dose of NPK
T_7=Cowdung + 1/2 recommended dose of NPK
T_8= Cowdung + 2/3 recommended dose of NPK
T_9=Quick compost + 1/2 recommended dose of NPK
T_{10}= Quick compost + 2/3 recommended dose of NPK
T_{11}=Vermicompost + 1/2 recommended dose of NPK
T_{12}= Vermicompost + 2/3 recommended dose of NPK
T_{13}= Magic growth + 1/2 recommended dose of NPK
T_{14}== Magic growth + 2/3 recommended dose of NPK

The non effective tillers varied significantly on account of fertilizers and manures treatment (Fig 2). The highest non effective tiller (1.10) was produced by the T_1 treatment and the lowest non effective tiller was produced (0.46) by the T_2 treatment. The number of non-effective tillers were also lower with proper fertilization. From this study it was observed that excess application of inorganic fertilizers is not necessary to produce effective tillers if we can supplement it with organic manures. However, organic sources offer more balanced nutrition to the plants, especially micro nutrients which has caused better affectivity of tiller in plants grown with poultry manure and vermicompost (Miller, 2007). This result was also supported by Ayoub (1999), Uddin *et al.* (2002) and Rakshit *et al.* (2008).

4.6 Panicle length (cm)

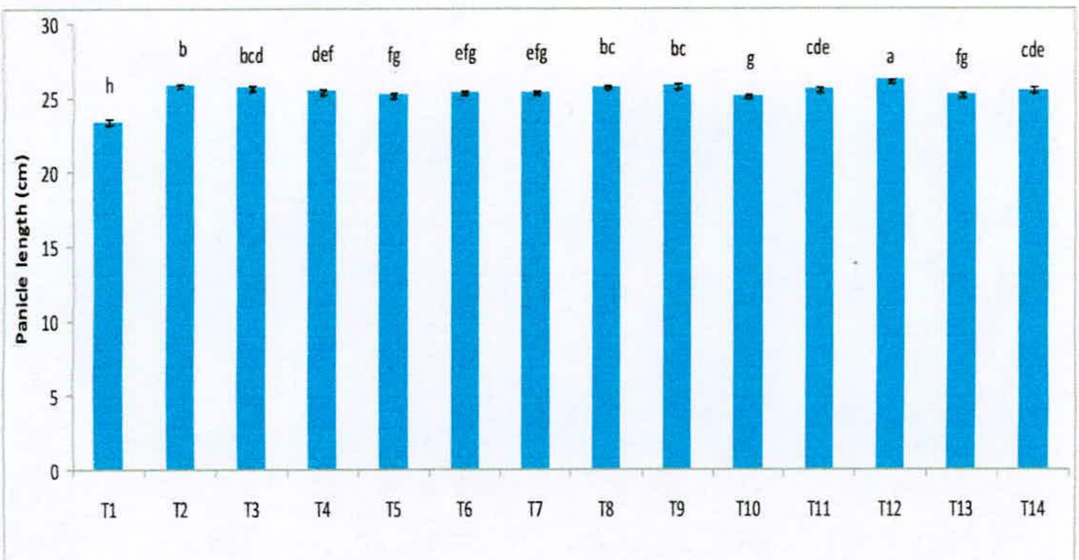

Figure 3. Effect of treatment on Panicle length (cm) of T. aman rice. Bars with different letters are significantly different at $p \leq 0.05$ applying LSD

T_1=Control
T_2=Recommended Dose of NPK
T_3=Green manure + 1/2 recommended dose of NPK
T_4= Green manure + 2/3 recommended dose of NPK
T_5=Poultry manure + 1/2 recommended dose of NPK
T_6= Poultry manure + 2/3 recommended dose of NPK
T_7=Cowdung + 1/2 recommended dose of NPK
T_8= Cowdung + 2/3 recommended dose of NPK
T_9=Quick compost + 1/2 recommended dose of NPK
T_{10}= Quick compost + 2/3 recommended dose of NPK
T_{11}=Vermicompost + 1/2 recommended dose of NPK
T_{12}= Vermicompost + 2/3 recommended dose of NPK
T_{13}= Magic growth + 1/2 recommended dose of NPK
T_{14}== Magic growth + 2/3 recommended dose of NPK

Panicle length was influenced significantly due to fertilizers and manures treatment. The longest panicle (26.13) was recorded by T_{12} and shortest panicle was measured by control (Fig 3). Haque (1999) noted a significant increase in panicle length due to the application of organic manure and chemical fertilizers. Babu *et al.* (2001), Ahmed and Rahman (1991) and Apostol (1989) also reported similar results.

