ASSESSING THE RESIDUAL EFFECT OF ORGANIC MANURE AND FERTILIZER MANAGEMENT IN T. AMAN RICE

ISRAT ZAHAN CHOWDHURY

DEPARTMENT OF AGRONOMY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA-1207

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ISRAT ZAHAN CHOWDHURY

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APPROVED BY:

Prof. Dr. A.K.M. Ruhul Amin **Supervisor**	**Prof. Dr. Md. Shahidul Islam** **Co-Supervisor**

Prof. Dr. Md. Shahidul Islam
Chairman
Examination Committee

DEDICATED TO

MY

BELOVED PARENTS

DEPARTMENT OF AGRONOMY

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar

Dhaka-1207

CERTIFICATE

*This is to certify that the thesis entitled **"ASSESSING THE RESIDUAL EFFECT OF ORGANIC MANURE AND FERTILIZER MANAGEMENT IN T. AMAN RICE ."** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS)** in **AGRONOMY**, embodies the results of a piece of bona fide research work carried out by **ISRAT ZAHAN CHOWDHURY**, registration no. **13-05421** under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

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

Dated:

Dhaka, Bangladesh

Prof. Dr. A.K.M. Ruhul Amin
Department of Agronomy
SAU, Dhaka-1207

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ABSTRACT

A pot experiment was conducted at the net house of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka-1207 during July to December, 2018 in T. aman season to evaluate the residual effect of organic manure and different levels of chemical fertilizer. The experiment consisted of two factors viz- Factor A: Organic manure (3 levels); O_0: Control (Without organic manure), O_1: Cowdung and O_2: Vermicompost and Factor B: Chemical Fertilizer doses (4 levels); F_0 = Control(without fertilizer), F_1 = 50% of RDF (Recommended dose of all chemical fertilizer), F_2 = 75% of RDF and F_3 = RDF . Cowdung and vermicompost were applied in the pot @ 10 and 5 ton ha^{-1} during wheat cultivation. Recommended doses of fertilizers such as urea, TSP, MOP and zypsum were applied in the pot @ 90, 55, 60 and 55kgha^{-1} during T. aman rice cultivation. The experiment was laid out in Completely Randomized Design (CRD) with three replications. Results revealed that residual effect of different organic manure and chemical fertilizer treatment exerted significant effect on most of the yield and yield contributing parameters studied in this experiment. Similarly, most of the traits were also affected significantly due to the combination effect. Among the residual effect of treatments, vermicompost (O_2) showed best results in terms of plant height, dry matter, filled grains panicle^{-1}, 1000-grain weight, grain yield, straw yield, biological yield, harvest index. For chemical fertilizer, the treatment F_3 (RDF) showed outstanding performance for getting the better growth and higher yield compared to those of other treatments. Most of the studied traits were also influenced significantly due to the interaction effect of O_2F_3 but F_2 (75% of RDF) treatment also showed similar performance with $F_{3.}$The interaction of vermicompost with RDF and 75% of RDF(O_2F_3 and O_2F_2) showed the higher yield (5.90 and 5.87 t ha^{-1} respectively) which may be attributed to higher number of effective tillers hill^{-1}(10.47 and 9.83, respectively), 1000 grain weight (20.60 g and 20.27 g, respectively), grains panicle^{-1} (102.83 and 99.67, respectively) in this two interaction treatments. Considering the above fact, organic manure O_2 (vermicompost) and chemical fertilizer F_2 (75% of RDF) and combination O_2F_2 could be considered the best fertilizer management practice which reduces the use of 25% chemical fertilizer in BRRI dhan34 cultivation.

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SOME COMMONLY USED ABBREVIATIONS

ABBREVIATIONS	FULL WORD
%	Percent
@	At the rate of
0C	Degree celsius
AEZ	Agro-Ecological Zone
As	Arsenic
BRRI	Bangladesh Rice Research Institute
Cm	Centimeter
CRD	Completely Randomized Design
CV%	Percentage of Co-efficient of Variation
DAT	Days after transplanting
e.g.	As for example
et al.	and others
G	Gram
Ha	Hectare
i.e.	that is
K	Potassium
Kg	Kilogram
kg ha^{-1}	kg per hectare
LSD	Least Significant Difference
L	Liter
M	Meter
ml/L	Milliliter per Liter
mg/L	Milligram per Liter
MoP	Muriate of Potash
N	Nitrogen
Nm	Nano Meter
Ng	Nano Gram
P	Phosphorus
pH	Hydrogen ion concentration
Ppm	Parts Per Million
S	Sulphur
SAU	Sher-e-Bangla Agricultural University
t ha^{-1}	Ton per hectare
TSP	Triple Super Phosphate
µg/kg	Microgram per kg
Zn	Zinc

CHAPTER I

INTRODUCTION

Rice (Oryza sativa L.) is the principal cereal and staple food under the family Poaceae for 160 million people of Bangladesh. Rice sector contributes to 70% of the agricultural GDP and one-sixth of the national income of Bangladesh. Rice covers about 81% of the total cropped area and provides nearly 48% of rural development (BBS, 2012). It is the main source of food for more than 60% of the world's population and the second most important crop in the world after wheat, more than 90% of which is produced in Asia. In Bangladesh, over 80% of the irrigated area and about 75% of the total cropped area is planted to rice (BRKB, 2017).

The total rice production in our country is about 34.00 million tons to feed her 149.69 million people (Mandal and Choudhury, 2014). The increase in rice production becomes possible largely due to adoption of rice modern rice varieties on around 66% of the rice land which contributes to about 73% of the country's total rice production (BRKB, 2017). BBS (2010) reported that the population will have possibly increased to 230 million by the year 2030 which need more cereal crops for meet their demand. The population of Bangladesh is increasing at an alarming rate and the cultivable land is reducing due to urbanization and industrialization resulting in more shortage of food. Horizontal expansion of rice area, rice yield unit^{-1} area is not possible due to over-increasing population, rather vertical expansion of rice area by increasing. Management practices also can help for vertical expansion of rice area and yield unit^{-1} area.

Bangladesh is one of the major rice growing countries. Rice plays a vital role in the livelihood of the people of Bangladesh. But cultivation is always vulnerable to unfavorable weather events and abiotic stresses. Growth and development of the crops including rice depend on environmental factors such as atmosphere, temperature, light, humidity, nutrients etc. Many abiotic factors such as heat, cold, drought, salinity and heavy metal contamination reduce the growth and development of the crops. Organic manure can supply a good amount of plant nutrients thus can contribute to crop yields. Thus, it is necessary to use fertilizer and manure in an integrated way in order to obtain sustainable crop yield without affecting soil fertility. The integrated approach by using the organic and inorganic sources of nutrients helps to improve the efficiency of nutrients. Mineralization and immobilization are biochemical in nature and are mediated through the activities of microorganisms. The rate and extent of mineralization determines crop availability of nutrients. The transformation of N, P and S in soil depends on the quality and quantity of organic matter as well as soil fertility and microbial activity.

Cropping intensity 191% (BBS, 2017) is increasing in Bangladesh without adequate and balanced use of fertilizer managements and with little or no use of organic manures. Higher is the crop yield, higher is the nutrient removal from soil. Nutrient deficiency in this country's soils has arisen chronologically N, P, K, S, Zn and B (Islam, 2008; Jahiruddin and Satter, 2010). As a result, soil fertility is causing deterioration and crop productivity is declining. Soil organic matter supplies a substantial quantity of some macro and micronutrients for the growing plants and it improves soil health. Sarkar (2004) showed that Effect of residual cowdung and fertilizer managements was significantly positive on the availability of nitrogen, phosphorus, potassium, sulphur, copper, zinc, manganese and nutrient content of soil. It also contributes to soil fertility and productivity through its positive effect on the chemical, physical and biological properties of the soil. But, the organic matter content in most of the soils of Bangladesh is below 1.5%. About 45% of net cultivable areas of Bangladesh contain less than 1% OM (FRG, 2012). In spite of that the farmers are using lesser quantities of animal manures and crop residues because most of these materials are being used for cooking, for building houses and as feed for cattle. Hence, management of soil organic matter has now become a major issue in dealing with the problem of soil fertility and crop productivity in Bangladesh. Combined use of organic and inorganic manures helps to maintain soil fertility and crop productivity for a long-term basis. Residual effects of manure or compost application on crop production and soil properties can last for several years (Eghball *et al*. 2005). Rice (Oryza sativa L.) is intensively cultivated in Bangladesh covering about 75% of arable land. By applying integrated use of organic and inorganic manures, farmers may cultivate rice crops without any harmful impact on soil environment. Using of various organic manure and inorganic fertilizers for the production of rice can reduce the application of fertilizer managements ultimately reducing cost of production. Badruzzaman *et al*. (2002) showed that organic manures had direct and residual effects on rice, mungbean and wheat yields and the effect of OM was dominant Therefore, the goal of the study will be conducted to evaluate the residual effects of organic manures and different level of RDF on the yield of BRRI dhan34 and the suitability of different sources of organic materials for using as manures for rice cultivation in T. aman rice.

OBJECTIVES OF THE RESEARCH WORK:

i. To evaluate the residual effects of organic manures and different level of fertilizer on the yield and yield components of rice.
ii. To determine reduction limit of fertilizer.
iii. To determine most useful combination between organic manure for residual effect and fertilizer for higher yield of T. aman rice.

CHAPTER II

REVIEW OF LITERATURE

Soil organic manure and inorganic fertilizer is the essential factor for sustainable soil fertility and crop productivity because is the store house of plant nutrients. Sole and combined use of cow-dung, poultry manure, compost, and inorganic manure acts as a source of essential plant nutrients. Experimental evidences in the use of cowdung, vermicompost, and urea, TSP, MOP and zypsum showed an intimate effect on the yield and yield attributes of rice. Yield and yield contributing characters of rice are considerably influenced by different doses of urea, TSP, MOP and zypsum fertilizer and cowdung & vermicompost manure and their combined application. On the other hand cropping pattern also an important factor for the sustainable soil fertility and crop productivity. Some literature related to the " Assessing the residual effect of organic manure and fertilizer management in T. aman rice" are reviewed below-

2.1 Effect of residual vermicompost (VC)

The importance of composts as a source of humus and nutrients to increase the fertility of soil and growth of plant has been well recognized. Vermicompost and fertilizer management were taken first for chemical analysis and then to find the effect of these composts on the growth of SRI Rice Cultivation. It was found that the vermicompost was rich in nutrients like Potassium, Nitrate, Sodium, Calcium, Magnesium, and Chloride and have the potential for improving plant growth than Fertilizer. The optimal growth of SRI Rice in the study conducted for a period of four month. The study also showed distinct differences between vermicompost and fertilizer management in terms of their nutrient content and their effect on SRI Rice plant growth (Kandan and Subbulakshmi, 2015)

Kumar *et al*. (2014) carried out field experiment during kharif season of 2011 to study the effect of organic and inorganic sources of nutrient on yield, yield attributes and nutrient uptake of rice cv. PRH-10. Application of organic and inorganic sources of nutrient in combination remarkably increased yield, yield attributes and nutrient uptake of rice than alone. 125% RDF + 5 t/ha vermicompost recorded significantly higher yield, yield attributes and nutrient uptake in comparison to other treatments and this was followed by 100% RDF + 5 t/ha vermicompost. 125% RDF + 5 t/ha vermicompost was increased the number of panicles (20.50%), panicle length (23.12%), panicle wt. (13.02%), 1000 grain wt.(12.90%), grain yield (31.15%), straw yield (37.12%), protein content (18.77%), N uptake in grain (36.81%) and straw (42.81%), P uptake in grain (32.62%) and straw (31.56%) and K uptake in grain (35.46%) and straw (25.39%) over control. The lower yield, yield attributes, gross return and nutrient uptake was recorded in control.

Tharmaraj *et al*. (2011) studied the effect of vermicompost on soil chemical and physical properties was evaluated during samba rice cultivation studies. The study was carried out to know the impact of various vermiproduct such as vemicompost, vermiwash and mixture of vermicompost and vermiwash on soil physico-chemical properties during the pot culture studies with samba rice. The physical properties such as, electrical conductivity (EC), porosity, moisture content, water holding capacity and chemical properties like nitrogen, phosphorous, potassium, calcium and magnesium were found distinctly enhanced in vermicompost treated soil, where as the corresponding physicochemical values in control were minimum. The soil treated with vermicompost had significantly more electrical conductivity in comparison to unamended pots. The addition of vermicompost in soil resulted in decrease of soil pH. The physical properties such as water holding capacity, moisture content and porosity in soil amended with vermicompost were improved. The vermiproduct treated plants exhibit faster and higher growth rate and productivity than the control plants. Among the treated group, the growth rate was high in the mixture of vermicompost and vermiwash treated plants, than the vermicompost and vermiwash un-treated plants. The maximum range of some plant parameter's like number of leaves, leaf length, height of the plants and root length of plant, were recorded in the mixture of vermicompost and vermiwash. The results of this experiment revealed that addition of vemicompost had significant positive effects on the soil physical, chemical properties and plant growth parameters.

Upedrarao and Srinivasulureddy, (2004) reported that conjuctive use of vermicompost @ 2 t/ha along with 50 per cent N/ha enabled hybrid rice to produce grain yield at par that obtained by application of recommended dose of fertilizer along.

Murali and Setty, (2004) conducted a field experiment during wet season of 1997 to study the response of scented rice (cv. Pusa basmati1) to different levels of NPK, vermicompost and growth regulator at ARS, Siraguppa. The results revealed that application of 150:75:75 NPK kg ha^{-1} has recorded significantly higher growth, yield attributes and yield (5261 kg ha^{-1}) as compared to lower levels of NPK. Scented rice Pusa $Basmati^{-1}$ responded significantly to the organic manure. Application of vermicompost @ 5 t ha^{-1} resulted in significantly higher yield (4889 kg ha^{-1}) as compared to no vermicompost application. Significantly response was observed from spraying of triacontanol (GR) @ 500 ml ha^{-1} with respect to growth, yield attributes and yield (4861 kg ha^{-1}) as compared to spraying @ 250 ml ha^{-1} and water spray.

Vermicomposting is the bioconversion of organic waste materials into nutritious compost by earthworm activity and is an important component of organic farming package. Meena (2003) reported multifarious effects of vermicompost on growth and yield of crops.In a recent field experiment conducted at Kerala Agricultural University, vermicompost @ 6 t/ha was tried as an organic manure for short duration rice variety in Kanchana. It was found that vermicompost addition had a positive influence on growth and yield attributes of rice to result in a better grain yield of 4.54 t/ha and straw yield of 5.15 t/ha along with the NPK dose of 105: 52.5: 52.5 kg/ha supplied through inorganic sources. Apart from the improvement in fertilizer use efficiency, vermicompost ensured a steady supply of secondary nutrients like Mg as well as micronutrients throughout the growth period, which improved the chlorophyll content of leaves and reduced the chaff percentage.

Sudhakar, *et al*.,(2002) reported that increased availability of nutrients in vermicompost compared to non-ingested soil resulted in significantly better growth and yield of rice. Earthworms can live in decaying organic wastes and can degrade it into fine particulate materials, which are rich in nutrients. Vermicomposting is the application of earthworm in producing vermin-fertilizer, which helps in the maintenance of better environment and results in sustainable agriculture, earthworm make the soil porous and help in better aeration and water infiltration. Vermicompost can be prepared from different organic materials like sugarcane trash, coir pith, pressmud, weeds, cattle dung, bio digested slurry etc.

Jeyabal and Kuppuswamy, (2001) observed that application of vermicompost with fertilizer N and bio-fertilizer increased the rice yield by 16 per cent over the application of fertilizer N alone. On the other hand vermicompost applied with FYM recorded higher grain and straw yield of rice.

Ravi and Srivastava (1997) reported that combined application of vermicompost and inorganic manures recorded signiicantly higher plant height, effective tillers per hill, seed and straw yield of rice, compared to application of inorganic manure alone.

Gopal Reddy (1997) reported that vermicompost contains 1.98 per cent nitrogen 1.23 per cent phosphorus, 1.59 per cent potassium and 132, 70.5, 1440.2 and 317.5 mg per kg of total Zn, Cu, Fe and Mn, respectively.

Senapathi *et al*. (1985) reported that paddy crop applied with vermicompost resulted in highest grain and straw production.

Das and Patra (1979) reported that vermicompost contained 0.47% N compared to 0.35% N in the surrounding soil. Nitrogen contribution from mucus, dead earthworm tissue and wormcasts amounted to 180 kg ha^{-1} $year^{-1}$.

2.2 Effect of residual cowdung

Buri *et al*. (2006) concluded in an experiment with poultry manure, cattle manure, and rice husks, applied solely or in combination with mineral fertilizer (using urea or sulphate of ammonia as N source) that a combination of a half rate of organic amendments and a half rate of mineral fertilizer significantly contributed to the growth and yield of rice.

Nyalemegbe *et al*. (2010) found that combining 10 t ha-1 of cowdung with 45 kg N ha^{-1} urea, or 10 t ha^{-1} poultry manure with 60 kg N ha^{-1}, gave yields comparable to those under high levels of nitrogen application (i.e., 90 and 120 kg N ha^{-1}) applied solely.

Nyalemegbe *et al*. (2009) found that rice straw surpassed poultry manure and cowdung in the Vertisols of the Accra Plains of Ghana.

