INFLUENCE OF CROP RESIDUES, PRESS MUD AND TANNERY WASTE ON THE GROWTH AND YIELD OF AUS RICE

BY

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CERTIFICATE

This is to certify that the thesis entitled "***Influence of Crop Residues, Press Mud and Tannery Waste on the Growth and Yield of Aus Rice***" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE in Soil Science, embodies the result of a piece of bonafide research work carried out by **Md. Ashadul Islam**, Registration number: **08-03175** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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TO

MY BELOVED PARENTS

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ABSTRACT

An experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from February to July 2009 to study the influence of crop residues, press mud and tannery waste on the growth and yield of aus rice. The experiment consisted of 10 treatments such as- T_1: No chemical fertilizer, no organic amendment (control); T_2: 100% recommended N, P, K and S (100 kg N, 60 kg P_2O_5, 40 kg K_2O and 25 kg S/ha); T_3: Decomposed crop residues (rice straw) without nutrient enrichment; T_4: Decomposed crop residues (rice straw) with nutrient enrichment; T_5: Decomposed tannery waste without nutrient enrichment; T_6: Decomposed tannery waste with nutrient enrichment; T_7: Decomposed sugar mill waste (press mud) without nutrient enrichment; T_8: Decomposed sugar mill waste (press mud) with nutrient enrichment; T_9: Decomposed crop residues (rice straw) + tannery waste with nutrient enrichment and T_{10}: Decomposed crop residues (rice straw) + press mud with nutrient enrichment. The experiment was laid out in a randomized complete block design (RCBD) with 3 replications. The maximum plant height (88.87 cm at harvest), number of total tillers per hill (17.71), number of effective tillers per hill (13.43), length of panicle (24.50 cm), number of filled grain per plant (91.40), grain yield (7.23 t/ha), straw yield T_2 (7.60 t/ha), NPKS concentrations and their uptake were obtained from 100% of the recommended NPKS treatment. The performance of press mud was as good as the chemical fertilizer treatment. Composts produced through nutrient enrichment increased yield of rice compared to without nutrient enrichment during composting The application of composts increased organic matter and NPKS content of post harvest soil.

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Introduction

CHAPTER 1
INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food of Bangladesh. It has tremendous influence on agrarian economy of the country. Rice is intensively cultivated in Bangladesh covering about 80% of arable land. Among the three types of rice transplant aus covers about 56.66% of total rice area and it contributes about 43.24% of the total rice production of Bangladesh (BBS, 2008). Rice alone constitutes 95% of the food grain production in Bangladesh. Unfortunately, the yield of rice is low compared to the other rice growing countries like South Korea and Japan where the average yield is 7.00 and 6.22 t/ha, respectively (FAO, 1999). On the other hand, the demand for increasing rice production is mounting up to feed the ever-increasing population.

Sustainable agriculture demands for a suitable combination of organic and inorganic sources of nutrients and that can ensure food production with high quality. Nambiar (1991) views that integrated use of organic manure and chemical fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining better soil fertility. 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 use of the organic and inorganic sources of nutrients helps improve the efficiency of nutrients. Mineralization and immobilization are biochemical processes in nature and are mediated through the activities of microorganisms. The transformation of N, P, K and S in soil depends on the quality and quantity of organic matter as well as soil fertility and microbial activity. Cycling of organic matter in soil is a pre–requisite for efficient cycling of nutrients. Unless due attention is paid to the improvement and maintenance of soil organic matter it may not be possible to achieve the goal to increase and sustained productivity of crop.

Most of the soils of Bangladesh are low in organic matter content with an average of less than 1% organic matter (Ashan and Karim, 1988; Hossain, 2001) whereas a fertile soil should contain at least 3.5% organic matter. Moreover, this important component of soil is declining with time due to intensive cropping and use of higher dose of chemical fertilizers with little or no addition of organic manure in the farmer's field. In addition, rapid mineralization of soil organic matter occurs due to humid tropic climatic conditions of Bangladesh. As the organic matter supplies plant nutrients and improves physical, chemical and biological condition of soil, the productivity of the soils of Bangladesh is declining day by day (Moslehuddin *et al.*, 1997). Therefore it is required to add organic matter to soil to sustain crop yield.