4.7 No. of filled grain panicle^{-1}

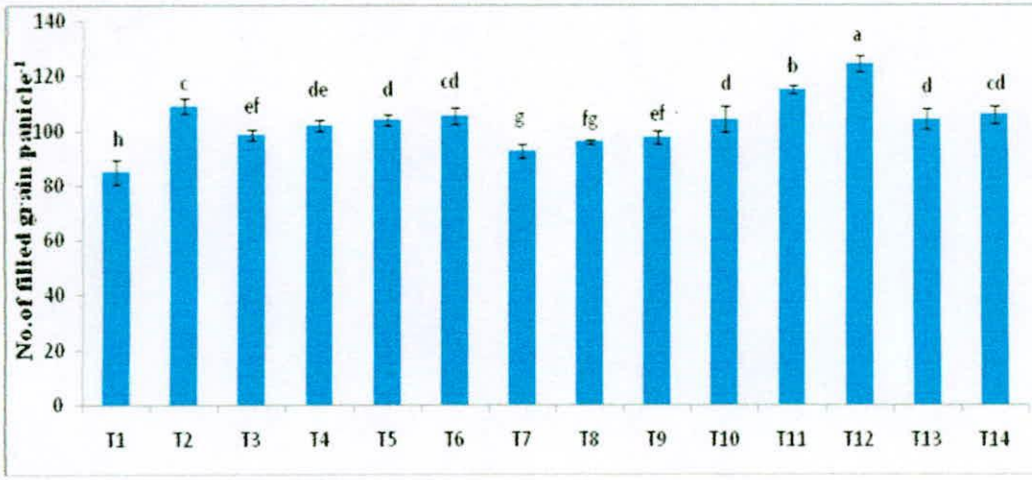

Figure 4. Effect of treatment on no. of filled grain panicle^{-1} of T. aman rice. Bars with different letters are significantly different at $p \leq 0.05$ applying LSD

T_1=Control
T_2=Recommended Dose of NPK
T_3=Green manure + 1/2 recommended dose of NPK
T_4= Green manure + 2/3 recommended dose of NPK
T_5=Poultry manure + 1/2 recommended dose of NPK
T_6= Poultry manure + 2/3 recommended dose of NPK
T_7=Cowdung + 1/2 recommended dose of NPK
T_8= Cowdung + 2/3 recommended dose of NPK
T_9=Quick compost + 1/2 recommended dose of NPK
T_{10}= Quick compost + 2/3 recommended dose of NPK
T_{11}=Vermicompost + 1/2 recommended dose of NPK
T_{12}= Vermicompost + 2/3 recommended dose of NPK
T_{13}= Magic growth + 1/2 recommended dose of NPK
T_{14}== Magic growth + 2/3 recommended dose of NPK

Significant variation was observed in filled grain due to the effect of manures and fertilizers treatment over the control (Fig 4). T_{12} produced the boost number of filled grains panicle^{-1} (124.33) and lowest number of filled grains panicle^{-1} (85) was produced by control. The effect of manure with chemical fertilizers on increasing the number of grains panicle^{-1} was more pronounced as compared to fertilizers. This might be due to more availability of nutrient from the manure. Grains panicle $^{-1}$ significantly increased due to the application of organic manures and chemical fertilizers (Razzaque, 1996). These results are also in agreement with Hoque (1999).

4.8 No. of unfilled grain panicle^{-1}

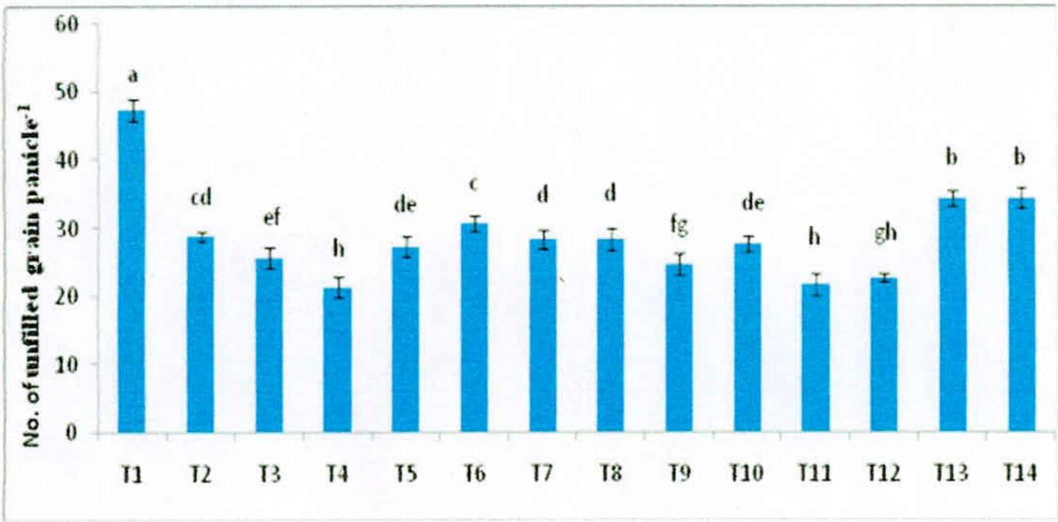

Figure 5. Effect of treatment on no. of unfilled grain panicle^{-1} of T. aman rice. Bars with different letters are significantly different at $p \leq 0.05$ applying LSD.