Islam *et al*. (2013) studied to evaluate the effect of nitrogen supplied from organic sources (cowdung, poultry manure and compost) and inorganic source (urea) on the yield and nitrogen use efficiency of BRRI dhan28. The treatments were T_0 (Control), T_1 (100% N from RFD), T_2 (70% N from RFD, RFD + 30% N from CD), T_3 (70% N from RFD + 30% N from PM), T_4 (70% N from RFD + 30% N from CoM), T_5 [70% N from RFD + 30% N from (CD + PM + CoM)], T_6 [100% N from (CD + PM + CoM), T_7 [100% N from RFD + 30% N from (CD + PM + CoM)]. The highest grain yield of 5847 kg $ha^{–1}$ was observed in the treatment T_7 and the lowest grain yield of 2426 kg $ha^{–1}$ was found in T_0. The highest N uptake (138.9 kg $ha^{–1)}$ was found in T_7 followed by T_1 (119.8 kg $ha^{–1}$). The highest nitrogen use efficiency was observed in T_6 and the lowest value was noted in T_5

Rifat-E-Mahbuba (2013) found that the Application of N as PU, USG alone or in combination with cowdung significantly increased yield components, grain and straw yields of BRRI dhan28 rice. The treatment T_3 (78 kg N $ha^{–1}$ from USG) produced the highest grain yield of 5.85 t $ha^{–1}$ and straw yield of 5.50 t $ha^{–1}$ due to the treatment T_6. The treatment T_2 (104 kg N $ha^{–1}$ from USG) performed better than T_1 and T_4, indicating the superiority of USG over PU. The N, P and K uptake by BRRI dhan28 rice were influenced profoundly due to the application of USG alone or in combination with cowdung. The overall results indicate that application of USG in combination with cowdung could be considered more effective in rice production.

2.3 Effect of fertilizer management on the growth and yield of T. aman rice

Jeffery *et al*. (2011) Increased attention is being given to the improvement of such soils, since they are potentially productive and require less investment, effort, and time for restoring their productivity than is required for the reclamation of new land. Anwar *et al*. (2005) Soil fertility management through the application of organic matter and other soil amendments to supply at least a part of plants' nutrient requirement, rather than rely entirely on inorganic manure, and to improve the soil fertility level is imperative for making such soils productive.

Satyanarayana *et al*. (2002) Significant influence of different inorganic manure levels on grain and straw yield, tiller numbers, filled grains per panicle and 1000-grain weight of rice. Application of 120:60:45 kg $N:P_2O_5:K_2O$ ha^{-1} produced significantly greater grain yield (3.63 t ha^{-1}) as compared to that obtained with lower fertilizer levels of $N:P_2O_5:K_2O$ ha^{-1} (3.17 t ha^{-1}).

Behera *et al*. (2009) Application of higher fertilizer level of 160:80: $N:P_2O_5:K_2O$ ha^{-1} produced grain yield of 3.76 t ha^{-1}, which was statistically similar to that obtained with application of 120:60:45 kg $N:P_2O_5:K_2O$ ha^{-1}. Similar effects were also observed for straw yield, number of tillers, filled grains per panicle and 1000-grain weight. These effects were due mainly to low available N and P in the soil.

Amim *et al*. (2004) conducted an experiment to evaluate the effect of increased plant density and fertilizer dose on yield of rice variety IR-6. He found that increased fertilizer dose of NPK increase plant height.

Ahmed *et al*. (1997) conducted an experiment to compare the grain yield and yield components of seven modern rice varieties (BR4, BR5, BR10, BR11, BR22, BR23, and BR25) and a local improved variety, Nizersail. The fertilizer dose was 60-60-40 kg ha^{-1} of N, P2O5 and K2O, respectively for all the varieties and found that percent filled grain was the highest in Nizersail followed by BR25 and the lowest in BR11 and BR23.

Naidu *et al*. (2013) reported that the highest growth, yield attributes, lesser spikelet sterility and higher grain yield were obtained with the application of 100–50–50 kg ha^{-1} N, P2O5, K2O and these parameters were at their minimum with the supply of 60– 30–30 kg ha^{-1} of N, P2O5, K2O. The increase in yield with supply of 100–50– 50 kg ha^{-1} N, P2O5, K2O (N3), compared to supply of 60–30–30 kg ha^{-1} N P2O5, K2O (N1) was 15.1 and 15.4% respectively during 2006 and 2007, respectively.

2.4 Effect of fertilizer management and vermicompost

Mahmud *et al.* (2016) studied the combined effect of vermicompost and fertilizer managements on the nutrient content in grain, straw and post harvest soil of boro rice cv. BRRI dhan29, a field experiment was conducted in December, 2013 to June, 2014 at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. Sixteen combinations of 4 vermicompost level @ 0, 1, 2, 4 t ha 1 and 4 NPKS levels i.e. 0-0-0-0, 50-8-33-6, 100-16-66-12, 150-24-99-18 kg ha^{-1}, respectively were applied in a Randomized Complete Block Design (RCBD) with three replications. Results showed that the highest dose of vermicompost and fertilizer management increased the concentration of P, K and S by rice grain and straw significantly at the harvesting stage. Combined application of vermicompost and fertilizer management failed to increase the total N content of post-harvest soil. Combination of vermicompost and fertilizer managements also increased the organic matter, P, K and S status of post harvest soil significantly.

Sultana *et al*. (2015) conducted experiment at Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh during December, 2011 to April, 2012 to assess the effect of integrated use of vermicompost, pressmud and urea on the nutrient status of grain and straw of rice (Hybrid Dhan Hira 2). Ten treatments coded from T1 to T10 were used in this experiment. The highest amount of nitrogen (1.092%), phosphorus (0.297 %), potassium (0.374 %) in grain and the highest amount of potassium (1.213%), sulfur (0.091%) in straw were observed in T3 treatment receiving 90 kg N/ha from urea along with 30 kg N/ha from vermicompost. The highest sulfur (0.124 %) content in grain and the highest nitrogen (0.742%), the highest phosphorus (0.182 %) in straw was recorded in treatment T2 receiving 120 kg N/ha from urea. The highest amount of nitrogen (93.81 kg/ha), phosphorus (26.07 kg/ha), potassium (32.82 kg/ha) and sulfur (10.79 kg/ha) uptake by grains and the highest amount of nitrogen (55.70 kg/ha), phosphorus (13.79 kg/ha), potassium (92.43 kg/ha) and sulfur (6.91 kg/ha) uptake by straw of rice were observed in T3 treatment. On the other hand the lowest values of these parameters were obtained from control treatment T1. Dekhane, *et al*. (2014) conducted a trial with three replications and six treatments was laid out in Randomized Block Design to assess the performance of different organic and inorganic manure on growth and yield of paddy crop during Kharif season. Different doses of fertilizers were applied to all the plots except untreated control. Application of 50 % N through RDF + 50% N through vermicompost recorded higher growth attributes like plant height was 42.2 cm and 118.1 cm, no. of tillers per plant was 8.7 and 12.1 at 45 DAT and at harvest time respectively, panicle length (22.3 cm), grains per panicle (128.0), 1000-grain weight (19.7 g) and grain yield (4.97 t/ha.) and straw yield (5.77 t/ha.) of rice variety GR 11. The data clearly revealed that the yield obtained with treatment T5 (50% RDF + 50% N through vermicompost) was recorded significantly higher growth as well as yield attributes than all other treatments.

2.5 Interaction effect

Shaha (2014) reported that the different rates of cowdung with inorganic manures showed significant effect on all growth parameters viz. plant height and tillers hill^{-1}. Among the cowdung levels with BRRI RD of inorganic manures, highest grain yield (5.62 t ha^{-1}) was obtained from cowdung 7.5 t ha^{-1} with inorganic manures and lowest (5.07 t ha^{-1}) was recorded in control. Similarly, the highest grain yield (6.25 t ha^{-1}) was obtained from the treatment combination of (BR11 and cowdung 7.5 t ha^{-1}) with inorganic manures which was statistically identical with all BR11 in cowdung treated plot.

Sarkar (2014) found that the application of 75% RD of inorganic manures + 50% cowdung showed superiority in terms of plant height (123.3 cm) and total tillers hill^{-1} (13.87) where those were also highest in combination of BRRI dhan34 × 75% RD of inorganic manures + 50% cowdung. Nutrient management of 75% RD of inorganic manures + 50% cowdung (5 t ha^{-1}) gave the highest grain yield (3.97 t ha^{-1}) and the lowest grain yield (2.87 t ha^{-1}) was found in control. The highest grain yield (4.18 t ha^{-1}) was found in BRRI dhan34 coupled with 75% RD of inorganic manures + 50% cowdung and the lowest grain yield (2.7 t ha^{-1}) was found in BRRI dhan37 in control. Liza *et al*. (2014) found that the treatment T_6 50% RFD + Effect of residual CD 2.5 t ha$^{-1,}$ PM 1.5 t ha^{-1}, and Com. 2.5 t ha^{-1} produced the highest grain yield (6.87 t ha^{-1}) and straw yield (7.24 t ha^{-1}). The lowest grain yield (3.22 t ha–1) and straw yield (4.55 t ha–1) were found in T0. Treatment T6 receiving 50% RFD along with the Effect of residual 2.5 t ha^{-1} cowdung, 1.5 t ha^{-1} poultry manure and 2.5 t ha^{-1} compost was found to be the best combination of organic and inorganic nitrogen for obtaining the maximum yield of BRRI dhan29 and nutrient content and uptake by grain and straw.

Haque (2013) evaluated the use of manures and fertilizers for maximizing the growth and yield of BRRI dhan28. The maximum grain yield of 5651 kg ha^{-1} and straw yield of 6572 kg ha^{-1} were recorded in T_3 [(PM) + STB–CF]. The lowest grain and straw yields were found for T0. The NPKS content and uptake by BRRI dhan28 were also influenced significantly due to integrated use of manures and fertilizers.

Islam *et al*. (2013) studied the fertilizer and manure effect on the growth, yield and nutrient concentration of BRRI dhan28 at Sher–e–Bangla Agricultural University research farm, Dhaka. They observed that T5 (50% RDCF + 4 ton PM ha–1) showed the highest effective tillers hill–1, plant height, panicle length, 1000 grain wt., grain yield (5.92 kg plot–1) and straw yield (5.91 kg plot–1). The higher grain and straw yields were obtained organic manure plus inorganic manures than full dose of fertilizer management and manure.

Hossain *et al*. (2010) conducted an experiment to evaluate the effect of Urea, poultry manure (PM) and cowdung (CD) on the nutrient content and uptake by BRRI dhan29. The experiment was laid out in a RCBD with eight treatments in three replications. Application of poultry manure, cowdung and Urea significantly influenced the yield and yield components of BRRI dhan29 and N, P, K and S contents and uptake. The overall results indicate that application of PM @ 3 t ha^{-1} in combination with N 100 kg ha^{-1} can reduce the use of N fertilizer at a substantial level. The findings of the study suggest that integrated use of manure and fertilizer is more important for sustainable production of BRRI dhan29.

Islam (2008) showed that the highest plant height (109.49 cm), number of effective tillers $hill^{-1}$ (9.43), number of total tillers $hill^{-1}$ (13.33), grain yield (6.13 t ha^{-1}) and harvest index (46.04%) were obtained from the combination of 50% recommended fertilizer with 5 t ha^{-1} cowdung.

Aziz (2008) reported that effective tillers $hill^{-1}$, panicle length, 1000–grain weight and grain yield were highest

Saleque *et al*. (2004) studied with six treatments viz. absolute control (T_1), 1/3 of RFD (T_2), 2/3 of RD (T_3), full doses of RF (T_4), T_2 + 5 t cowdung and 2.5 t ash ha^{-1} (T_5) and T_3 + 5 t cowdung ha^{-1} + 2.5 t ash ha^{-1} (T_6) were compared. The results showed that application of cowdung and ash (T_5 and T_6) increased rice yield by about 1 t ha^{-1} $year^{-1}$ over that obtained with fertilizer management alone.

Jha *et al*. (2004) observed that 50: 40:30 kg NPK ha^{-1} + 3 t cowdung and urea mixture ha^{-1} produced significantly higher plant height, number of effective tiller $hill^{-1}$ and grain yield. Gowda *et al*. (2004) reported that plant height of Phalguna variety was highest due to application of 10 t ha^{-1} and 15 t ha^{-1} cowdung than Jaya variety of rice.

Ghosh *et al*. (2013) were carried out a field experiments to study the effect of nutrient management in summer sesame and its residual effect on succeeding kharif black gram during 2003 and 2004 in sub-humid lateritic tract of West Bengal. The crop growth was better with integrated application of 50% recommended dose of NPK through fertilizer (RDF), 50% N through vermicompost (VC) or FYM along with Azospirillum in sesame. The number of capsules plant$^{-1,}$ seeds capsule^{-1}, seed and oil yield of sesame increased significantly due to integrated application of 50% RDF+50% N through FYM along with Azospirillum in sesame during both the years. However, the treatment was at par with those of 75% RDF+25% N through FYM or VC along with Azospirillum and 50% RDF+50% N through VC along with Azospirillum. Integrated use of fertilizer, organic manure and Azospirillum produced higher seed and oil yield of sesame compared to 100% RDF through fertilizer alone.

CHAPTER III

MATERIALS AND METHODS

The pot experiment was conducted during the period from July to December 2018 at the net house of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka. The experiment was designed to study the residual effect of organic manure and inorganic fertilizer in T.aman rice. The materials and methods followed in this experiment are presented in this chapter under the following headlines-

3.1 Description of the experimental site

3.1.1 Location

The experiment was conducted at the Agronomy farm of Sher-e-Bangla Agricultural University, Dhaka-1207 which is situated at $23^{o}46^{o}$ N latitude and $90^{o}23^{o}$ E longitude at an altitude of 8.45 meter above the sea level.

3.1.2 Soil :

The land was under the Agro-ecological zone of Madhupur Tract (AEZ 28) of Tejgaon soil series. The topography is high and the soil texture is silty clay loam. The pH of the soil is 5.6. The experimental area was flat having available irrigation and drainage system.

3.1.3 Climate and weather

The climate of this area is sub-tropical. High temperature and heavy rainfall during Kharif season (March-September) and scanty rainfall in rabi season is the characteristics of this climate

3.2 Planting materials

The variety used as the test crop is BRRI dhan34. The seeds of this variety were collected from Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur. It is a recommended variety of rice which was developed by Bangladesh Rice Research Institute.

3.3 Experimental details

The experiment was conducted under Wheat-Mungbean-T. aman cropping pattern .Cowdung and vermicompost was applied in the pot @ 10 and 5 t ha^{-1} during wheat cultivation. After cultivation of wheat, mungbean was grown in that pot where recommended fertilizers of mungbean was applied. After harvest of mungbean T. aman was cultivated in the same pots. During T.aman cultivation, the previous organic manure applied pots were used to evaluate their residual effect (Appendix I and II) in such a way where treatments were arranged as mentioned in section 3.3.1.

3.3.1 Treatments

The experiment consisted of two factors as mentioned below:

Factor A: Organic manure

i. O_0=Control (Without organic manure)

ii. O_1=Cowdung

iii. O_2= Vermicompost

Factor B: Fertilizer management

i. F_0= Control (Without fertilizer management)

ii. F_1= 50% of RDF

iii. F_2= 75% of RDF

iv. F_3= RDF (Recommended dose of fertilizer)

N.B. Cowdung and vermicompost was applied in the pot @ 10 and 5 t ha^{-1} under wheat cultivation.Fertilizers such as urea, TSP,MOP and Zypsum were applied 90 $kgha^{-1,}$ 55 $kgha^{-1}$, 60 $kgha^{-1}$, 55 $kgha^{-1}$, respectively under T. aman rice cultivation.

Treatment combinations were as: 12

O_0F_0, O_0F_1, O_0F_2, $O_0F_{3,}$ O_1F_0, O_1F_1, O_1F_2, O_1F_3, O_2F_0, O_2F_1, O_2F_2, $O_0F_{0.}$

3.3.2 Experimental design and layout

The pot experiment was laid out two factors following completely randomized design (CRD) with three replications.Three extra replications were planted which were used for taking growth datas. The size of the individual pot was 22 cm diameter and 25cm on height and total numbers of pots were 36. Organic manure were assigned as the main factor and fertilizer was assigned as sub-factor. (Appendix II)

3.4 Pot preparation

The pots were filled with the soil of Sher-e-Bangla Agricultural university experiment field.Before filling the soils, the pots are fertilized with the amount of fertilizer per pot were calculated as per treatment mentioned in 3.3.1.

3.5 Fertilizer Application

Full amounts of TSP, MP, Gypsum and Zinc sulphate were applied as basal dose before transplanting of rice seedlings. Urea were applied in 3 equal splits: one third was applied at basal before transplanting, one third at active tillering stage (30 DAT) and the remaining one third was applied at the time of panicle initiation stage (55 DAT). Fertilizers were applied into the core and outside the core during final land preparation.

3.5.1 Raising of seedlings

The seedlings of rice were raised wet-bed methods. Seeds (95% germination) @ 5 kg per ha were soaked and incubated for 48 hour and sown on a well-prepared seedbed. During seedling growing, no fertilizers were used. Proper water and pest management practices were followed whenever required.

3.6 Transplanting

Thirty days old seedlings of BRRI dhan34 were carefully uprooted from the seedling nursery and transplanted in 9 August, 2018 in well puddle pot. Each pot contained four seedlings. Two seedlings per hill were used following a spacing of 20 cm × 15 cm. After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings of same age whenever required.

3. 7 Intercultural operations

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

3.7.1 Irrigation

Necessary irrigations were provided to the pots when required during the growing period of rice crop.

3.7.2 Gap filling

Seedlings in some hills were died off and those were replaced by healthy seedling within 10 days of transplantation.

3.7.3 Weeding

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

3.7.4 Insect and Pest Control

There was no infestation of diseases in the field but leaf roller (*Chaphalocrosismedinalis*, Pyralidae, Lepidoptera) was observed in the field and was controlled by spraying Malathion @ 1.12 Liter per ha.

3.7.5 Crop Harvest

The crop was harvested at full maturity when 80-90% of the grains were turned into straw colored on December 2018. The crop was cut at the ground level and pot wise crop was bundled separately and brought to the threshing floor. Data on yield attributes and yield parameters were taken from that plants.

3.8 General observations of the experimental field

Regular observations were made to see the days after transplanting of the crop. In general, the crop looked nice with normal green plants which were vigorous and luxuriant in the treatment pots than that of control pots.