Incorporation of crop residues- with or without composting – adds an enormous quantity of organic matter into soil and recycles plant nutrients in soil -plant system (Sharma *et al.*, 2000, Sutradhar and Chhonkar, 2003) and conserves soil nitrogen (Sutradhar *et al.*, 2006).

Sugar mill wastes or press mud is available in a huge quantity in the sugar mills of Bangladesh. Sometimes it is problematic to dispose press mud in the mill area. Press mud usually contains more than 1% N, 2.75% total P with a C:N ratio of 8.55 (www.ikishan.com/links/compost.shtml) . It has a potential to improve organic matter content, nutrient availability, physical properties of soil and to increase crop yield (Gilbert *et al.*, 2008, Bokhtiar and Sakurai, 2005)

Tannery wastes are also available in Bangladesh in a large amount. Only in the tannery industrial area at Hazaribag in Dhaka, a huge quantity of tannery wastes are created daily, a major portion of which is disposed in the Buriganga river. Tannery sludge could be an excellent material for soil amendment as it is found to improve the physical properties of soil and contain a considerable amount of plant nutrients (Hughes, 1988).

If these materials are composted and applied in agricultural land, the application of costly chemical fertilizers can be reduced and their disposal problems can also be solved to a some extent leading to reduction in environmental pollution.

Considering the potential effectiveness of crop residues, press mud and tannery wastes as a source of nutrients with proper processing, the present research has been undertaken to study their safe and favourable use for crop production with following specific research objectives-

i. To evaluate the effects of crop residues, press mud and tannery waste composted with or without nutrients on the yield and yield components of aus rice.
ii. To evaluate the efficacy of composted crop residues (rice straw) sugar mill wastes (press mud) and tannery wastes on soil quality.

Chapter 2

Review of Literature

CHAPTER 2
REVIEW OF LITERATURE

Crop residues, press mud and tannery waste composted with or without inorganic fertilizer acts as a source of essential plant nutrient. Experimental evidences in the use of crop residues, press mud and tannery waste and inorganic fertilizer showed an intimate effect on the yield and yield attributes of rice. However, research works regarding the use of crop residues, press mud and tannery wastes are very scarce. Some related literature in this regard are reviewed below-

2.1 Effect of crop residues

Two field experiments were conducted by Phongpan and Mosier (2002) in a rice-fallow-rice cropping sequence during consecutive dry and wet seasons of 1997 on a clay soil to determine the fate and efficiency of broadcast urea in combination with three residue management practices (no residue, burned residue and untreated rice crop residue). During a 70 days fallow period prior to flooding the soil for wet season rice, emissions of N_2O measured at weekly intervals from no residue, burned residue and residue treatments ranged from 25 to 128, 19 to 59 and 24 to 75 mg N m^{-2} ha^{-1}, respectively. Grain yield and N uptake were significantly increased by N application in the dry season but not significantly affected by residue treatments in either season.

Gale and Cambardella (2000) reported that as a physical buffer, crop residues protect soil from the direct impacts of rain, wind and sunlight leading to improved soil structure, reduced soil temperature and evaporation, increased infiltration, and reduced runoff and erosion. While some studies suggest that plant roots contribute more carbon to soil than surface residues, crop residue contributes to soil organic matter and nutrient increases, water retention, and microbial and macro invertebrate activity. These effects typically lead to improved plant growth and increased soil productivity and crop yield.

Russo (1976) observed that incorporation of rice straw (approx one month before flooding) with supplemental N produced the highest average yield in a three years period (6.9 t ha^{-1}). Almost double dose of fertilizers were needed to achieve the identical yields from normal fertilizer dose with straw incorporation.