T_1=Control
T_2=Recommended Dose of NPK
T_3=Green manure + 1/2 recommended dose of NPK
T_4= Green manure + 2/3 recommended dose of NPK
T_5=Poultry manure + 1/2 recommended dose of NPK
T_6= Poultry manure + 2/3 recommended dose of NPK
T_7=Cowdung + 1/2 recommended dose of NPK
T_8= Cowdung + 2/3 recommended dose of NPK
T_9=Quick compost + 1/2 recommended dose of NPK
T_{10}= Quick compost + 2/3 recommended dose of NPK
T_{11}=Vermicompost + 1/2 recommended dose of NPK
T_{12}= Vermicompost + 2/3 recommended dose of NPK
T_{13}= Magic growth + 1/2 recommended dose of NPK
T_{14}== Magic growth + 2/3 recommended dose of NPK

Number of unfilled grains panicle^{-1}plays a vital role and it is the most important traits for yield production. Number of unfilled grains panicle^{-1} was significantly influenced by the different fertilization. The (Fig 5) shows that the highest number of unfilled grains panicle^{-1} (47.33) was obtained in the control treatment. The lowest number of unfilled grains panicle^{-1} (21.33) was obtained by T_4 which was statistically close with T_{12} treatment. In case of control treatment there was deficiency of N and other essential nutrients which was required for grain production while the other treatments supplied it which rendering the higher number of heaviest grain. Haque (1999) reported grain panicle^{-1} heavily depend on organic manures and NPK fertilization.

4.9 1000-grain weight

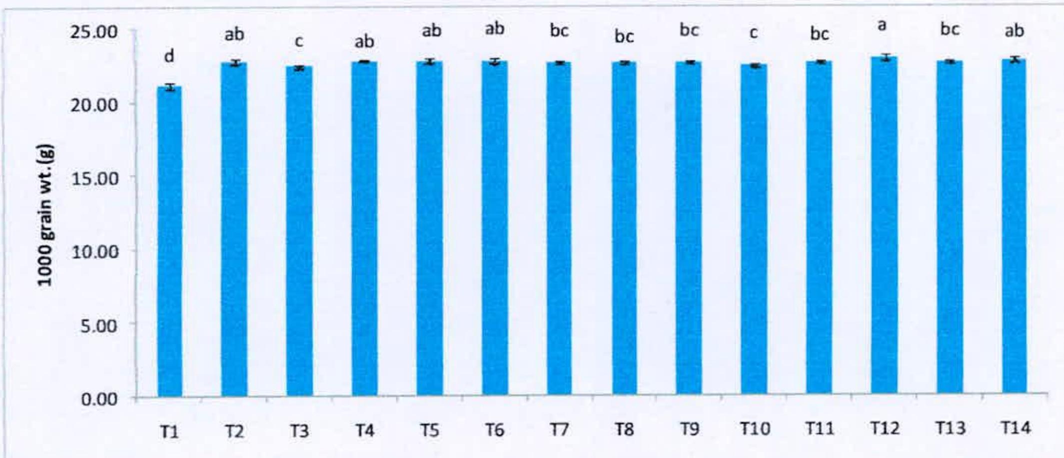

Figure 6. Effect of treatment on 1000 grain weight (g) of T. aman rice. Mean (±SD) was calculated from three replicates for each treatment. Bars with different letters are significantly different at $p \leq 0.05$ applying LSD.

T_1=Control
T_2=Recommended Dose of NPK
T_3=Green manure + 1/2 recommended dose of NPK
T_4= Green manure + 2/3 recommended dose of NPK
T_5=Poultry manure + 1/2 recommended dose of NPK
T_6= Poultry manure + 2/3 recommended dose of NPK
T_7=Cowdung + 1/2 recommended dose of NPK
T_8= Cowdung + 2/3 recommended dose of NPK
T_9=Quick compost + 1/2 recommended dose of NPK
T_{10}= Quick compost + 2/3 recommended dose of NPK
T_{11}=Vermicompost + 1/2 recommended dose of NPK
T_{12}= Vermicompost + 2/3 recommended dose of NPK
T_{13}= Magic growth + 1/2 recommended dose of NPK
T_{14}== Magic growth + 2/3 recommended dose of NPK

The weight of seed is related with the magnitude of seed development because it is an important yield determinant factor and plays a decisive role in expressions yield potential of a variety (Sana *et al.* 2003). It is evident from the Fig. 6 that 1000 seed weight greatly affect the yield. The highest 1000 grain weight (23gm) was obtained in the T_{12} treatment which was statistically similar with T_2, T_5, T_6 , T_4, T_{14}, but the lowest 1000 grain weight (21.33gm) was obtained by (control). Thousand grain weight is mostly mediated by genetic potential but in this case it declines significantly with single application of organic manures as well as with control treatment due to severe deficiency of essential nutrients and hence the plants failed to produce a bold grain. The increased values of yield attributes with the application of manures was due to the fact that use of green manures and other organic matter can improve soil structure, improve nutrient exchange and maintain soil health has again raised interest in organic farming (Becker *et al.*, 1995; Ayoub, 1999). Yang *et al.* (2004) recorded that 1000-grain weight was increased by the application of chemical fertilizer along with organic manure.