3.9 Collection of data

3.9.1 Crop growth characters

Growth characters data were taken from the extra three replicated Growth pots. The growth characters data were

i. Plant height (cm) at 25, 50, 75 days after transplanting (DAT) and at harvest

ii. Tillers hill^{-1} (no) at 25, 50, 75 DAT and at harvest.

iii. Dry matter content plant^{-1} (g) at 25, 50, and 75 DAT.

3.9.2 Yield contributing characters and yield data

Yield contributing characters and yield data were taken from the three replicated pots. They were

i. Effective tillers $hill^{-1}$ (no)

ii. Non-effective tillers $hill^{-1}$ (no)

iii. Length of panicle (cm)

iv. Panicle $hill^{-1}$ (no)

v. Filled grains $panicle^{-1}$ (no.)

vi. Weight of 1000 grain (g)

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

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

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

x. Harvest index (%)

3.10 Procedure of taking data

3.10.1 Plant height (cm)

The height of the rice plants was recorded at 25, 50, 75 DAT and at harvest, beginning from the ground level up to tip of the flag leaf was counted as height of the plant. The average height of two hills was considered as the height of the plant for each pot.

3.10.2 Tillers $hill^{-1}$ (no.)

Total tiller number was taken at 25, 50, 75 DAT and at harvest.

The average number of tillers of two hills was considered as the total tiller no $hill^{-1}$

3.10.3 Dry matter content $plant^{-1}$ (g)

One sample hill uprooted from each pot at randomly, wash them in water and then dried them in an electric oven maintaining 70^0C for 72 hours. Then the hills were weighed in an electric balance and averaged them to have dry matter content hill^{-1}.

3.10.4 Effective and non-effective tillers hill^{-1}

Tillers having at least single grain in the panicle were considered as effective tiller.

3.10.5 Panicle hill^{-1}

Total number of panicles were counted from two hills and averaged them to have number of panicles hill$^{-1.}$

3.10.6 Number of filled grains panicle^{-1}

Number of filled grains from 2 hills were counted and average of which gave the number of filled grains panicle^{-1}. Presence of any food material inside the grains was considered a filled grain.

3.10.7 Weight of 1000-grain (g)

One thousand cleaned dried grains were randomly collected from the seed stock obtained from 2 hills of each pot and were sun dried properly at 14% moisture content and weight by using an electric balance.

3.10.8 Grain and straw yield (t ha^{-1})

Two hills pot^{-1} were harvested for yield measurement. The crop of each pot was bundled separately, tagged properly and brought to threshing floor and brought to threshing floor .The bundles were dried in open sunshine, threshed and then grains were cleaned. The grain and straw weights for each pot were recorded after proper drying in sun after that the weight was converted to t/ ha.

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

Biological yield was calculated by using the following formula:

Biological yield = Grain yield + straw yield

3.10.10 Harvest index (%)

Harvest index is the relationship between grain yield and biological yield. It was calculated by using the following formula

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

3.11 Statistical analysis

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program Statistix 10.0 and the mean differences were adjusted by Least Significance Difference (LSD) test at 5% level of significance (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

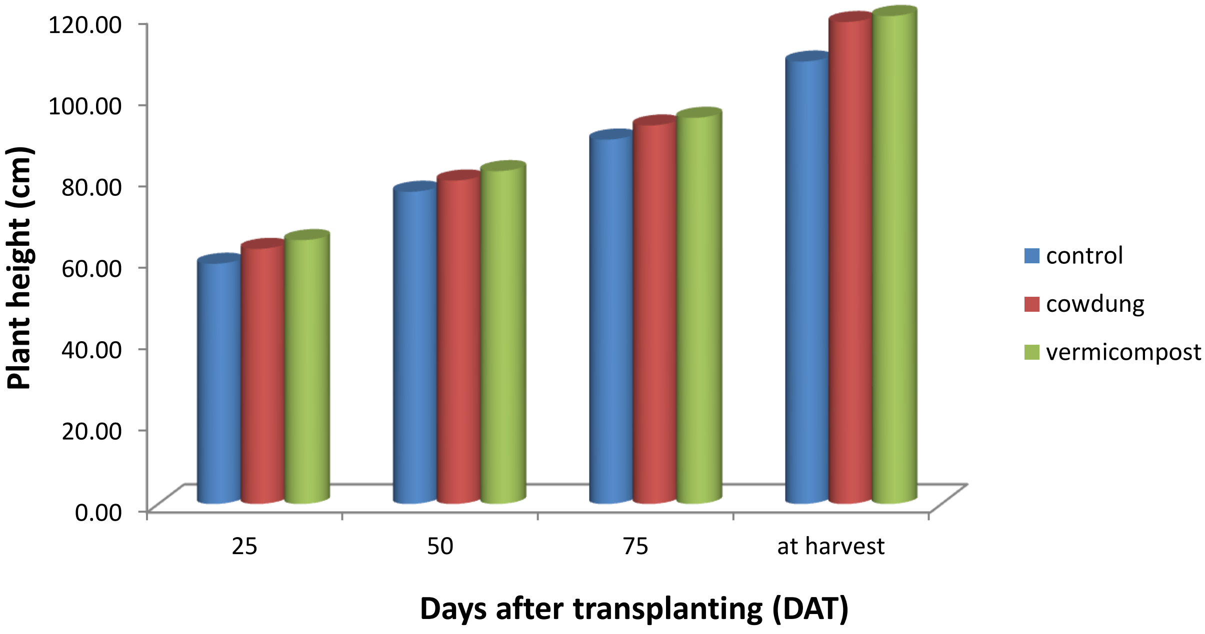
Results obtained from the study " Assessing the residual effect of organic manure and fertilizer management in T. aman rice" have been presented and discussed in this chapter. Treatments effect of organic manure and fertilizer management levels on all the studied parameters have been presented in various tables and figures and discussed below under the following sub-headings.

4.1 Growth Performance of T. aman rice

4.1.1 Plant height (cm)

4.1.1.1 Effect of residual organic manure

Significant variation at 5 % level on plant height of T. aman rice (BRRI dhan34) was found at different days after transplanting except at 15 DAT influenced by different organic manure treatment (Fig 1) Among the organic manures Vermicompost (O_2) showed significantly the tallest plant (64.74, 81.71, 94.82, and 119.84 cm at 25, 50, 75 and at harvest, respectively) which was statistically similar with Cowdung (O_1) at harvest. Significantly the shortest plant (58.93, 76.64, 89.48, and 108.67 cm at 25, 50, 75 DAT and harvest, respectively) was found in Control (Without organic manure) (O_0) treatment which was statistically similar with O_1 at 25, 50, 75 DAT and at harvest, respectively. The results consistent with the findings of Roy *et al*. (2016), Islam *et al*. (2015) and Bisne *et al.* (2008) who observed plant height differed significantly among the varieties.

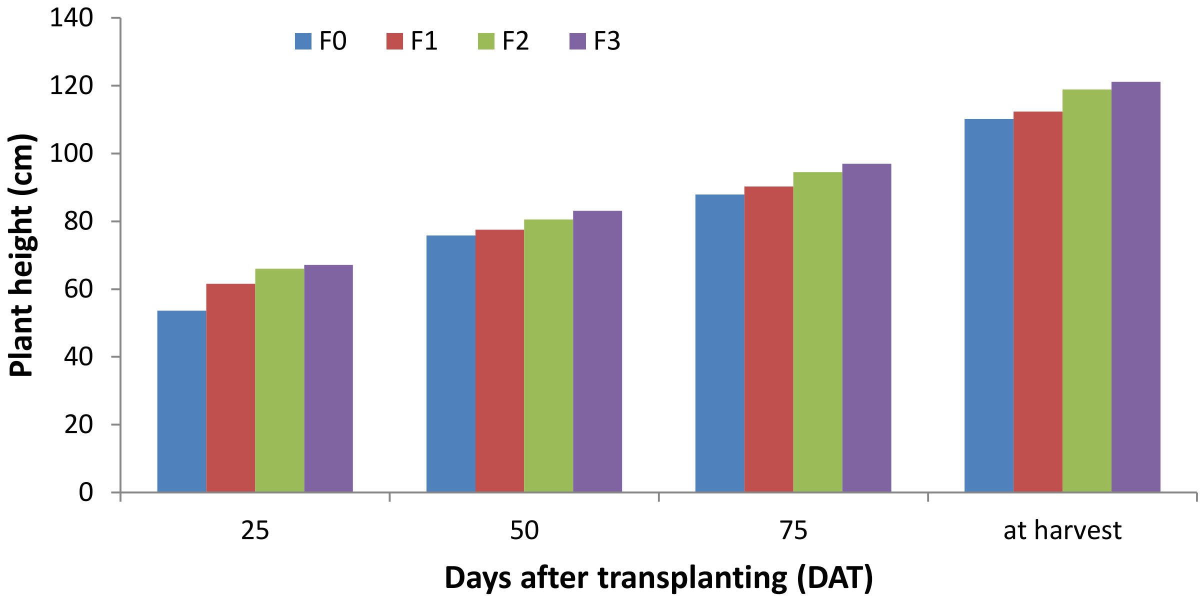


O_0= Control (Without organic manure), O_1=Cowdung , O_2= Vermicompost

Fig. 1. Effect of residual organic manure on plant height at different days after transplanting of T. aman rice (LSD $_{(0.05)}$ = 3.16) (LSD $_{(0.05)}$ = 3.90) (LSD $_{(0.05)}$ = 4.54) (LSD $_{(0.05)}$ = 6.09) for 25, 50, 75 DAT and at harvest, respectively

4.1.1.2 Effect of fertilizer management

Effect of fertilizer management showed a significant variation at 5 % level on plant height for all days after transplanting (Fig.2) At 25 DAT, the tallest plant (67.15 cm) was recorded from F_3 (RDF)which was statistically similar with (66.07 cm) F_2(75% of RDF), while the shortest plant (53.58 cm) was recorded from F_0 (Control Without fertilizer), which was statistically similar with all fertilizer treatments (61.59 cm) F_1 (50% of RDF). At 50 and 75 DAT, the tallest plant (83.08 and 96.98 cm) was recorded from F_3 (RDF)which was statistically similar with (80.57 and 94.51 cm)F_2 (75% of RDF), while the shortest plant (75.82 and 87.90 cm) was recorded from F_0 (Control Without fertilizer), which was statistically similar with all fertilizer treatments (77.53 and 90.25 cm) F_1 (50% of RDF). At harvest, the tallest plant (121.11 cm) was recorded from F_3 which was statistically similar with (118.85 cm) F_2. while the shortest plant (110.22 cm) was recorded from F_0 ,which was statistically (112.35 cm) F_1.



F_0= Control (Without fertilizer), F_1= 50% of RDF, F_2= 75% of RDF, F_3= RDF (Recommended dose of Fertilizer)

Fig. 2. Effect of fertilizer management on plant height at different days after transplanting of T. aman rice (LSD $_{(0.05)}$ = 3.64) (LSD $_{(0.05)}$ = 4.50) (LSD $_{(0.05)}$ = 5.24) (LSD $_{(0.05)}$ = 7.03) for 25, 50, 75 DAT and at harvest, respectively

4.1.1.3 Interaction effect

Interaction effect of residual organic manure and fertilizer management increase gradually with advances of growth period in respect of plant height (Table 1). The increasing rate was much higher in the early stages of growth 25 DAT to 50 DAT. After that the increasing rate was much slower up to harvest. However, the tallest plant (69.62, 84.50, 98.97, and 125.27 cm at 25, 50, 75 DAT and harvest, respectively) was found in the treatment combination O_2F_3 which was statistically similar with the treatment combination of O_2F_2, O_1F_3, O_1F_2, O_2F_1 at 25, 50, 75 DAT and at harvest. The lowest plant height (51.80, 72.73, 84.66 and 103.67 cm at 25, 50, 75 DAT and at harvest, respectively) was obtained from the treatment combination of O_0F_0.

Table1. Interaction effect of residual organic manure and fertililizer management on plant height of T. aman rice at different days after transplanting

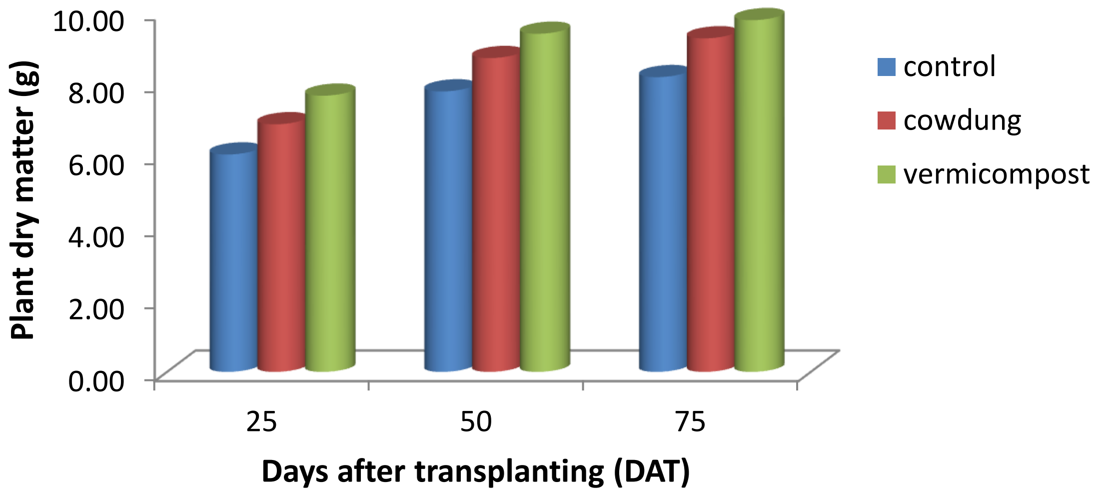
Treatment combination	Days after transplanting (DAT)			
	25	50	75	At harvest
O_0F_0	51.80 d	72.73 d	84.66 d	103.67 e
O_0F_1	57.61 cd	77.20 a-d	90.33 a-d	112.82 b-e
O_0F_2	62.90 bc	78.97 a-d	91.43 a-d	114.16 a-e
O_0F_3	63.41 a-c	79.93 a-d	92.93 a-d	114.67 a-e
O_1F_0	52.87 d	75.13 cd	87.17 cd	105.50 de
O_1F_1	62.63 bc	77.53 a-d	90.66 a-d	113.83 a-e
O_1F_2	66.42 ab	81.50 a-c	95.05 a-c	121.83 a-c
O_1F_3	68.42 ab	83.25 ab	97.06 ab	123.05 a-c
O_2F_0	56.08 d	75.76 b-d	88.71 b-d	111.67 c-e
O_2F_1	64.53 ab	81.06 a-c	94.65 a-c	116.87 a-d
O_2F_2	68.73 ab	83.46 ab	97.33 ab	124.25 ab
O_2F_3	69.62 a	84.50 a	98.97 a	125.27 a
$LSD_{0.05}$	**6.31**	**7.80**	**9.08**	**12.19**
CV(%)	**6.04**	**5.84**	**5.83**	**6.25**

O_0= Control (Without organic manure) O_1=Cowdung O_2= Vermicompost;F_0= Control (Without fertilizer), F_1= 50% of RDF, F_2= 75% of RDF, F_3= RDF (Recommended dose of fertilizer)

4.1.2 Dry matter content plant^{-1} (g)

4.1.2.1 Effect of residual organic manure

Significant variation on plant dry matter of T. aman rice (BRRI dhan34) was found at different days after transplanting as influenced by different organic manure treatment from (Fig 3). Among the organic manures, Vermicompost (O_2) showed significantly the maximum dry matter weight plant (8.16, 22.11 and 29.79 gm at 25.50 and 75 and respectively) which was statistically similar with Cowdung (O_1) (7.71, 20.83 and 28.05 gm at 25.50 and 75 DAT respectively). Significantly the minimum dry matter weight plant (6.73, 17.81 and 22.94 gm at 25.50 and 75 DAT respectively) was found in 0_0 (Control Without organic manure).The results consistent with the findings of Jafrul *et al*. (2016), Islam *et al*. (2015) and Sumon *et al.* (2015) who observed plant height differed significantly among the treatment.