Dhillon and Dev (1984) reported that incorporation of wheat straw into the soil produced higher rice grain yield compared to its removal or burning. However, incorporation of rice straw for wheat in rice-wheat sequence showed no significant effect on grain yield of wheat.

In a long term field trial in rice-wheat system, Zhu *et al.,* (1988) observed that the highest yield in the first rice crop was given by incorporation of 2.5 t ha-1 straw along with nitrogen (180 kg N ha-1) and P fertilizer (60 kg P2O5 ha-1). The treatment of 5.0 t ha-1 straw with N P fertilizers gave the highest yield in the first wheat crop and the highest total yield of 5 rice and wheat crops grown within 3 years, which was 13.2 per cent higher than the control (without straw but with N P fertilizer). Sarkar *et al.* (1991) reported that wheat straw incorporation treatments under flooded condition resulted in the higher rice yield.

Application of 15-20 kg N ha^{-1} in excess of the recommended dose of fertilizer as a starter dose during incorporation of crop residues in rice-wheat cropping system had always a favourable effect on grain yield (Yadav, 1997).

Narang *et al.* (1999) observed an increase in crop yield with increasing residue incorporation in rice-wheat system. The incorporation of the intermediate level of crop residues together with application of the recommended level of nitrogen (120 kg ha-1) gave the highest grain yield.

Singh *et al.* (2000) reported that wheat residue incorporation with no nitrogen or inadequate nitrogen (60 kg N ha-1) had an adverse effect on productivity. When adequate nitrogen (180 kg N ha-1) was applied, incorporation of crop residue increased productivity and resulted in the increase in grain yield to the order of 0.4-0.7 t ha-1 in rice-wheat system when compared to treatments related to removal or burning of residues.

On introduction of a crop of summer mungbean in rice-wheat system and incorporating its residues in soil.

Sharma *et al.* (2000) observed an increase in rice yield by 0.5-0.9 t ha-1 and succeeding wheat yield by 0.4-0.7 t ha-1.

Many researchers have reported a marginal effect or decrease in yield, specially in the first crop, with crop residue application. Incorporation of straw of rice or wheat after harvest in rice-wheat cropping system had no effect on yield of succeeding crop in North Western Himalayas (Sharma *et al.*, 1985; Sharma *et al.*, 1987). Powlson *et al.* (1985) reported a small decrease in grain yield (from 10.8 to 10.5 t ha-1) when wheat straw (3 t ha-1) was incorporated into a silty clay loam soil sown to winter wheat. However, Kavimandan *et al.* (1987) reported that incorporation of wheat/rice straw (5 t ha-1) with 60 kg N, 30 kg P2O5 and 30 kg K2O ha-1 increased the seed and straw yield of rice and wheat significantly over absolute control.

Wheat straw incorporation decreased rice dry matter and yields, the decrease was greater with higher rates of straw application (Azam *et al.*, 1991). Grain yield was greatly reduced by straw incorporation at low N-rates but the effect was mitigated by high N-rates. Malik and Jaiswal (1993) reported that substitution of fertilizer N with wheat straw depressed yield of rice. However, grain yield of rice did not differ when urea was supplemented with wheat straw (@ 29 kg N ha-1).

2.2 Effect of press mud

Chauhan *et al.* (2008) conducted a field experiment during spring of 2006–07 at Sugarcane Research Institute, Shahjahanpur using sugarcane variety CoS 97264 to work out the effect of biocompost (prepared from biodegradation from pressmud) application on yield and quality of sugarcane crop and status of organic carbon content in the soil before planting and after harvest of the crop. It is clear from experimental results that highest cane yield was achieved in the treatment 50 % N through biocompost + 50 % N through inorganic source followed by the treatments 33 % N through biocompost + 67 % N through inorganic source and 75 % N through biocompost + 25 % N through inorganic source. The cane yield of treatments with biocompost application showed significantly superior over the treatment without biocompost application.