4.10 Straw yield

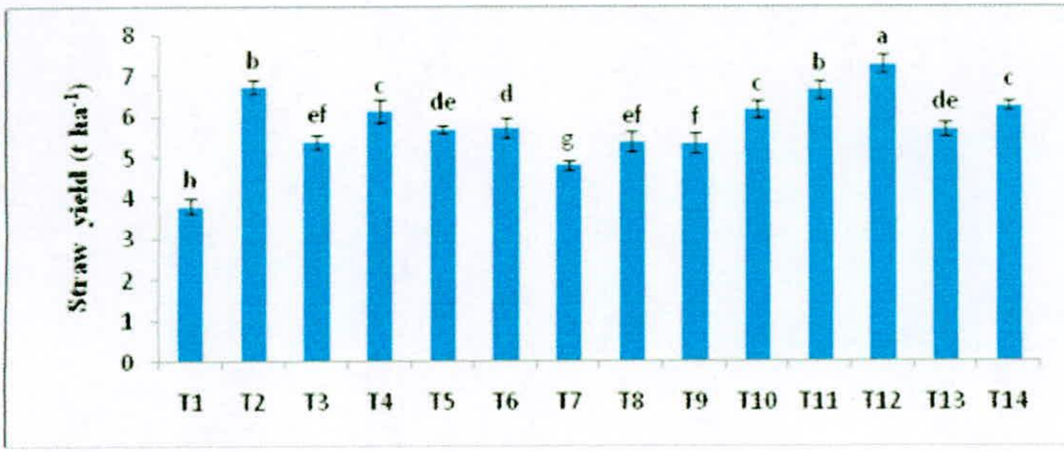

Figure 7. Effect of treatment on straw yield (t ha^{-1}) of T. aman rice. Bars with different letters are significantly different at $p \leq 0.05$ applying LSD.

T_1=Control
T_2=Recommended Dose of NPK
T_3=Green manure + 1/2 recommended dose of NPK
T_4= Green manure + 2/3 recommended dose of NPK
T_5=Poultry manure + 1/2 recommended dose of NPK
T_6= Poultry manure + 2/3 recommended dose of NPK
T_7=Cowdung + 1/2 recommended dose of NPK
T_8= Cowdung + 2/3 recommended dose of NPK
T_9=Quick compost + 1/2 recommended dose of NPK
T_{10}= Quick compost + 2/3 recommended dose of NPK
T_{11}=Vermicompost + 1/2 recommended dose of NPK
T_{12}= Vermicompost + 2/3 recommended dose of NPK
T_{13}= Magic growth + 1/2 recommended dose of NPK
T_{14}= Magic growth + 2/3 recommended dose of NPK

There was positive effect on account of fertilization and manure application on straw yield. Fig 7 indicated that, straw yield raised due to fertilizers and manures combination treatment over control. The superior straw yield (7.29 t ha^{-1}) was found in T_{12} treatment on the contrary inferior straw yield (3.80t ha^{-1}) was found from control. Mannan *et al.* (2000) reported that the application of organic manures and chemical fertilizers increased the straw yields of rice. These findings are well corroborated with the work of Islam (1997) and Khan (1998).

It is clear that combination of organic manures and inorganic fertilizers encouraged vegetative growth of plants and thereby increasing straw yield.

4.11 Grain yield

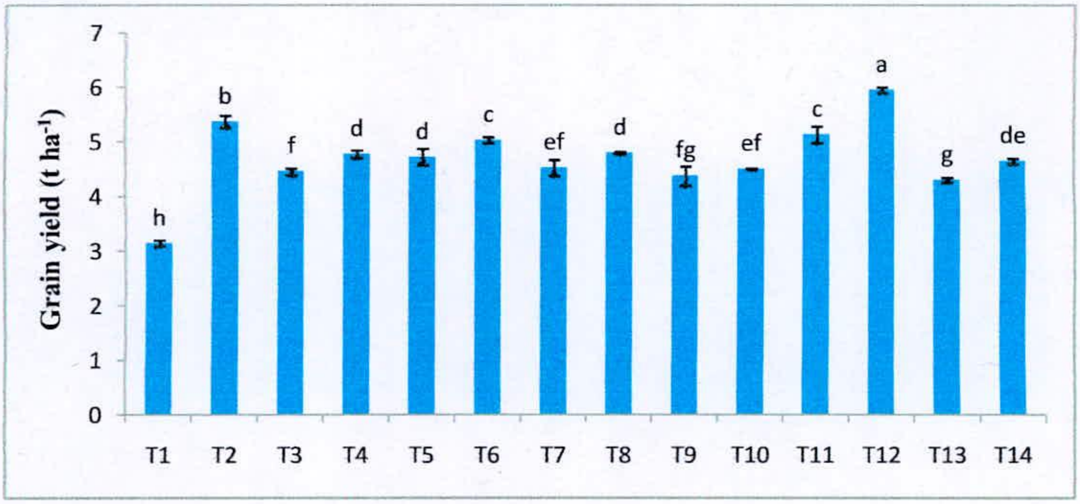

Fig 8: Effect of treatment on grain yield (t ha^{-1}) of T. aman rice. Bars with different letters are significantly different at $p \leq 0.05$ applying LSD.

T_1=Control
T_2=Recommended Dose of NPK
T_3=Green manure + 1/2 recommended dose of NPK
T_4= Green manure + 2/3 recommended dose of NPK
T_5=Poultry manure + 1/2 recommended dose of NPK
T_6= Poultry manure + 2/3 recommended dose of NPK
T_7=Cowdung + 1/2 recommended dose of NPK
T_8= Cowdung + 2/3 recommended dose of NPK
T_9=Quick compost + 1/2 recommended dose of NPK
T_{10}= Quick compost + 2/3 recommended dose of NPK
T_{11}=Vermicompost + 1/2 recommended dose of NPK
T_{12}= Vermicompost + 2/3 recommended dose of NPK
T_{13}= Magic growth + 1/2 recommended dose of NPK
T_{14}== Magic growth + 2/3 recommended dose of NPK