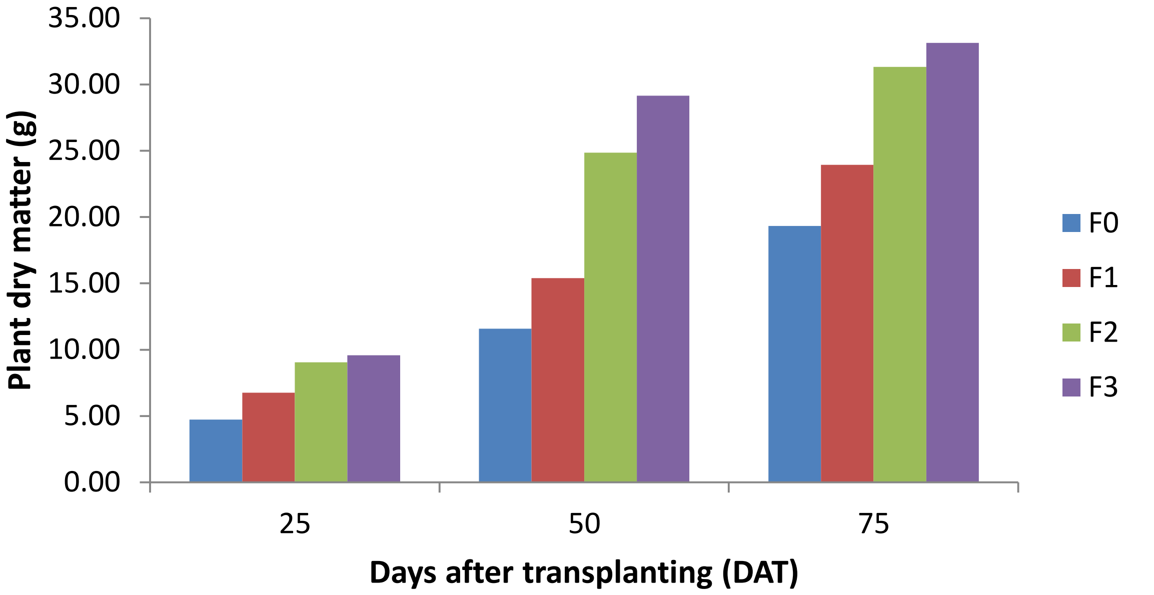


O_0= Control (Without organic manure), O_1=Cowdung , O_2= Vermicompost

Fig. 3. Effect of residual organic manure on plant dry matter at different days after transplanting of T. aman rice (LSD $_{(0.05)}$ = 0.52) (LSD $_{(0.05)}$ = 1.51) (LSD $_{(0.05)}$ = 2.06) for 25, 50, 75 DAT, respectively

4.1.2.2 Effect of fertilizer management

Effect of fertilizer management showed a significant variation at 5 % level on plant dry matter for all days after transplanting (Fig 4). At 25 DAT, The maximum plant dry matter weight (9.59 gm) was recorded from F_3 (RDF of Urea, TSP, MOP, Zypsum)which was statistically similar with (9.06 gm) F_2(75% of Urea, TSP, MOP), while the minimum plant dry matter weight (4.73 gm) was recorded from F_0 (Control (Without fertilizer)), which was statistically similar with all fertilizer treatments (6.76 gm) F_1 (50% of RDF). At 50 and 75 DAT, the maximum plant dry matter (29.16 and 33.14 gm) was recorded from F_3 (RDF) which was statistically similar with (24.85 and 31.32 gm)F_2 (75% of RDF), while the minimum plant dry matter (11.59 and 19.32 gm) was recorded from F_0 (Control (Without fertilizer)), which was statistically similar with all fertilizer treatments (15.40 and 23.93 gm) F_1 (50% of RDF).



F_0= Control (Without fertilizer), F_1= 50% of RDF, F_2= 75% of RDF, F_3= RDF (Recommeded dose of fertilizer)

Fig. 4. Effect of fertilizer management on plant dry matter at different days after transplanting of T. aman rice (LSD $_{(0.05)}$ = 0.60) (LSD $_{(0.05)}$ = 1.74) (LSD $_{(0.05)}$ = 2.38) for 25, 50, 75 DAT, respectively

4.1.2.3 Interaction effect

Interaction effect of residual organic and fertilizer management showed an increasing trend with advances of growth period of T. aman rice in respect of plant dry matter (Table 2). The increasing rate of dry matter was higher in the mid stages of growth 50 DAT to 75 DAT. After that the increasing rate of dry matter was much slower up to harvest. However, The maximum plant dry matter (10.28, 30.25 and 36.89 gm at 25, 50, and 75 DAT) was found in the treatment combination O_2F_3 which was statistically similar with the treatment combination of $O_2F_{2,}$ $O_1F_{3,}$ $O_1F_{2,}$ O_1F_3 at 25, 50 and 75 DAT except O_1F_2 at 50 DAT. Here treatment combination $O_0F_{3,}$ $O_0F_{2,}$ $O_2F_{1,}$ O_1F_1 which was statistically similar (25, 50 and 75 DAT, respectively) with all other interactions except O_0F_1 at 50DAT time. The minimum plant dry matter (4.04, 8.89 and 16.25 gm at 25, 50, and 75 DAT) was obtained from the treatment combination of O_0F_0 which was statistically similar with the treatment combination of O_0F_1 at 25, 50 DAT. Also similar O_1F_0, O_2F_0 treatment combination except O_2F_0 at 75 DAT.

Table2. Interaction effect of residual organic manure and fertilizer management on plant dry matter of T. aman rice at different days after transplanting

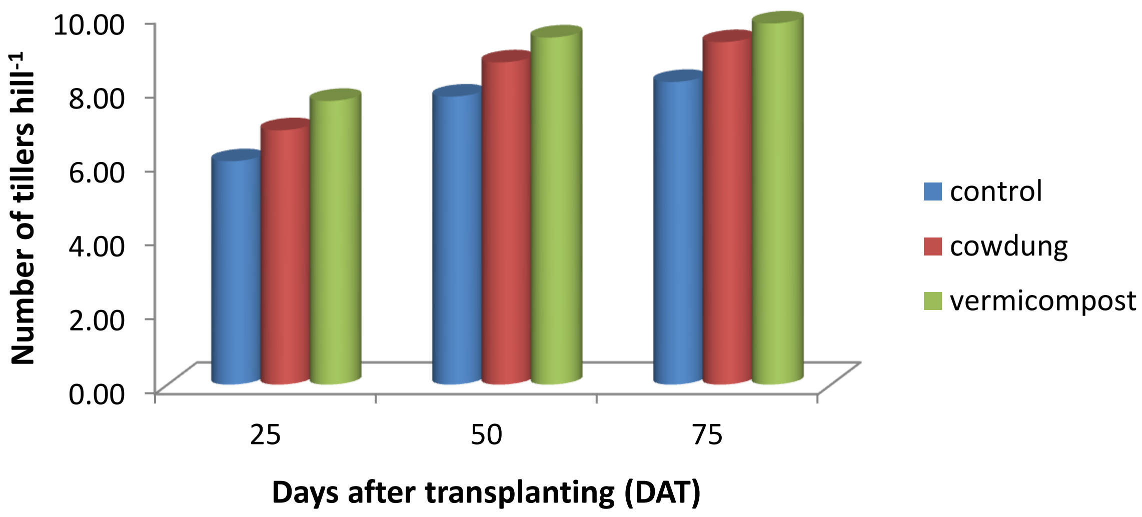
Treatment combination	Days after transplanting (DAT)		
	25	50	75
O_0F_0	4.04 h	8.89 h	16.25 e
O_0F_1	6.25 ef	13.813 fg	22.32 cd
O_0F_2	8.01 cd	22.24 d	26.23 bc
O_0F_3	8.63 bc	27.9 a-c	28.48 b
O_1F_0	4.867 gh	12.07 g	19.39 de
O_1F_1	6.86 e	16.76 ef	25.22 bc
O_1F_2	9.25 ab	25.13 cd	32.99 a
O_1F_3	9.87 a	29.34 ab	34.047 a
O_2F_0	5.28 fg	12.217 g	20.81 d
O_2F_1	7.17 de	17.21 e	25.773 bc
O_2F_2	9.927 a	27.18 bc	34.73 a
O_2F_3	10.28 a	30.25 a	36.89 a
$LSD_{0.05}$	**1.04**	**3.02**	**4.13**
CV(%)	**8.21**	**8.84**	**9.10**

O_0= Control (Without organic manure) O_1=Cowdung O_2= Vermicompost;F_0= Control (Without fertilizer), F_1= 50% of Urea, TSP, MOP, Zypsum, F_2= 75% of Urea, TSP, MOP, Zypsum, F_3= RDF of Urea, TSP, MOP, Zypsum

4.1.3 Number of tillers hill^{-1} (no.)

4.1.3.1 Effect of residual organic manure

Significant variation at 5 % level on number of tillers hill^{-1} of T. aman rice (BRRI dhan34) was found at different days after transplanting influenced by different organic manure treatment (Fig 5). Among the organic manure, Vermicompost (O_2) showed significantly the maximum number tillers hill^{-1} (7.67, 9.38 and 9.75 at 25,50 and 75 DAT, respectively) which was statistically similar with Cowdung (O_1) (6.88, 8.71 and 9.25 at 25.50 and 75 DAT and respectively). Significantly the minimum number tillers hill^{-1} (6.04, 7.78 and 8.18 at 25.50 and 75 and respectively) was found in Control (Without organic manure). The results consistent with the findings of Jafrul *et al*. (2016), Islam *et al*. (2015) and Sumon *et al.* (2015) who observed plant height differed significantly among the varieties.



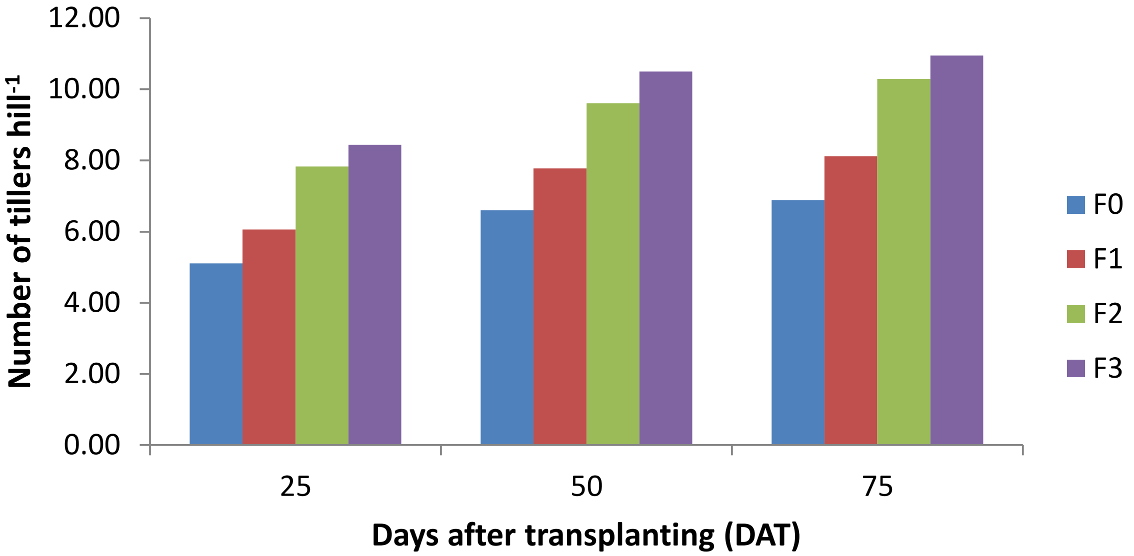
O_0= Control (Without organic manure), O_1=Cowdung , O_2= Vermicompost

Fig. 5. Effect of residual organic manure on number of tillers hill^{-1} at different days after transplanting of T. aman rice (LSD $_{(0.05)}$ = 0.51) (LSD $_{(0.05)}$ = 0.53) (LSD $_{(0.05)}$ = 0.54) for 25, 50, 75 DAT, respectively

4.1.3.2 Effect of fertilizer management

Effect of fertilizer management level showed a significant variation at 5 % level on number tillers hill^{-1} for all days after transplanting in rice (Fig 6). At 25 DAT, The maximum number (8.44) was recorded from F_3 (RDF) which was statistically similar with (7.83) F_2(75% of RDF), while the minimum number of tillers hill^{-1} (5.11) was recorded from F_0 (Control Without fertilizer), which was statistically similar with all fertilizer treatments (6.06) F_1 (50% of RDF). At 50 and 75 DAT, the maximum plant dry matter (10.50 and 10.94) was recorded from F_3 (RDF) which was statistically similar with (9.61 and 10.29)F_2 (75% of RDF), while the minimum number of tillers hill^{-1} (6.60 and 6.89) was recorded from F_0 (Control Without fertilizer), which was statistically similar with all fertilizer treatments (6.60 and 8.11) F_1 (50% of RDF).

The results agreed with the findings of Bayan and Kandasamy (2002), Islam *et al.* (2008) and Mannan *et al.* (2010).



F_0= Control (Without fertilizer), F_1= 50% of RDF,F_2= 75% of RDF, F_3= RDF (Recommended dose of fertilizer)

Fig. 6. Effect of fertilizer management on number of tillers hill^{-1} at different days after transplanting of T. aman rice (LSD $_{(0.05)}$ = 0.59) (LSD $_{(0.05)}$ = 0.61) (LSD $_{(0.05)}$ = 0.62) for 25, 50, 75 DAT, respectively

4.1.3.3 Interaction effect

A significant variation on number of tillers hill^{-1} was observed due to interaction of organic manure and fertilizer management (Table 3). The result revealed that highest interaction of O_2F_3 Showed the highest number of tillers hill^{-1} (9.33, 11.5 and 11.67 at 25, 50, and 75 DAT, respectively) which was statistically similar with O_2F_2, O_1F_3 except O_1F_1 at 50 DAT. The minimum tillers hill^{-1} (4.33, 5.8 and 5.83 at 25, 50, and 75 DAT, respectively) was obtained from the treatment combination of O_0F_0. At 25 DAT O_0F_1, O_1F_0 and at 50DAT O_1F_0 interaction showed statistically similar result with the lowest one which observed at O_0F_0 interaction.

Table3. Interaction effect of residual organic manure and fertilizer management on number of tillers hill^{-1} of T. aman rice at different days after transplanting

Treatment combination	Days after transplanting (DAT)		
	25	**50**	**75**
O_0F_0	4.33 h	5.8 f	5.83 h
O_0F_1	5.33 gh	7.33 c-e	7.67 fg
O_0F_2	6.83 d-f	8.33 c	9.38 de
O_0F_3	7.67 c-e	9.67 b	9.83 cd
O_1F_0	5.17 gh	6.83 ef	7.17 g
O_1F_1	6.17 fg	7.83 c-e	8 fg
O_1F_2	7.83 b-d	9.83 b	10.5 bc
O_1F_3	8.33 a-c	10.33 b	11 ab
O_2F_0	5.83 fg	7.17 de	7.67 fg
O_2F_1	6.67 ef	8.17 cd	8.67 ef
O_2F_2	8.83 ab	10.67 ab	11.33 ab
O_2F_3	9.33 a	11.5 a	11.67 a
$LSD_{0.05}$	**1.02**	**1.05**	**1.08**
CV(%)	**8.86**	**7.24**	**7.09**

O_0= Control (Without organic manure) O_1=Cowdung O_2= Vermicompost;F_0= Control (Without fertilizer), F_1= 50% of RDF, F_2= 75% of RDF, F_3= RDF (Recommended dose of fertilizer)

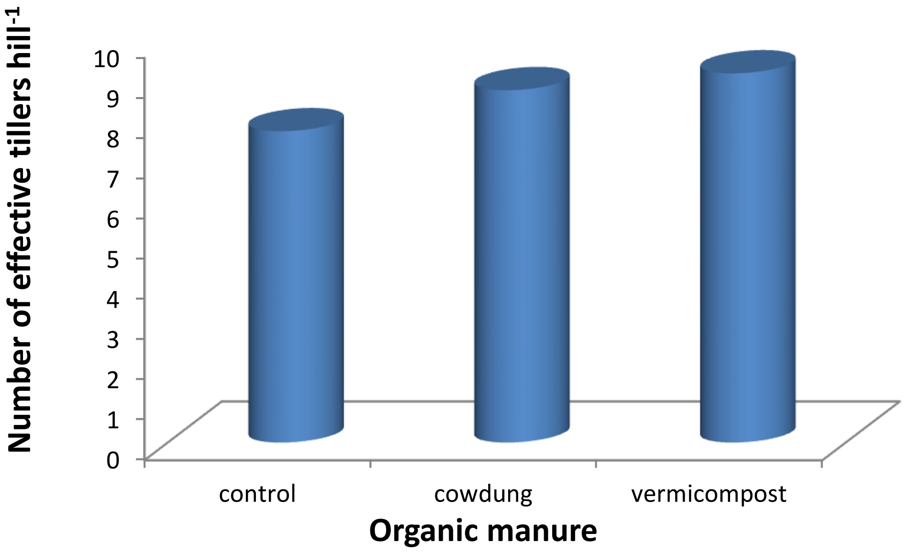
4.2 Yield contributing characters T. aman rice

4.2.1 Effective tillers hill^{-1} (no.)

4.2.1.1 Effect of residual organic manure

Significant variation was observed on number of number of effective tillers hill^{-1} among the organic manure treatments in T.aman rice (Fig 7**.** The figure showed that the highest number of effective tillers hill^{-1} (9.18) was found in Vermicompost (O_2) followed by cowdung (8.76). The lowest number of effective tillers hill^{-1} was obtained in (control Without organic manure) (7.73). The result indicated that

Vermicompost produced 18.76% higher effective tillers hill^{-1} than control. The probable reason of the differences in producing number of effective tillers hill^{-1} may be the activity of Vermicompost which is primarily influenced by soil environment. These findings collaborate with those reported by Shiyam *et al.* (2014), Roy *et al.* (2014), BINA (1998), Om *et al.* (1998) and Bhowmick and Nayak (2000) who stated that number of effective tillers hill^{-1} was varied with variety.

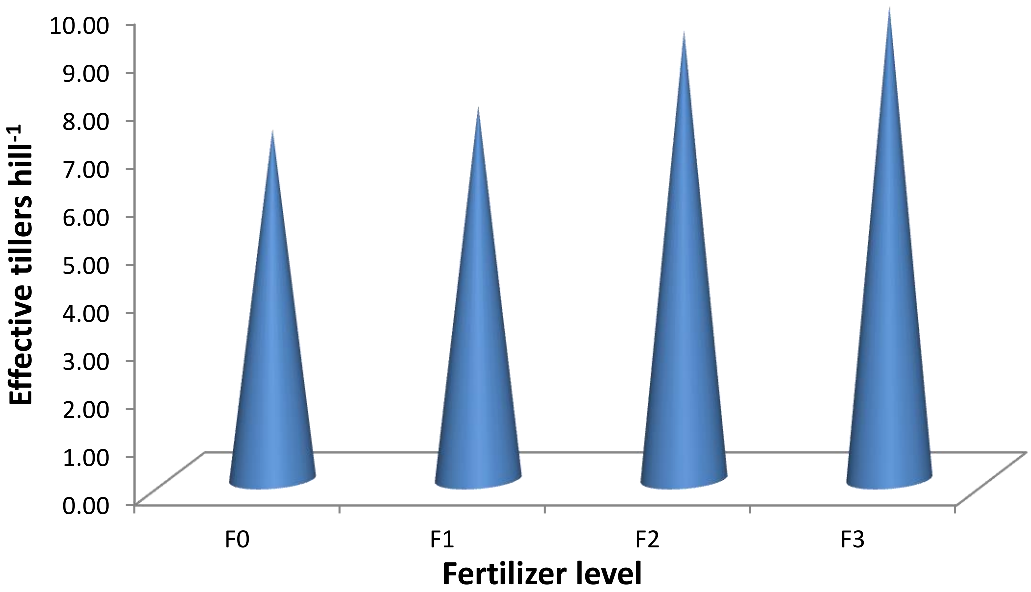


O_0= Control (Without organic manure), O_1=Cowdung , O_2= Vermicompost

Fig. 7. Effect of residual organic manure on number of effective tillers hill^{-1} at different days after transplanting of T. aman rice (LSD $_{(0.05)}$ = 0.69)

4.2.1.2 Effect of fertilizer management

Number of effective tillers hill^{-1} was significantly affected due to different fertilizer management management at 5 % level of significance (Fig 8). The highest number of effective tillers (9.84) hill^{-1} was obtained due to application of treatment F_3 which was statistically similar with F_2. The lowest number of effective tillers (7.28) hill^{-1} was obtained in F_0 which was statistically similar with F_1. The results agreed with the findings of Manzoor *et al.* (2006) and Kandil *et al.* (2010)



O_0 = Control (Without fertilizer), F_1= 50% of RDF, F_2= 75% of RDF, F_3= RDF (Recommended dose of fertilizer

Fig. 8. Effect of fertilizer management on number of effective tillers hill^{-1} at different days after transplanting of T. aman rice (LSD $_{(0.05)}$ = 0.79)

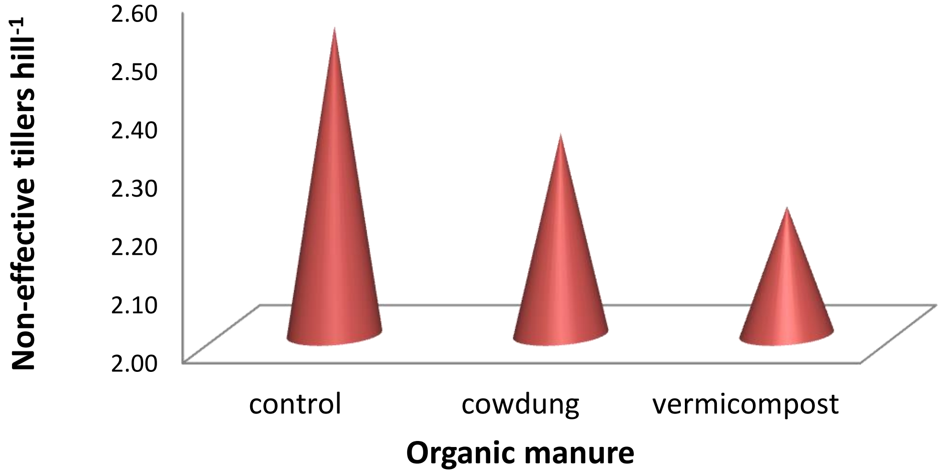
4.2.1.3 Interaction effect

Significant interaction between organic manure and fertilizer management level interact significantly on producing number of effective tillers hill^{-1} in T. aman rice (Table 4). The highest number of effective tillers hill^{-1} (10.47) was counted in the interaction of O_2F_3 which was statistically similar with O_1F_3 and O_2F_2. The lowest number of effective tillers hill^{-1} (6.47) was counted in O_0F_0 interaction treatment which was statistically similar with O_0F_1 and O_1F_0.

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

4.2.2.1 Effect of residual organic manure

Significant variation was observed on number of non-effective tillers hill^{-1} among the organic manure in T. aman rice (Fig 9**).** The figure showed that the highest number of non-effective tillers hill^{-1} (2.22) was found in Vermicompost (O_2) followed by cowdung (2.35). The highest number of non-effective tillers hill^{-1} was obtained in control (without organic manure) (2.53). The result indicated that control produced 13.89% higher non-effective tillers hill^{-1} than Vermicompost. The probable reason of the differences in producing number of effective tillers hill^{-1} may be the activity of Vermicompost which is primarily influenced by soil environment.

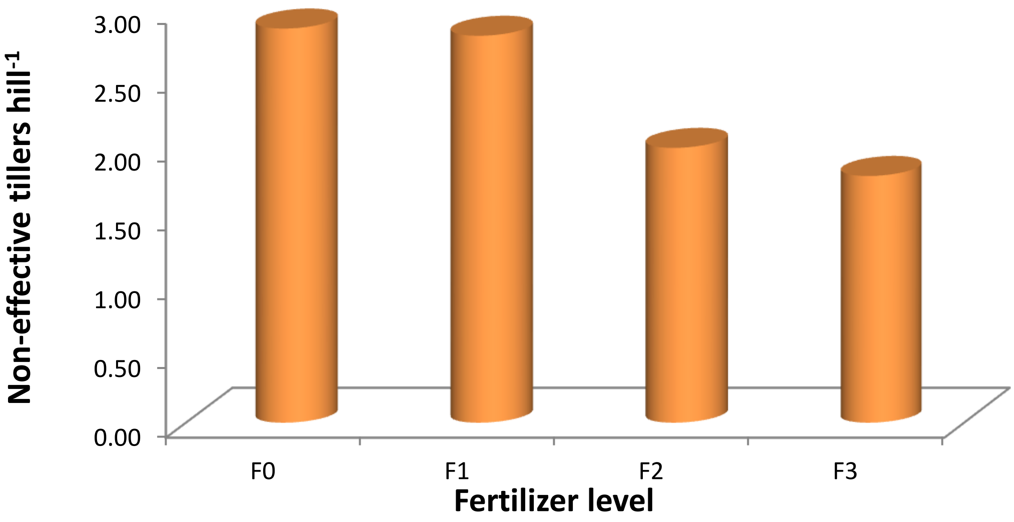


O_0= Control (Without organic manure), O_1=Cowdung , O_2= Vermicompost

Fig. 9. Effect of residual organic manure on number of non-effective tillers hill^{-1} at different days after transplanting of T. aman rice (LSD $_{(0.05)}$ = 0.59)

4.2.2.2 Effect of fertilizer management

Number of non-effective tillers hill^{-1} was significantly affected due to different fertilizer management levels at 5 % level of significance (Fig 10). The highest number of non-effective tillers (2.86) hill^{-1} was obtained due to application of treatment F_0 which was statistically similar with F_1.The lowest number of non-effective tillers (1.79) hill^{-1} was obtained in F_3 which was statistically similar with F_2. The results agreed with the findings of Manzoor *et al.* (2006) and Kandil *et al.* (2010).



F_0= Control (Without fertilizer), F_1= 50% of RDF, F_2= 75% of RDF, F_3= RDF (Recommended dose of fertilizer)

Fig. 10. Effect of fertilizer management on number of non-effective tillers hill^{-1} at different days after transplanting of T. aman rice (LSD $_{(0.05)}$ = 0.69)

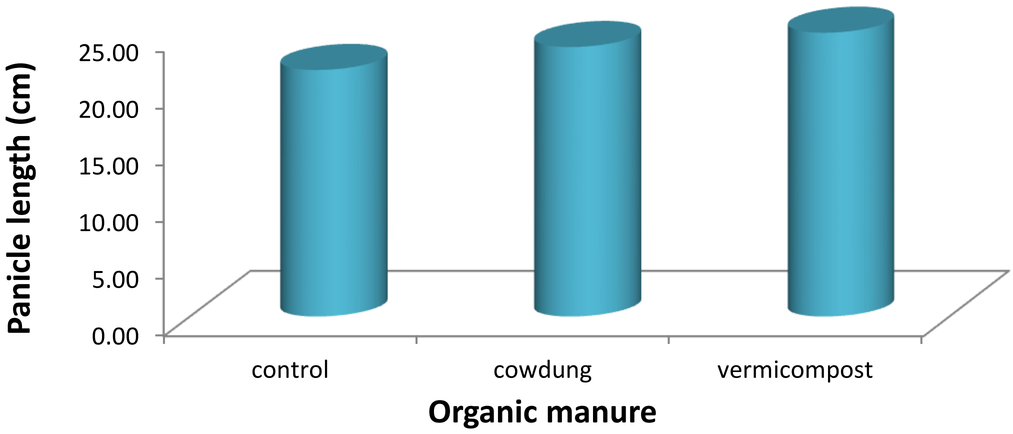
4.2.2.3 Interaction effect

Significant interaction between organic manure and fertilizer management level was found in producing number of non-effective tillers hill^{-}1in rice (Table 4). The highest number of non-effective tillers hill^{-1} (3.34) was counted in the interaction of O_0F_0 which was statistically similar with O_0F_1 and O_1F_0. The lowest number of non-effective tillers hill^{-1} (1.70) was counted in O_1F_3 interaction treatment which was statistically similar with all intractions except O_0F_0, O_0F_1 and O_1F_0 .

4.2.3 Panicle length (cm)

4.2.3.1 Effect of residual organic manure

Significant variation was observed on panicle length among the organic manure in T. aman rice (Fig 11). The figure showed that the maximum panicle length (24.99 cm) was found in vermicompost (O_2) which is statistically similar with cowdung (O_1) (23.74). The minimum panicle length was obtained in control (O_0) (21.72cm). The results agreed with the findings of Hossain *et al.* (2014) and Sarker *et al.* (2013).

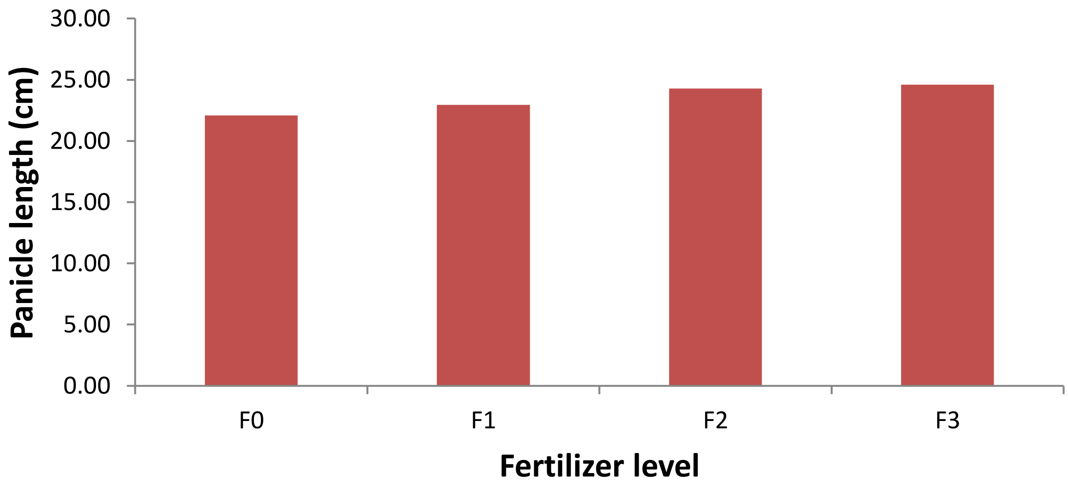


O_0= Control (Without organic manure), O_1=Cowdung , O_2= Vermicompost

Fig. 11. Effect of residual organic manure on panicle length (cm) at different days after transplanting of T. aman rice (LSD $_{(0.05)}$ = 1.15)

4.2.3.2 Effect of fertilizer management

Panicle length was significantly affected due to different fertilizer management at 5 % level of significance **(**Fig 12**).** The maximum panicle length (24.59 cm) was obtained due to application of treatment F_3 which was statistically statistically similar with F_2. The minimum panicle length (22.09 cm) was obtained in F_0 and followed by F_1. The results agreed with the findings of Mannan *et al.* (2010), Kandil *et al.* (2010) and Islam *et al.* (2008) in respect of panicle length.



F_0= Control (Without fertilizer), F_1= 50% of RDF, F_2= 75% of RDF, F_3= RDF (Recommended dose of fertilizer)

Fig. 12. Effect of fertilizer management on panicle length (cm) at different days after transplanting of T. aman rice (LSD $_{(0.05)}$ = 1.15)

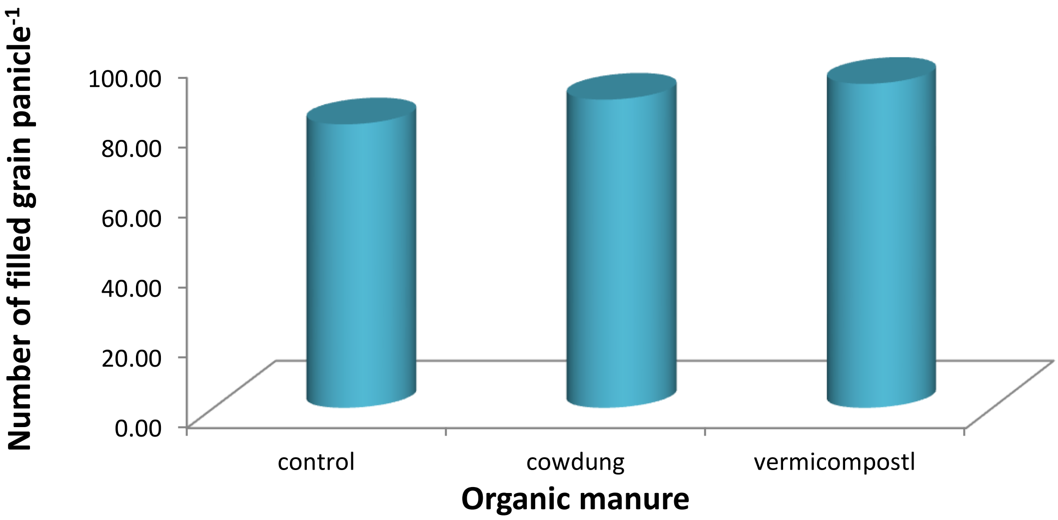
4.2.3.3 Interaction effect

Significant interaction between organic manure and fertilizer management exerted significant variation on panicle length (Table 4). The maximum panicle length (10.47) was observed in the interaction of O_2F_3 which was statistically similar with O_1F_2, O_1F_3, O_2F_1 and O_2F_2. The lowest panicle length (6.47) was observed in O_0F_0 interaction treatment which was statistically similar with O_0F_1 and O_1F_0.

4.2.4 Filled grain panicle^{-1} (no.)

4.2.4.1 Effect of residual organic manure

Significant variation was observed on number of filled grains panicle^{-1} among the organic manure in T. aman rice (Fig 13). The figure showed that the highest number of filled grains panicle^{-1} (92.58) was found in Vermicompost (O_2) followed by cowdung (88.04). The minimum number of filled grains panicle^{-1} was obtained in control (without organic manure) (80.97). The result indicated that Vermicompost produced 14.34% higher filled grains panicle^{-1} than control. The probable reason of the differences in producing number of filled grains panicle^{-1} may be the activity of Vermicompost which is primarily influenced by soil environment. Similar results were also found by several authors (Shiyam *et al.*, 2014; Hossain *et al.*, 2014; and Sarker *et al.*, 2013).

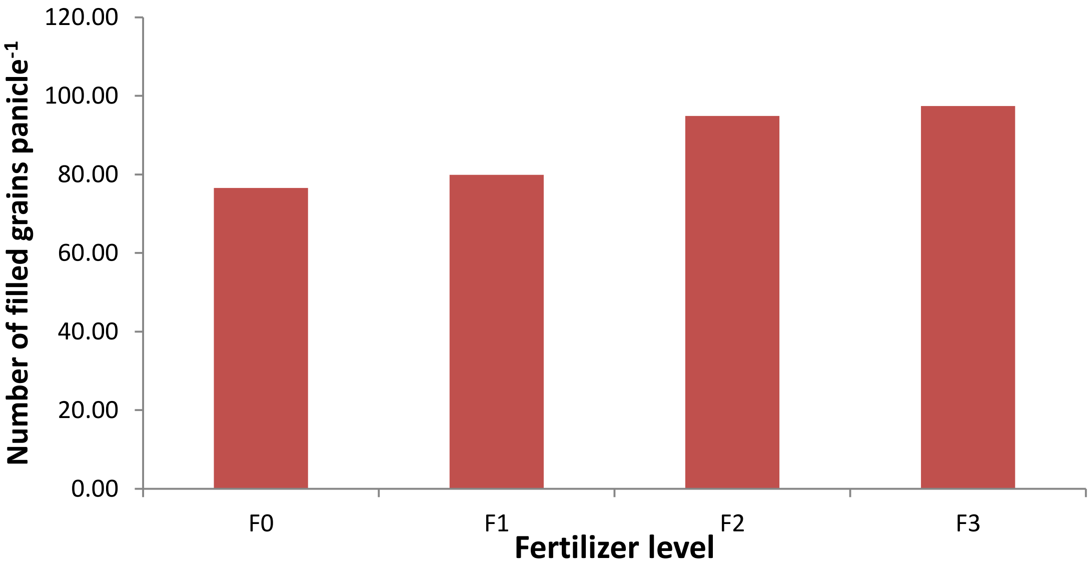


O_0= Control (Without organic manure), O_1=Cowdung , O_2= Vermicompost

Fig. 13. Effect of residual organic manure on number of filled grains panicle^{-1} at different days after transplanting of T. aman rice (LSD $_{(0.05)}$ = 4.94)

4.2.4.2 Effect of fertilizer management

Number of filled grains panicle^{-1} was significantly affected due to different fertilizer management of T. aman rice at 5 % level of significance (Fig 14**).** The maximum number of filled grains panicle^{-1} (97.43) was obtained due to application of treatment F_3 which was statistically statistically similar with F_2. The minimum number of filled grains panicle^{-1} (76.56) was obtained in F_0 and followed by F_1. The result revealed that treatment F_3 produced 27.27% higher number of filled grains panicle^{-1} than treatment F_0.