The augmented grain yield (5.95 t ha^{-1}) was obtained from the T_{12} treatment (vermicompost +2/3 recommended dose of NPK) but the prettier grain yield was obtained (3.15 t ha^{-1}) from untreated treatment. Furthermore it can be inferred from the Fig. 8 that manurig and fertilization get the higher yield. In general grain yield extended with fertilizer and manures. Rajni Rani *et al.* (2001) reported the grain yield was significantly increased due to application of organic manure and chemical fertilizers. This is also in agreement with the findings of Haque *et al.* (2001)

4.12 Biological yield

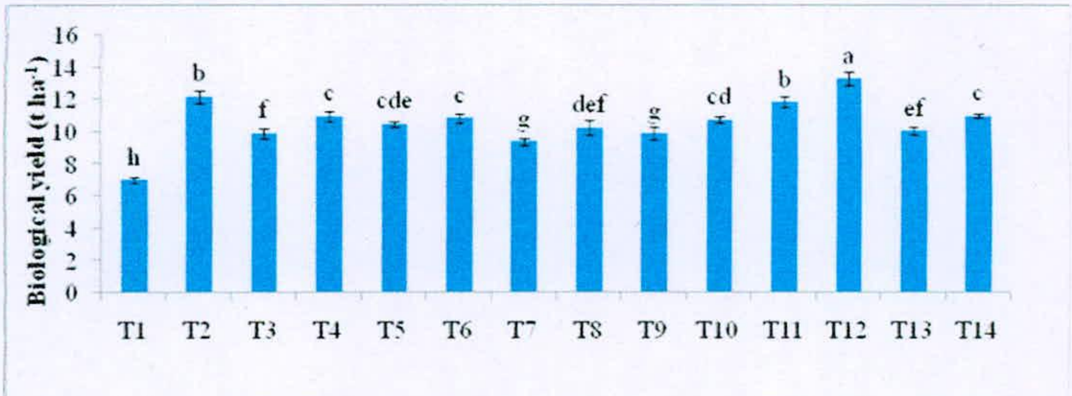

Figure 9. Effect of treatment on biological yield (t ha^{-1}) of T. aman rice. Bars with different letters are significantly different at $p \leq 0.05$ applying LSD.

T_1=Control
T_2=Recommended Dose of NPK
T_3=Green manure + 1/2 recommended dose of NPK
T_4= Green manure + 2/3 recommended dose of NPK
T_5=Poultry manure + 1/2 recommended dose of NPK
T_6= Poultry manure + 2/3 recommended dose of NPK
T_7=Cowdung + 1/2 recommended dose of NPK
T_8= Cowdung + 2/3 recommended dose of NPK
T_9=Quick compost + 1/2 recommended dose of NPK
T_{10}= Quick compost + 2/3 recommended dose of NPK
T_{11}=Vermicompost + 1/2 recommended dose of NPK
T_{12}= Vermicompost + 2/3 recommended dose of NPK
T_{13}= Magic growth + 1/2 recommended dose of NPK
T_{14}== Magic growth + 2/3 recommended dose of NPK

The biological yield varied significantly due to fertilizers and manures application shown in fig. 9. It was observed that T_{12} produced highest biological yield (13.24 t ha^{-1}). The second highest biological yield was (12.12 t ha^{-1}) which was produced by T_2. The lowest biological yield was (6.95 t ha^{-1}) which was produced by untreated treatment. Biological yield is the sum of grain yield (economic yield) and straw yield and thus it was also followed the trend like straw yield. These results were supported by Channabasavanna and Biradar (2001).

4.13 Harvest index

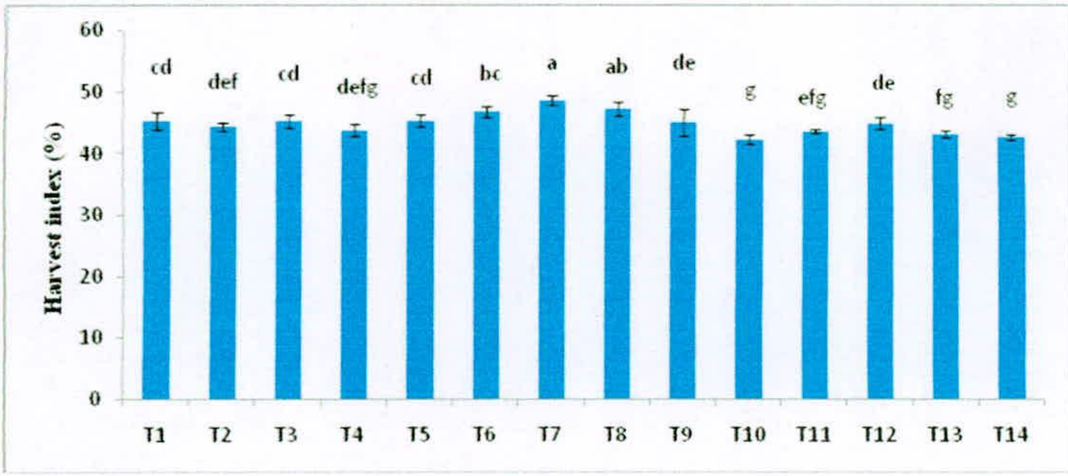

Figure 10. Effect of treatment on harvest index (%) of T. aman rice. Bars with different letters are significantly different at $p \leq 0.05$ applying LSD.

T_1=Control
T_2=Recommended Dose of NPK
T_3=Green manure + 1/2 recommended dose of NPK
T_4= Green manure + 2/3 recommended dose of NPK
T_5=Poultry manure + 1/2 recommended dose of NPK
T_6= Poultry manure + 2/3 recommended dose of NPK
T_7=Cowdung + 1/2 recommended dose of NPK
T_8= Cowdung + 2/3 recommended dose of NPK
T_9=Quick compost + 1/2 recommended dose of NPK
T_{10}= Quick compost + 2/3 recommended dose of NPK
T_{11}=Vermicompost + 1/2 recommended dose of NPK
T_{12}= Vermicompost + 2/3 recommended dose of NPK
T_{13}= Magic growth + 1/2 recommended dose of NPK
T_{14}== Magic growth + 2/3 recommended dose of NPK

Harvest index (HI) is the ratio of seed yield to total above ground plant yield. Analysis of variance of harvest index shows that there were significant differences among different manures on the probability level of 5% (Fig 9). Treatment T_7 (Cowdung + 1/2 recommended dose of NPK) was above all whose performance (48.53 %) which was statistically intimate with T_8 . On the other hand T_{10} was bottom in the line (42.23%) and statistically close with T_{14}, T_{11}, T_{13}, T_4. Strengthen yield and harvest index of T_7 (cowdung + ½ recommended dose NPK) indicates better partitioning of photosynthetic substance to economic yield. Kusalkar *et al.* (2003) appreciably high harvest index shows the efficiency of converting biological yield into economic yield.

4.14 Economic performance of different combination of treatments

The economic analysis revealed the performance of manures and fertilizers treatment vary under different treatment (Table 4). The highest cost of production T_4 (64424.08 Tk. ha^{-1}) and T_8 (64424.08 Tk. ha^{-1}).

Table 4. Cost of production, return and benefit cost ratio of T.aman rice under different treatment combination.

Treatment	Cost of production Tk ha^{-1}			Gross return Tk ha^{-1}			Net income Tk ha^{-1}	BCR
	Fixed cost	Fertilizer cost	Total	From grain	From straw	Total		
T_1	31505.8	0	31505.8	33762.04	3800	37562.04	6056.24	1.19
T_2	31505.8	5968.53	37473.53	57556.25	6750	64306.25	26832.72	1.7
T_3	31505.8	31790.84	63296.64	62231.5	5400	69631.5	7400.00	1.1
T_4	31505.8	32918.28	64424.08	63765.38	6140	69265.38	6140.10	1.0
T_5	31505.8	26790.84	58296.64	59592.92	5700	65292.92	6996.34	1.1
T_6	31505.8	27918.28	59424.08	60912.09	5730	66642.1	7218.0	1.0
T_7	31505.8	31790.84	63296.64	65445.85	4800	70245.59	6949.03	1.1
T_8	31505.8	32918.28	64424.08	65446.92	5380	70826.92	6402.7	1.1
T_9	31505.8	7040.84	38546.64	46838.14	5340	52178.14	13631.5	1.3
T_{10}	31505.8	8168.28	39674.08	48231.50	6160	54391.5	14717.42	1.4
T_{11}	31505.8	14179.84	45685.1	54983.90	6650	61633.9	15948.8	1.3
T_{12}	31505.8	14291.28	45797.1	63772.80	7290	71062.8	25265.7	1.6
T_{13}	31505.8	1878.34	33384.14	46087.90	5700	51787.9	18403.76	1.5
T_{14}	31505.8	3005.78	34511.58	49839.20	6270	60890.7	26379.12	1.6

T_1=Control
T_2=Recommended Dose of NPK
T_3=Green manure + 1/2 recommended dose of NPK
T_4= Green manure + 2/3 recommended dose of NPK
T_5=Poultry manure + 1/2 recommended dose of NPK
T_6= Poultry manure + 2/3 recommended dose of NPK
T_7=Cowdung + 1/2 recommended dose of NPK
T_8= Cowdung + 2/3 recommended dose of NPK
T_9=Quick compost + 1/2 recommended dose of NPK
T_{10}= Quick compost + 2/3 recommended dose of NPK
T_{11}=Vermicompost + 1/2 recommended dose of NPK
T_{12}= Vermicompost + 2/3 recommended dose of NPK
T_{13}= Magic growth + 1/2 recommended dose of NPK
T_{14}== Magic growth + 2/3 recommended dose of NPK

4.15 Gross return

The highest gross return (71062.8 Tk. ha^{-1}) was obtained from the T_{12} treatment and lowest was obtained 37562.04 Tk. ha^{-1} from control.

4.16 Net return

Net return varied in different fertilizer and manure treatments (Table 4). The highest net return 26832.72 Tk. ha^{-1} was found in T_2 treatment, the second highest net return 26379.12 Tk. ha^{-1} from T_{14}. The lowest net return was found 218.01 Tk. ha^{-1} in T_6. T_{12} gave 25265.7 Tk. ha^{-1} net returns.

4.17 Benefit Cost Ratio

The benefit cost ratio was varied in different fertilizers and manures treatments. The highest benefit cost ratio was shown in T_2 treatment and lowest benefit cost ratio was found in T_4 and T_6.