F_0= Control (Without fertilizer), F_1= 50% of RDF, F_2= 75% of RDF, F_3= RDF (Recommended dose of fertilizer)

Fig. 14. Effect of fertilizer management on number of filled grains panicle^{-1} at different days after transplanting of T. aman rice (LSD $_{(0.05)}$ = 5.76)

4.2.4.3 Interaction effect

Interaction between organic manure and fertilizer management showed significant variation in producing number of filled grains panicle^{-1} (Table 4). The highest number of filled grains panicle^{-1} (102.83) was counted in the interaction of O_2F_3 which was statistically similar with O_2F_2 and O_1F_3. The lowest number of filled grains panicle^{-1} (70.83) was counted in O_0F_0 interaction treatment which was statistically similar with O_0F_1 ,O_1F_0 and O_1F_1

Table4. Interaction effect of residual organic manure and fertilizer management on effective tillers hill^{-1}(no.), effective tillers hill^{-1}(no.), panicle length (cm), filled grains panicle^{-1} (no.) of T. aman rice

Treatment combination	Effective tillers hill^{-1} (no.)	Non-effective tillers hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)
O_0F_0	6.47 h	3.34 a	20.34 d	70.83 h
O_0F_1	6.913 gh	3.16 ab	21.03 cd	74.1 gh
O_0F_2	8.62 c-f	1.77 cd	22.68 bc	88.83 c-e
O_0F_3	8.933 b-e	1.84 cd	22.83 bc	90.13 b-d
O_1F_0	7.33 f-h	2.9 a-c	22.56 b-d	77.17 f-h
O_1F_1	8.01 e-g	2.76 a-d	23.27 bc	79.5 e-h
O_1F_2	9.57 a-d	2.02 b-d	24.35 ab	96.16 a-c
O_1F_3	10.11 ab	1.7c-d	24.77 ab	99.34 ab
O_2F_0	8.03 e-g	2.34 a-d	23.38 b	81.67 d-g
O_2F_1	8.37 d-f	2.50 a-d	24.58 ab	86.16 d-f
O_2F_2	9.83 a-c	2.20 a-d	25.81 a	99.67 ab
O_2F_3	10.47 a	1.84 cd	26.2 a	102.83 a
$LSD_{0.05}$	**1.37**	**1.19**	**2.29**	**9.97**
CV(%)	**9.54**	**29.81**	**5.79**	**6.78**

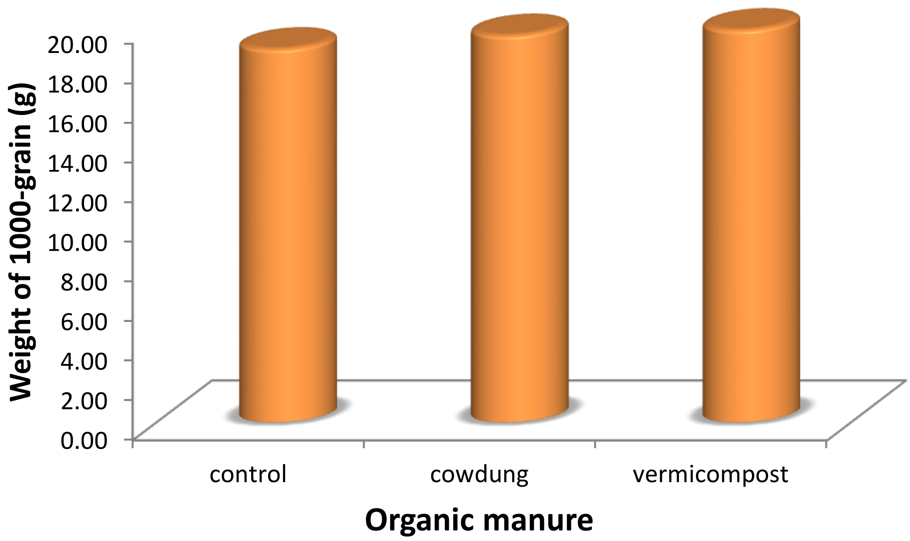
In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 5% level of probability

O_0= Control (Without organic manure) O_1=Cowdung O_2= Vermicompost;F_0= Control (Without fertilizer), F_1= 50% of RDF, F_2= 75% of RDF, Zypsum, F_3= RDF (Recommended dose of fertilizer)

4.2.5 Weight of 1000-grain (g)

4.2.5.1 Effect of residual organic manure

Significant variation was observed on the weight of 1000-grain among the organic manure treatments in T. aman rice **(**Fig 15). The figure showed that the maximum weight of 1000-grains (19.79 g) was found in Vermicompost (O_2) followed by cowdung (19.51 gm). The minimum the weight of 1000-grains 18.83g was obtained in control (without organic manure). The result indicated that Vermicompost produced 5.11% and 1.44% higher weight of 1000-grains than control and cowdung respectively. The probable reason of the differences in producing weight of 1000-grains may be the activity of Vermicompost which is primarily influenced by soil environment. The results agreed with the findings of Shiyam *et al.* (2014) and Sarker *et al.* (2013).

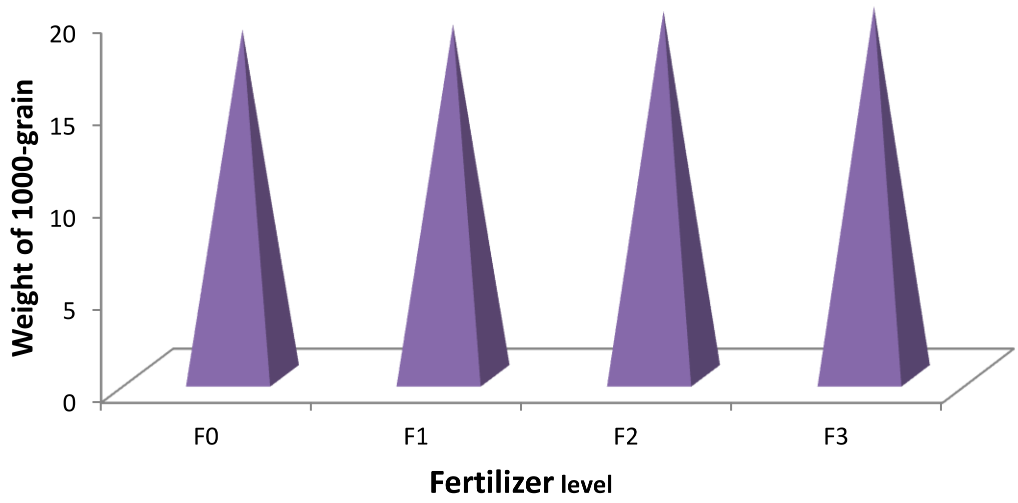


O_0= Control (Without organic manure), O_1=Cowdung , O_2= Vermicompost

Fig. 15. Effect of residual organic manure on weight of 1000-grain at different days after transplanting of T. aman rice (LSD $_{(0.05)}$ = 1.33)

4.2.5.2 Effect of fertilizer management

The weight of 1000-grain was significantly affected due to different fertilizer management at 5 % level of significance in rice **(**Fig 16**).** The maximum the weight of 1000-grains (19.98 g) was obtained due to application of treatment F_3 which was statistically similar with F_2. The minimum the weight of 1000-grains (18.76 g) was obtained in F_0 and followed by F_1 treatment F_3 produced 6.50% higher the weight of 1000-grains than treatment F_0.



F_0= Control (Without fertilizer), F_1= 50% of RDF, F_2= 75% of RDF, F_3= RDF (Recommended dose of fertilizer)

Fig. 16. Effect of fertilizer management on weight of 1000-grain at different days after transplanting of T. aman rice (LSD $_{(0.05)}$ = 1.53)

4.2.5.3 Interaction effect

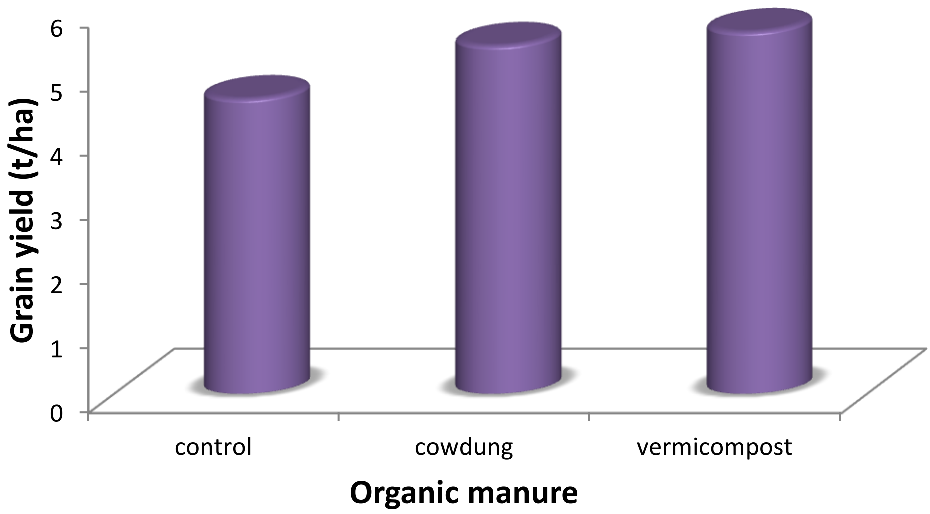
Non-significant variation was recorded on 1000-seed weight of rice grain due to interaction effect of organic manure and fertilizer level (Table 5).

4.2.6 Grain yield

4.2.6.1 Effect of residual organic manure

Significant variation was observed on the grain yield (t/ha) among the organic manure T. aman rice (Fig. 17).

The figure showed that the maximum of grain yield 5.64 t/ha was found in Vermicompost (O_2) followed by cowdung (5.42 t/ha). The minimum grain yield 4.60 t/ha was obtained in control (without organic manure). Vermicompost showed its superiority in producing highest grain than cowdung and control. The results agreed with the findings of Hossain *et al.* (2014), Shiyam *et al.* (2014) and Sarker *et al.* (2013).

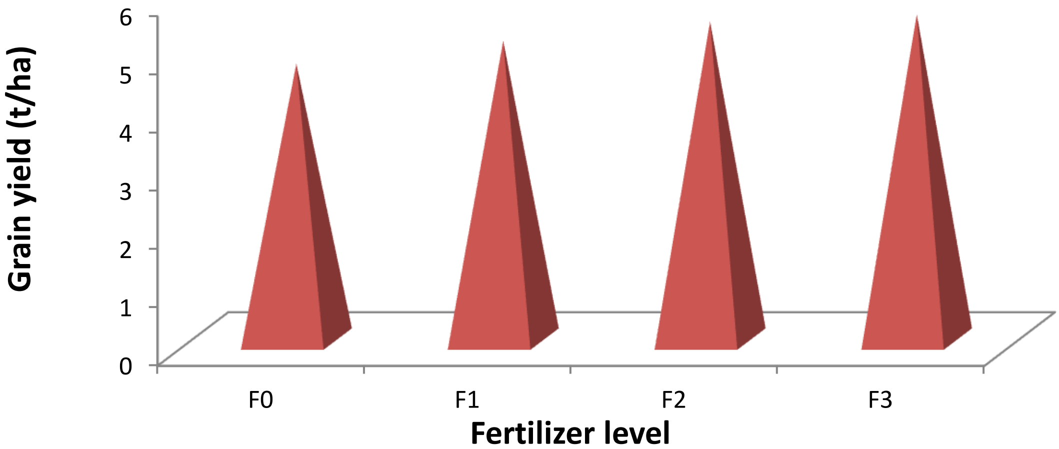


O_0= Control (Without organic manure), O_1=Cowdung , O_2= Vermicompost

Fig. 17. Effect of residual organic manure on grain yield (t/ha) at different days after transplanting of T.aman rice (LSD $_{(0.05)}$ = 0.30)

4.2.6.2 Effect of fertilizer management

The grain yield (t/ha) was significantly affected due to different fertilizer management at 5 % level of significance in rice (Fig 18). The maximum the grain yield 5.58 t/ha was obtained due to application of treatment F_3 which was statistically similar with F_2. The minimum grain yield (t/ha) (4.73 t/ha) was obtained in F_0 and followed by F_1. It can be inferred from the result that treatment F_3 produced 17.98% higher the grain yield than treatment F_0. Improvement of yield component such as number of effective tillers hill^{-1} and number of grains panicle^{-1} in these treatments ultimately resulted in high yield of grains. The results agreed with the findings of Mannan *et al.* (2010), Kandil *et al.* (2010), Islam *et al.* (2008) and Manzoor *et al.* (2006).



F_0= Control (Without fertilizer), F_1= 50% of RDF, F_2= 75% of RDF, F_3= RDF (Recommended dose of fertilizer)

Fig. 18. Effect of fertilizer management on grain yield (t/ha) at different days after transplanting of T. aman rice (LSD $_{(0.05)}$ = 0.35)

4.2.6.3 Interaction effect

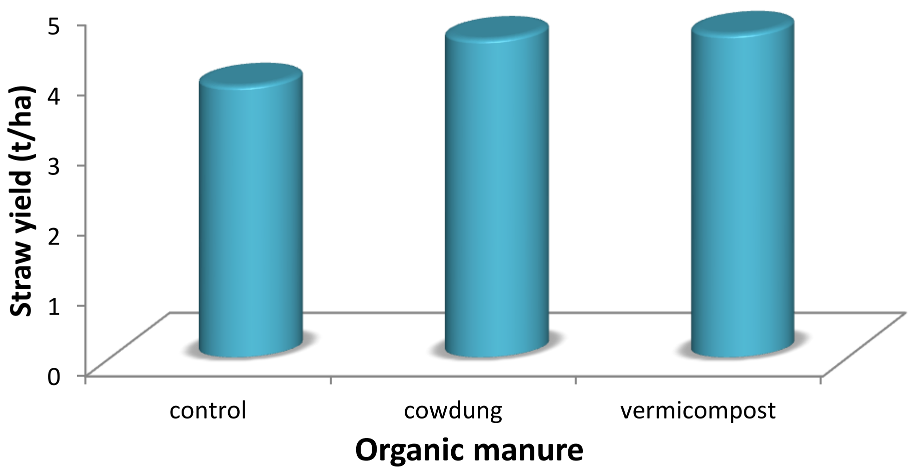
Grain of rice exerted significant variation due to interaction between organic manure and fertilizer management (Table 5). The highest grain yield (5.90 t/ha) was observed in the interaction of O_2F_3 which was statistically similar with O_2F_2, O_2F_1, O_1F_1, O_1F_2

and O_1F_3. The lowest grain yield (4.20 t/ha) was recorded in O_0F_0 interaction treatment which was statistically similar with O_0F_1.

4.2.7 Straw yield

4.2.7.1 Effect of residual organic manure

Significant variation was observed on the straw yield (t/ha) among the organic manure in T. aman rice (Fig 19). The figure showed that the maximum straw yield (4.60 t/ha) was found in Vermicompost (O_2) followed by cowdung (4.53 t/ha). The minimum straw yield was obtained 3.86 t/ha in control (without organic manure). The result indicated that Vermicompost produced 19.17 % higher straw yield (t/ha) than control. The probable reason of the differences in producing straw yield (t/ha) may be the activity of Vermicompost which is primarily influenced by soil environment. Several researchers also obtained variable straw yield among the organic manure (Chowdhury *et al.*, 1993; Kumar *et al.*, 1995; and Patel, 2000).

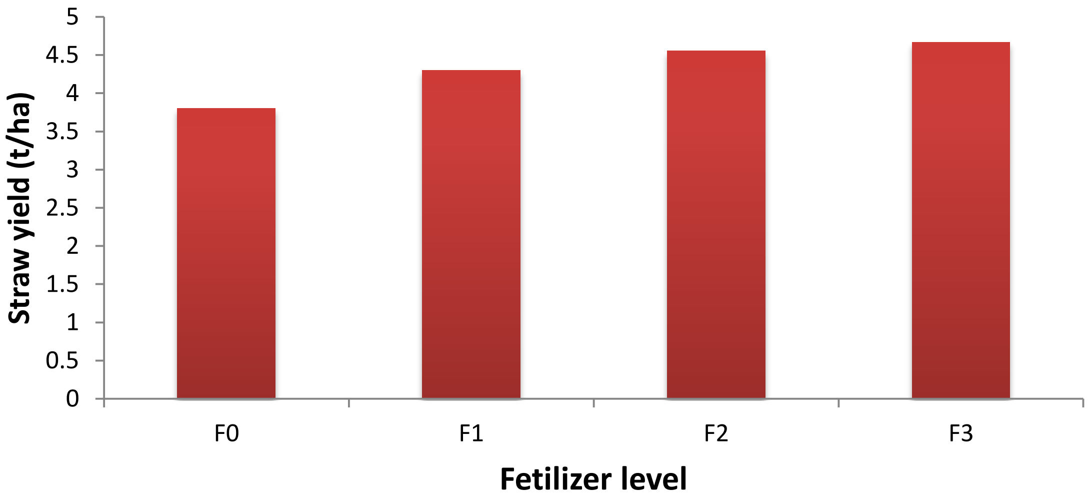


O_0= Control (Without organic manure), O_1=Cowdung , O_2= Vermicompost

Fig. 19. Effect of residual organic manure on straw yield (t/ha) at different days after transplanting of T. aman rice (LSD $_{(0.05)}$ = 0.35)

4.2.7.2Effect of fertilizer management

The straw yield was significantly affected due to different fertilizer management at 5 % level of significance (Fig 20). The maximum the straw yield (4.67 t/ha) was obtained due to application of treatment F_3 which was statistically similar with F_2. The minimum straw yield (t/ha) (3.81 t/ha) was obtained in F_0 and followed by F_1.It is revealed that treatment F_3 produced 22.57% higher the straw yield over F_0 treatment.