Chapter 5

SUMMARY AND CONCLUSION

An experiment was conducted at the Sher-e-Bangla Agricultural University during the period from aman season (June-December 2013) with a view to study the effect of different organic manures and chemical fertilizers on the morphophysiological and yield contributing characters of transplant aman rice cv. BRRIdhan54. There were several treatments viz. T_1=Control, T_2=Recommended Dose of NPK , T_3=Green manure +1/2 recommended dose of NPK, T_4= Green manure +2/3 recommended dose of NPK, T_5=Poultry manure +1/2 recommended dose of NPK, T_6= Poultry manure +2/3 recommended dose of NPK, T_7=Cowdung +1/2 recommended dose of NPK, T_8= Cowdung +2 /3 recommended dose of NPK, T_9=Quick compost +1/2 recommended dose of NPK, T_{10}= Quick compost +2 /3 recommended dose of NPK, T_{11}=Vermicompost +1/2 recommended dose of NPK, T_{12}= Vermicompost +2/3 recommended dose of NPK, T_{13}= Magic growth +1/2 recommended dose of NPK, T_{14}= Magic growth +2/3 recommended dose of NPK. The experiment was laid out in a RCBD design with three replications. Recommended dose of NPK were applied two days before transplanting. Urea was applied in three split dose at 7, 28, days after transplanting and before panicle initiation. Daincha was incorporate before 10 days before transplanting and allow them rotten. Quick compost, Vermicompost, Cow dung, Poultry manure was applied 5 days before transplanting. Magic Growth was applied 1.6

L decimal^{-1} in the evening, three times and 15 days interval. Seedlings were raised on nursery bed and 27 days old seedlings were transplanted on 4 august in 2013 by maintaining a space of 15cm between hills and 25cm between rows. Necessary gap filling was done at 7 days after transplanting. Intercultural operations such as gap filling, weeding, water management and pest management were done as and when necessary. Data were collected different agronomic characters related to growth and important yield components. Data were analyzed using the "Analyses of variance" and mean difference were adjusted by LSD.

Treatments had significant influence on almost all the parameter of studied. Taller plant (59.53, 92.96, 121.83, 122.67, 113, and 110.17cm at 30, 45, 60, 75, 90 DAT and at harvest, respectively) was produced by T_{14} treatment (Magic growth +2/3 recommended dose of NPK) and the shorter (53, 62.50, 83.67, 91, 85 and 80 cm at 30,45, 60, 75, 90 DAT and at harvest, respectively) was produced by control. Total tillers hill^{-1} was maximum (7.93, 10.06, 12.02, 14.93, 12.93, and10.16 at 30, 45, 60, 75, 90 DAT and at harvest, respectively) by T_{12} treatment (Vermicompost +2/3 recommended dose of NPK) while prettier tiller hill^{-1} (5.06, 7.26, 9.26, 10.16, 8.33 and 6.83 at 30,45, 60, 75, 90 DAT and at harvest, respectively) by untreated treatment. Dry weight was highest in (6.65, 20.66, 28.83, 37.83 and 48.76 at 30, 45, 60, 75, 90 DAT respectively) by T_{12} treatment (Vermicompost +2/3 recommended dose of NPK) on the other hand lowest dry weight was shown (3.87, 11.52, 18.50, 28.92 and 35.60 at 30, 45, 60, 75, 90 DAT respectively) by untreated treatment. T_{12} treatment bear higher effective tiller hill^{-1} (9.26) but without fertilization treatment bear lowest (7.06) effective tiller. Untreated treatment achieved augmented (1.10) non effective tiller on the contrary T_2 achieved lowest non effective tiller (0.46).The longest panicle (26.13) was obtained by T_{12} treatment moreover shortest panicle (23.40) was obtained by control. Aggravated filled grain (124.33) was observed in T_{12} treatment and lower filled grain (85) was observed in untreated treatment. Unfilled grain (47.33) was superior in control on the other hand unfilled grain (21.33) was inferior in T_4 treatment (Green manure +2/3 recommended dose of NPK). The highest 1000 grain weight (23 gm) was shown by T_{12} on the contrary lowest 1000 grain weight (21.33 gm) was observed in without fertilization. The highest amount of straw yield (7.29 t ha^{-1}) was found from T_{12} treatment but lowest (3.80 29 t ha^{-1}) was found in control. The highest grain yield (5.95 29 t ha^{-1}) was found in T_{12} on the contrary lowest grain yield (3.15 t ha^{-1}) was found in control. It was observed that T_{12} produced highest biological yield (13.24 t ha^{-1}) and the lowest biological yield was (6.95 t ha^{-1}) produced by untreated treatment. Raised harvest index (48.53) was calculated in T_7 treatment (Cowdung + 1/2 recommended dose of NPK) but slower harvest index (42.23) was calculated in T_{10} treatment (Quick compost +2/3 recommended dose of NPK). Benefit cost ratio was highest in T_2 recommended dose of NPK.Highest net return was found in T_{12} (Vermicompost +2/3 recommended dose of NPK).

From the above study it may be concluded that treatment T_{12} (Vermicompost +2/3 recommended dose of NPK) was yielded best performance most of the growth and yield contributing characters except plant height and harvest index. However, to reach a specific conclusion and recommendation the same experiment need to be repeated and more research work should be done over different agro-ecological zones of the country.