F_0= Control (Without fertilizer), F_1= 50% of RDF, RDF, F_2= 75% of RDF, F_3= RDF (Recommeded dose of fertilizer)

Fig. 20. Effect of fertilizer management on straw yield of T. aman rice

(LSD $_{(0.05)}$ = 0.30)

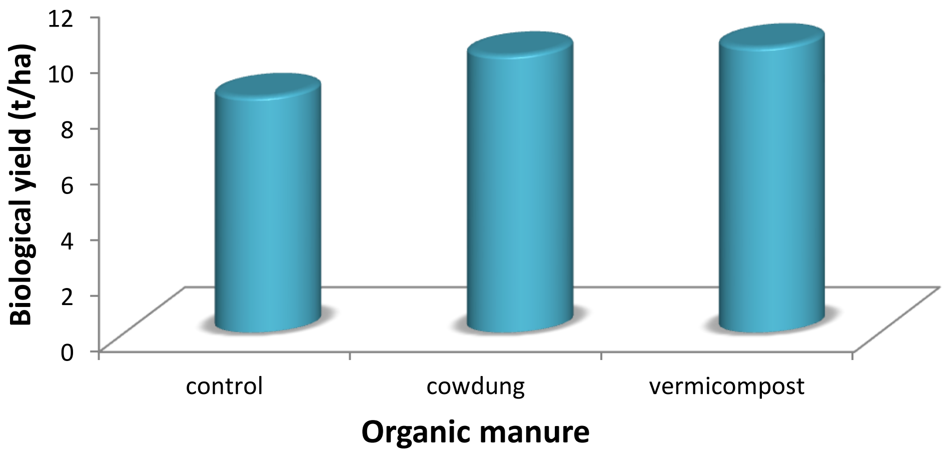
4.2.7.3 Interaction effect

Different was found on straw yield due to interaction between interaction between organic manure and fertilizer management in rice was found in producing straw yield (t/ha) (Table 5). The highest straw yield (4.93 t/ha) was measured in the interaction of O_2F_3 which was statistically similar with O_2F_2, O_1F_2, O_1F_1 and O_1F_3. The lowest straw yield (3.29 t/ha) was recorded in O_0F_0 interaction treatment which was statistically highest than any other interactions. The result also showed that vermicompost and F_3 (RDF) interaction treatment produced higher level of straw yield (t/ha) than other interactions.

4.2.8 Biological yield

4.2.8.1 Effect of residual organic manure

Significant variation was observed on the biological yield (t/ha) among the organic manure in T.aman rice (Fig 21). The figure showed that the maximum biological yield (10.24 t/ha) was found in Vermicompost (O_2) followed by cowdung (9.95). The minimum biological yield (t/ha) was obtained in control (without organic manure) (8.46 t/ha). The result indicated that Vermicompost produced 21.04% higher biological yield (t/ha) than control.

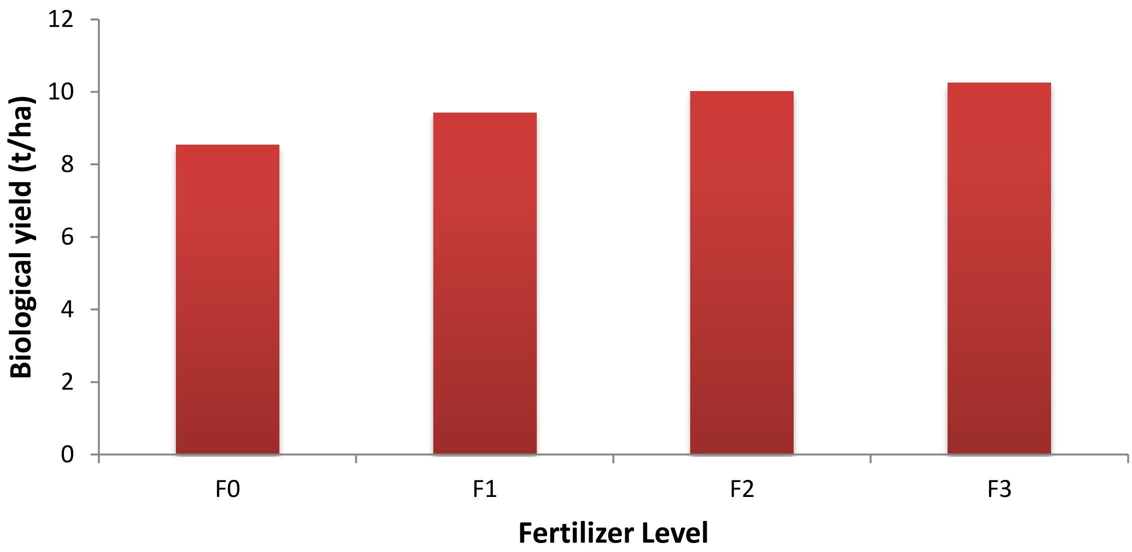


O_0= Control (Without organic manure), O_1=Cowdung , O_2= Vermicompost

Fig. 21. Effect of residual organic manure on biological yield (t/ha) at different days after transplanting of T. aman rice (LSD $_{(0.05)}$ = 0.39)

4.2.8.2 Effect of fertilizer management

The biological yield (t/ha) was significantly affected due to different fertilizer management management at 5 % level of significance (Fig 22**).** The maximum biological yield (10.25 t/ha) was obtained due to application of treatment F_3 which was statistically similar with F_2. The minimum biological yield (t/ha) (8.53 t/ha) was obtained in F_0 and followed by F_1.It can be inferred from the result that the treatment F_3 produced 20.16% higher biological yield over treatment F_0.



F_0= Control (Without fertilizer), F_1= 50% of RDF, F_2= 75% of RDF, F_3= RDF (Recommended dose of fertilizer)

Fig. 22. Effect of fertilizer management on biological yield (t/ha) of T. aman rice (LSD $_{(0.05)}$ = 0.45)

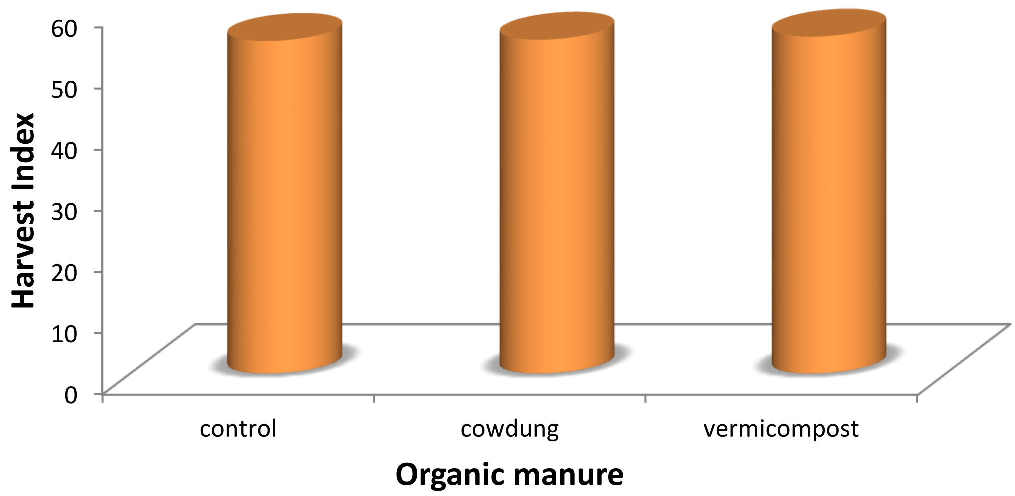
4.2.8.3 Interaction effect

Significant variation due to interaction between organic and fertilizer management was found in producing biological yield of rice (Table 5). The highest biological yield (t/ha) (10.82 t/ha) was counted in the interaction of O_2F_3 which was statistically similar with O_2F_2 and O_1F_3. The biological yield (t/ha) (7.49 t/ha) was counted in O_0F_0 interaction treatment which was statistically similar with O_0F_1 and O_1F_0. The result also showed that vermicompost and F_3 (RDF) treatment combination produced higher level of biological yield (t/ha) than other interactions irrespective of different levels of fertilizer.

4.2.9 Harvest Index yield

4.2.9.1 Effect of residual organic manure

Non-significant variation was observed on harvest index (%) among the organic manure in T.aman rice (Fig 23). The figure showed that harvest index (55.04%) was found in Vermicompost (O_2) followed by cowdung (54.55%). The minimum harvest index was obtained in control (without organic manure) (54.34%). Sakoto and Muhammad (2014) also found the similar results in case of harvest index due to organi fertilizer variations.

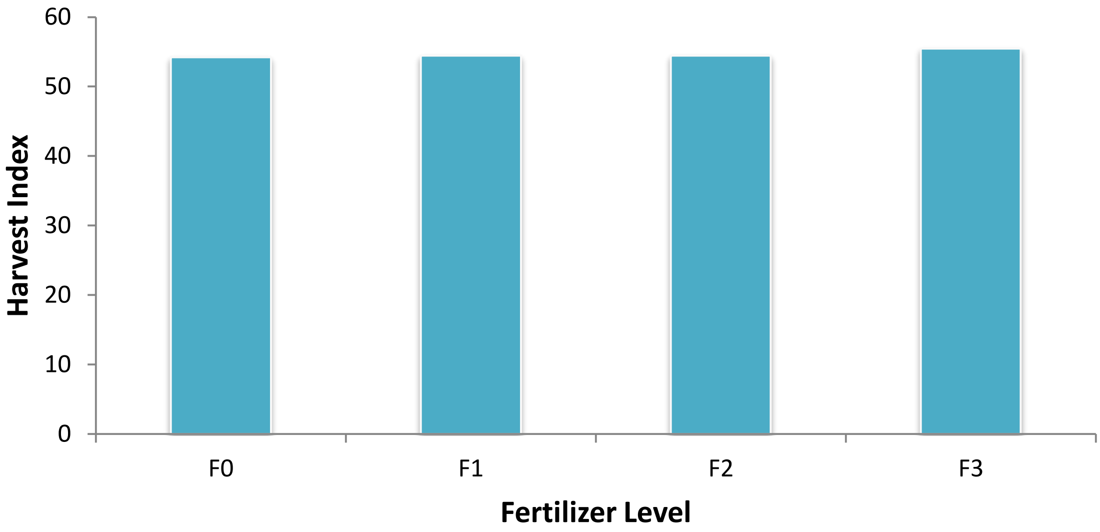


O_0= Control (Without organic manure), O_1=Cowdung , O_2= Vermicompost

Fig. 23. Effect of residual organic manure on harvest index at different days after transplanting of T. aman rice (LSD $_{(0.05)}$ = 2.28)

4.2.9.2 Effect of fertilizer management

The harvest index (%) was non significantly affected due to different fertilizer management at 5 % level of significance in rice **(**Fig 24**).** The maximum the harvest index (%) was obtained due to application of treatment F_1 which was statistically similar with F_2. The minimum harvest index (%) (18.76 gm) was obtained in F_3 and followed by F_1.



F_0= Control (Without fertilizer), F_1= 50% of RDF, F_2= 75% of RDF, F_3= RDF (Recommended dose of fertilizer)

Fig. 24. Effect of fertilizer management on harvest index at different days after transplanting of T. aman rice

4.2.9.3 Interaction effect

A non-significant variation was observed due to interaction between organic and fertilizer management in producing harvest index in rice (Table 5). However, the highest harvest index (%) (56.02) was counted in the interaction of O_0F_0 and he lowest harvest index (%) (51.47) was counted in O_0F_1.

Table5. Interaction effect of residual organic manure and fertilizer management on weight of 1000-grain, grain yield (t/ha), straw yield (t/ha), biological yield (t/ha), harvest index (%) of T. aman rice

Treatment combination	Weight of 1000-grains(g)	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index(%)
O_0F_0	18.53	4.20 d	3.29 c	7.49 f	56.02
O_0F_1	18.62	4.21 d	3.98 b	8.19 ef	51.47
O_0F_2	18.95	4.93c	4.01 b	8.94 de	55.16
O_0F_3	19.21	5.05 bc	4.18 b	9.23 cd	54.73
O_1F_0	18.78	4.95 bc	4.05 b	9.00 d	55.07
O_1F_1	19.14	5.40 a-c	4.38 ab	9.78 bc	55.35
O_1F_2	20.00	5.55 ab	4.80 a	10.35 ab	53.59
O_1F_3	20.14	5.79 a	4.90 a	10.68 a	54.19
O_2F_0	18.98	5.03 bc	4.08 b	9.11 cd	55.33
O_2F_1	19.31	5.75 a	4.55 ab	10.30 ab	55.85
O_2F_2	20.27	5.87 a	4.86 a	10.73 a	54.61
O_2F_3	20.60	5.90 a	4.93 a	10.82 a	54.37
$LSD_{0.05}$	**NS**	**0.61**	**0.58**	**0.77**	**NS**
CV(%)	**8.12**	**6.91**	**7.91**	**4.79**	**4.95**

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 5% level of probability

O_0= Control (Without organic manure) O_1=Cowdung O_2= Vermicompost;F_0= Control (Without fertilizer), F_1= 50% of RDF, F_2= 75% of RDF, F_3= RDF (Recommended dose of fertilizer)

CHAPTER V

SUMMARY AND CONCLUSION

The pot experiment was carried out at the Agronomy net house of Sher-e-Bangla Agricultural University, Dhaka during the period from July to December, 2018 to determine the effect of residual organic manure and fertilizer management in T. aman rice". The experimental area belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28. The soil of the experimental area belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon soil series. The experiment consisted of two factors.

Factor A: Organic manure 3 levels (whose residual effects were evaluated) viz. O_0: Control (Without organic manure), O_1: Cowdung and O_2: Vermicompost, and and

Factor B: fertilizer management levels – 4, viz. F_0= Control (Without fertilizer management), F_1= 50% of RDF, F_2= 75% of RDF and F_3= RDF (Recommended dose of fertilizer). The experiment consisting of 12 treatment combinations was laid out in the Completely Randomized Design (CRD) with three replications. Extra three replications were arranged to take the growth data. Transplanting seedings were planted in the pot 9 August, 2018. The collected data were analyzed using statistics 10 computerized program and the mean differences among the treatments were compared by Least Significant Differences (LSD) test at 5% level of significance. Data on growth characters, plant characters, yield attributes and yield data were taken most of the parameters like- plant height, plant dry weight, the total number of effective tillers/hill, panicle length, number of filled grain/panicle, 1000 grain weight, grain yield and straw yield were significantly affected by single effect of organic manure application.

Results revealed that organic manure and fertilizer managements and their interactions had significant effect on plant growth characters at different days after transplanting (DAT). The tallest plant (119.84 cm at harvest), maximum tillers hill^{-1}

(9.75 at 75 DAT) and maximum dry matter weight hill^{-1} (52.03 g at 75 DAT) was observed in vermicompost (O_2). The shortest plant (108.67 cm at harvest), minimum tillers/hill^{-1} (8.18 at 75 DAT) and minimum dry matter weight hill^{-1} (22.94 g at 75 DAT) was observed in O_0 Control (Without organic manure).

The tallest plant (121.11 cm at harvest), dry matter weight hill^{-1} (33.14 g at 75 DAT) and highest number of tillers hill^{-1} (10.94 at 75 DAT) were recorded from treatment F_3 (RDF). The shortest plant (110.22 cm at harvest), dry matter weight hill^{-1}(19.32 g at 75 DAT) and the lowest number of tillers hill^{-1} (6.89 at 75 DAT) were recorded from F_0 Control (Without fertilizer) treatment.

Considering interaction of organic manure and fertilizer management, the tallest plant (125.27 cm at harvest) and maximum dry matter weight hill^{-1} (36.89 g at 75 DAT) were found in O_2F_3. The shortest plant (103.67 cm at harvest) and minimum dry matter weight hill^{-1} (16.25 g at 75 DAT) was found in O_0F_0. At 75 DAT, the highest and lowest number of tillers hill^{-1} (11.67 and 5.83) was found in O_2F_3 and O_0F_0, respectively.

Significant difference was observed on yield contributing characters due to organic and fertilizer managements and their interactions. Vermicompost showed the highest number of effective tillers hill^{-1} (9.18) and lowest number of effective tillers hill^{-1} (7.73) were recorded from control (without organic manure). The highest and lowest number of effective tillers hill^{-1} (9.84 and 7.28) were counted in F_3 and F_0, respectively. The interaction of O_2F_3 (10.47) was found best in producing effective tillers hill^{-1} and lowest (6.47) was recorded with O0F0 interaction.

The highest number of non-effective tillers hill^{-1} (2.53) and shortest panicle (21.72 cm) was recorded in control (without organic manure), whereas vermicompost produced the lowest number of non-effective tillers hill^{-1} (2.22) and longest panicle (24.99 cm). The highest number of non-effective tillers hill^{-1} (2.86) and shortest panicle (22.09) were counted from F_0 treatment, whereas the lowest number of non-effective tillers hill^{-1} (1.79) and longest panicle (24.60 cm) was counted from F_3

treatment. The highest and lowest number of non-effective tillers hill^{-1} (3.34 and 1.84) were found in the O_0F_0 and O_2F_3, respectively. The longest (26.20 cm) and shortest (20.34 cm) panicle were found in O_2F_3 and $O_0F_{0,}$ respectively.

The highest number of filled grains panicle^{-1} (92.58) was observed with vermicompost (O_2). Whereas the lowest number of filled grains panicle^{-1} (80.97) were observed in O_0 Control (Without organic manure) treatment. For fertilizer management, the highest number of filled grains panicle^{-1} (97.43) were observed in F_3 (RDF) treatment. Whereas the lowest number of filled grains panicle^{-1} (76.56) were observed in F_0 Control (Without fertilizer) treatment. Interaction O_2F_3 produced the highest number of filled grains panicle^{-1} (102.83) whereas O_0F_0 produced the lowest number of filled grains panicle^{-1} (70.83).

The highest 1000-grains weight (19.79 g) were observed with vermicompost (O_2). Whereas the lowest 1000-grains weight (18.83 g) were observed in O_0 Control (Without fertilizer) treatment. For fertilizer management, the highest 1000-grains weight (19.98 g) were observed in F_3 (RDF) treatment. Whereas the lowest 1000-grains weight (18.53 g) were observed in F_0 Control (Without fertilizer) treatment. Interaction O_2F_3 produced the highest 1000-grains weight (20.60) whereas O_0F_0 produced the lowest number of 1000- grains weight 18.53g.

The maximum grain yield (5.64 t ha^{-1}), straw yield (4.60 t ha^{-1}), highest biological yield (10.24 t ha^{-1}) and highest harvest index (55.39%) was found in vermicompost (O_2), whereas the minimum grain yield (4.60 t ha^{-1}), straw yield (3.81 t ha^{-1}), lowest biological yield (8.46 t ha^{-1}) and lowest harvest index (54.34%) were found in O_0 Control (Without organic manure) treatment . The maximum grain yield (5.58 t ha^{-1}), straw yield (4.67 t ha^{-1}) and biological yield (10.25 t ha^{-1}) were recorded in F_3 whereas the minimum grain yield (4.73 t ha^{-1}), straw yield (3.81 t ha^{-1}) and biological yield (8.53 t ha^{-1}) were recorded in F_0. Significant variation was not observed in case of harvest index due to fertilizer management management. The interaction of O_2F_3 produced the highest grain yield (5.90 t ha^{-1}) and the interaction of O_0F_0 produced the lowest grain yield (4.20 t ha^{-1}). The maximum straw yield (4.93 t ha^{-1}) and biological yield (10.82 t ha^{-1}) were recorded in O_2F_3, whereas the minimum straw yield (3.29 t ha^{-1}) and biological yield (7.49 t ha^{-1}) were recorded in O_0F_0. The highest (56.02%) and lowest (51.47%) harvest index were recorded in O_0F_0 and O_0F_1, respectively.

From the above discussion it can be concluded that organic manure and fertilizer management had significant effect on yield and yield contributing characters of rice. In the present study, effect of residual vermicompost gave better yield and the yield attributes of rice. On the other hand 75% of recommended dose of fertilizer management showed similar performance with recommended dose of fertilizer management (RDF). So effect of residual vermicompost and 75% of RDF (F_2) may be recommended for T. aman rice cultivation as this interaction treatment reduces the use of 25% chemical fertilizer in this crop.

To reach a final recommendation, the following

i. More organic manure may be included in the further study.

ii. More combination of fertilizer may be included in the further study.

iii. Such study is needed to conduct in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance.

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CHAPTER VI

APPENDICES

Appendix I. Soil analysis result of the experimental pot in wheat-mungbean-T.aman rice cropping pattern

Treatment	p^H	Organic matter (%)	Total nitrogen(%)	Potassium (100 gm soil)	Phosphorus µg/gm (ppm)	Sulpher µg/gm (ppm)	Boron µg/gm (ppm)	Zinc µg/gm (ppm)
Initial soil	5.9	2.08	0.104	0.34	60.75	7.54	0.30	13.72

After cultivation of wheat

Control	6.7	2.62	0.131	1.80	113.96	5.50	0.17	14.56
Cowdung	6.7	2.76	0.138	0.49	93.13	5.94	0.60	18.42
Vermi-compost	6.5	2.49	0.125	0.39	84.85	14.21	0.08	17.54

After cultivation of mungbean

Treatment	p^H	Organic matter (%)	Total nitrogen (%)	Potassium (100 gm soil)	Phosphorus µg/gm (ppm)	Sulpher µg/gm(ppm)	Boron µg/gm(ppm)	Zinc µg/gm(ppm)
O_0F_0	4.9	1.9	0.095	0.13	15.21	7.68	0.24	1.15
O_OF_1	4.9	2.4	0.120	0.16	28.17	8.94	0.08	1.41
O_0F_2	5.1	1.9	0.095	0.15	20.57	8.53	0.36	1.31
O_OF_3	5.1	1.9	0.095	0.16	32.36	12.00	0.25	1.16
O_1F_0	4.8	2.5	0.125	0.20	48.67	19.62	0.26	2.05
O_1F_1	6.0	2.6	0.130	0.16	60.48	20.84	0.65	1.46
O_1F_2	4.9	2.4	0.120	0.21	65.11	14.55	0.60	1.41
O_1F_3	5.1	2.6	0.130	0.21	49.85	18.83	0.32	2.10
O_2F_0	5.4	2.5	0.125	0.19	35.75	18.39	0.43	1.83
O_2F_1	5.0	1.9	0.095	0.19	40.26	18.87	0.31	1.88
O_2F_2	5.5	2.6	0.130	0.22	26.76	28.53	0.24	2.29
O_2F_3	5.5	2.8	0.140	0.19	34.61	16.32	0.37	2.69

O_0= Control (Without organic manure) O_1=Cowdung O_2= Vermicompost;F_0= Control (Without fertilizer), F_1= 50% of RDF, F_2= 75% of RDF, F_3= RDF (Recommended dose of fertilizer)

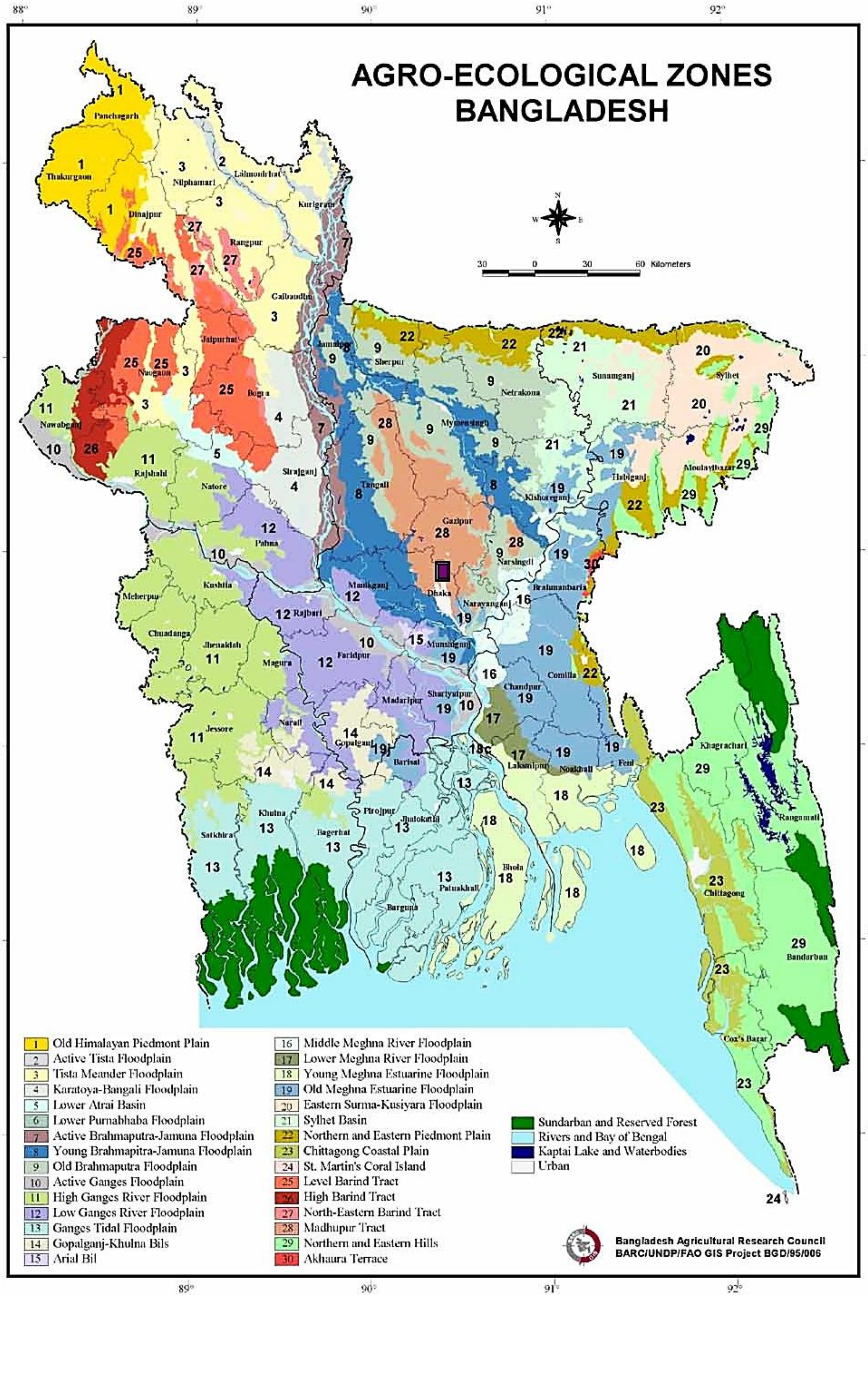
Source: Soil Resource Development Institute (SRDI), Khamarbari, Farmgate, Dhaka-1215

Appendix II. Pot arrangement of the experiment in Completely Randomized design.

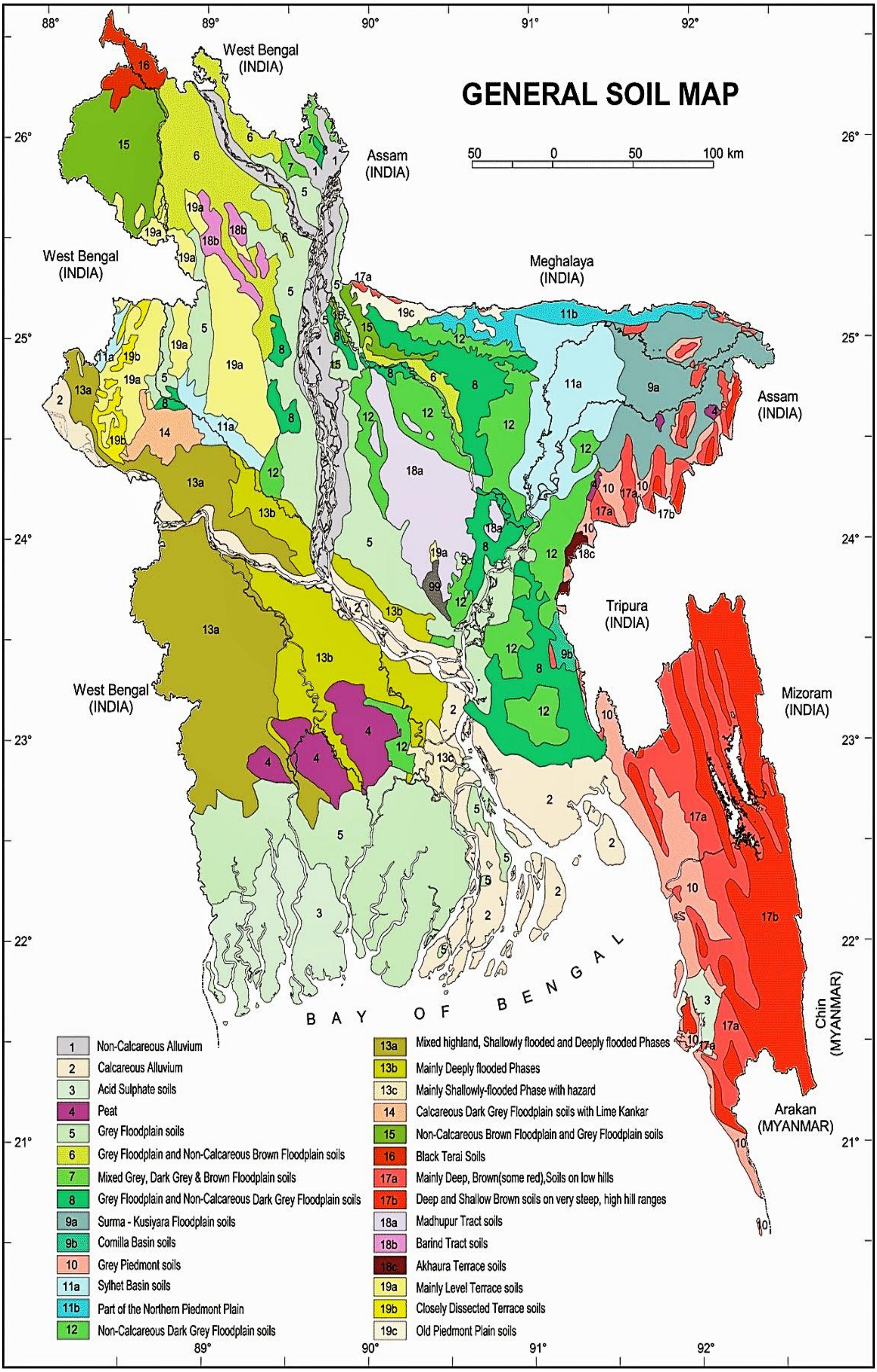
R_1	R_2	R_3
O_0F_0	**O_0F_0**	**O_0F_0**
O_0F_1	**O_0F_1**	**O_0F_1**
O_0F_2	**O_0F_2**	**O_0F_2**
O_0F_3	**O_0F_3**	**O_0F_3**
O_1F_0	**O_1F_0**	**O_1F_0**
O_1F_1	**O_1F_1**	**O_1F_1**
O_1F_2	**O_1F_2**	**O_1F_2**
O_1F_3	**O_1F_3**	**O_1F_3**
O_2F_0	**O_2F_0**	**O_2F_0**
O_2F_1	**O_2F_1**	**O_2F_1**
O_2F_2	**O_2F_2**	**O_2F_2**
O_2F_3	**O_2F_3**	**O_2F_3**

O_0= Control (Without organic manure) O_1=Cowdung O_2= Vermicompost;F_0= Control (Without fertilizer), F_1= 50% of RDF, F_2= 75% of RDF, F_3= RDF (Recommended dose of fertilizer

Appendix III (A): Map showing the experimental sites under study



Appendix III (B): Map showing the general soil types in Bangladesh



Appendix IV: Characteristics of Agronomy Farm soil is analysed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy Farm, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping Pattern	Potato-Aus rice-T.aman rice

B. Physical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% Clay	30

Source: Soil Resource Development Institute (SRDI), Khamarbari, Farmgate, Dhaka-1215

Appendix V: Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from June 2018 to December 2018

Year	Month	Temperature			Relative Humidity (%)	Total Rainfall (mm)	Sunshine (Hour)
		Max (°C)	Min (°C)	Mean (°C)			
2018	**June**	34	28	30	73	88.6	300
	July	33	27	30	76	46.53	268
	August	34	27	30	76	66.92	302
	September	34	27	30	71	64.14	292.5
	October	33	26	30	59	33	238
	November	33	25	29	51	12.3	210.5
	December	30	20	25	49	11.1	205

Source: Bangladesh Metrological Department (Climate and weather division) Agargaon, Dhaka.

Appendix VI: Mean sum- square values for plant height and dry weight hill^{-1} of transplant T.aman rice at different days after transplanting (DAT) and at harvest as influenced by residual organic manure, fertilizer management and their interaction

Source of variation	df	Plant height				Dry matter hill^{-1}		
		25 DAT	50 DAT	75 DAT	Harvest	25 DAT	50 DAT	75 DAT
Organic (A)	2	103.48**	77.386*	88.182 NS	442.962**	6.426**	58.489**	152.05**
Chemical (B)	3	340.85**	93.495*	151.037**	241.517**	45.132**	597.44**	374.03**
AB	6	2.707 NS	1.92*	0.449**	0.458*	0.158 NS	1.929*	4.407*
Error	24	14.059	21.436	29.037	152.283	0.38	3.207	6.06

NS=Non-Significant

* *Significant at 0.05 level of probability

*Significant at 0.01 level of probability

Appendix VII: Mean sum- square values for number of tillers hill^{-1} of transplant T.aman rice at different days after transplanting (DAT) and at harvest as influenced by residual organic manure, fertilizer management and their interaction

Source of variation	**df**	**Plant height**		
		25 DAT	**50 DAT**	**75 DAT**
Organic (A)	2	7.923**	7.679*	7.767**
Chemical (B)	3	21.467**	27.905*	151.037**
AB	6	0.081^{NS}	0.3847*	0.222^{NS}
Error	24	14.059	21.436	29.037

NS=Non-Significant

* *Significant at 0.05 level of probability

*Significant at 0.01 level of probability

Appendix VIII: Mean sum- square values for effective tillers hill^{-1}, non- effective tillers hill^{-1}, panicle length, total grains panicle^{-1}, filled grains panicle^{-1} and weight of 1000-grain of T.aman rice as influenced by residual organic manure, fertilizer management and their interaction

Source of variation	**df**	**Effective tiller hill^{-1}**	**Non-effective tiller hill^{-1}**	**Panicle length**	**Total grains panicle^{-1}**	**Filled grains panicle^{-1}**	**1000-grain weight**
Organic (A)	2	6.589**	0.288 ^{NS}	32.723**	309.563*	410.77**	2.946 ^{NS}
Chemical (B)	3	13.56*	2.710**	12.258*	537.254*	990.255*	2.999 ^{NS}
AB	6	0.041*	0.319 ^{NS}	0.107*	11.555*	2.867*	0.185 ^{NS}
Error	24	0.667	0.496	1.851	0.110	34.995	2.475

NS=Non-Significant

* *Significant at 0.05 level of probability

*Significant at 0.01 level of probability

Appendix IX: Mean sum- square values for grain yield, straw yield, biological yield, harvest index of T.aman rice as influenced by residual organic manure, fertilizer management and their interaction

Source of variation	**df**	**Grain yield**	**Straw yield**	**Biological yield**	**Harvest Index**
Organic (A)	2	3.616*	1.994**	10.953**	1.534^{NS}
Chemical (B)	3	1.298**	1.323**	5.225**	2.826^{NS}
AB	6	0.096**	0.025^{NS}	0.0520^{NS}	6.174^{NS}
Error	24	0.130	0.117	0.209	27.301

NS=Non-Significant

* *Significant at 0.05 level of probability

*Significant at 0.01 level of probability