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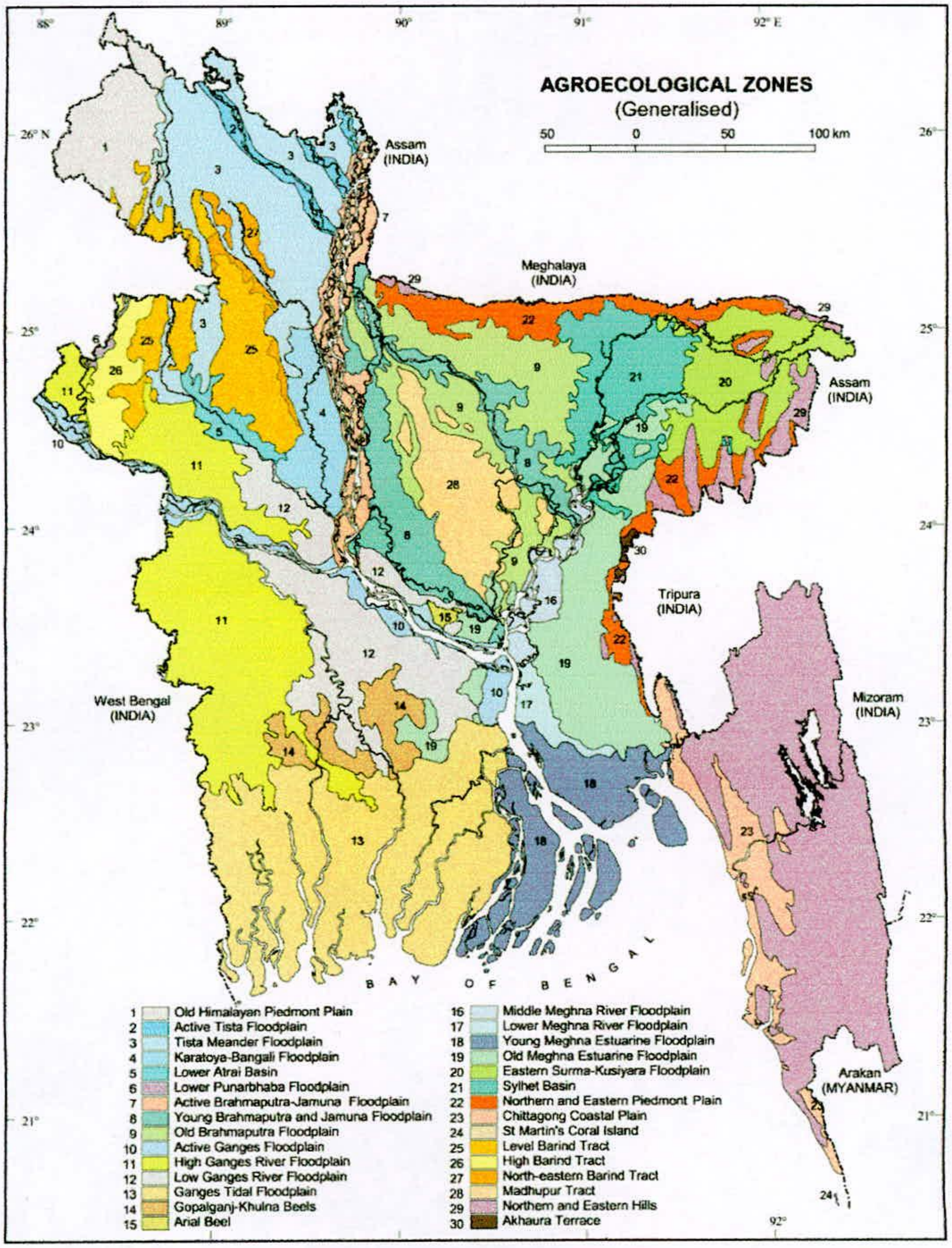
APPENDICES

Appendix I. Experimental location on the map of Agro-ecological Zones of Bangladesh.



Appendix II. Monthly average air temperature, relative humidity, total rainfall, wind speed, sunshine hour and evaporation rate of the experimental site during the period from August to November, 2013.

Month	RH (%)	Temperature (°C)		Wind speed (km hr^{-1})	Sunshine hour	Rain fall (mm day^{-1})	Evaporation rate (mm day^{-1})
		Maximum	*Minimum*				
August	74.41	31.02	15.27	3	5.11	5.1	2.07
September	73.20	31.46	14.82	2	4.15	6.3	2.05
October	67.82	30.18	14.85	1	7.48	4.2	2.05
November	58.18	28.10	6.88	1	7.85	1.56	1.82

Source: SAU Meteorological Yard , Sher-e-Bangla Nagar, Dhaka-1207.

Appendix III. Physical and Chemical properties of experimental soil analyzed at Soil Resource Development Institute (SRDI) Farmgate, Dhaka.

Characteristics	*Value*
Partical size analysis	
% Sand	26
%Silt	44
% Clay	332
Textural class	Silty-clay
pH	5.8
Organic carbon (%)	0.35
Organic matter (%)	0.78
Total N (%)	0.02
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.15
Available S (ppm)	45

Source: SRDI (Soil Resource Development Institute), Farmgate, Dhaka.