Singh *et al.* (2008) conducted field experiments for 4 years to study the effect of press mud cake (PMC) application to rice as N and P source in rice -wheat system. Application of 60 kg N ha^{-1} along with PMC (5 t ha^{-1}) produced grain yield of rice similar to that obtained with the 120 kg N ha^{-1} in unamended plots. In the following wheat, the residual effects of PMC applied to preceding rice were equal to 40 kg N and 13 kg P ha^{-1}.

Shankaraiah and Murthy (2005) studied the effect due to integrated use of chemical fertilizers (50%, 75% and 100% of recommended NPK) and Enriched Pressmud cake (10 t ha^{-1} and 15 t ha^{-1}) in comparison with raw Pressmud cake (15 t ha^{-1}) was studied on Sugarcane crop for three seasons from 1999–2000 to 2002–2003 at Zonal Agricultural Research station, Visweswaraiah Canal Farm, Mandya. Integrated use of Enriched Pressmud cake @ 15 t ha^{-1} at recommended fertilization resulted in increased cane and sugar yields to the tune of 21 per cent over chemical fertilizers alone. The findings were also indicative of saving in fertilizer NPK by 50 per cent by the addition of enriched Pressmud cake @101 ton ha^{-1} which was comparable with Raw Pressmud @ 15 t ha^{-1}. Enrichment of Pressmud cake exhibited enhanced efficiency and higher returns.

Bokhtiar and Sakurai (2005) carried out an experiment under the High Ganges River floodplain soils to examine the effects of organic manure viz. press mud and farmyard manure (FYM) in combination with inorganic fertilizer on productivity of sugarcane. The maximum cane yield and sugar yield of 119.14 and 10.99 ton ha^{-1}, respectively were recorded in the treatment that received press mud @ 15 ton ha^{-1} accompanied with 25% less of recommended inorganic fertilizer i.e., N113, P39, K68, S26 and Zn2.3 kg ha^{-1}. Result also revealed that the effects of press mud were significantly alike with the other treatments that received recommended inorganic fertilizer only and 25 % less of inorganic fertilizer with FYM @ 15 ton ha^{-1}. The organic carbon, total N and available P, K and S contents of soil increased slightly due to incorporation of organic manure in soils. It is indicated that 25% chemical fertilizer could be saved by use of press mud or FYM @ 15 ton ha^{-1} for obtaining higher yield of sugarcane without deterioration of soil fertility.

2.3. Effect of tannery waste

Tannery sludge could be an excellent material for soil amendment as it is found to improve the physical properties of soil and contain a considerable amount of plant nutrients (Hughes, 1988). The sludges contain nitrogen, calcium, magnesium, phosphorus, trivalent chromium and some sodium. Hughes (1988) also suggested that with given careful management these sludges could be used as soil amendments, either directly or after composting. Application rates of about 200 tonnes ha−1 had proved toxic to crops in pot trials, though larger applications than this had not adversely affected crops in the field. Much smaller rates, of less than 20 tonnes ha−1, had been used in the field to minimize nitrate contamination of groundwater. The effects of CrIII depended on complex interactions between the sludge, the soil to which it was added and the plant species grown. However, no research findings are available on the effect of tannery waste compost on the yield of rice.

2.4. Combined effect of organic manure and inorganic fertilizer on the yield of rice

Maskina *et al.* (1986) observed that 120 kg N/ha was significantly superior to 60 kg N/ha in terms of dry matter, plant height and seedling quality for rice. Addition of poultry manure, azolla and FYM improved the quality of seedling by 54, 21 and 10%, respectively compared with N alone and the use of healthy seedlings improved yield significantly.

Govividasaray *et al.* (1994) reported that the use of poultry litter was more economical at high target yields of rice than at low target yields and it was more economic on use of fresh litter than compost.

Bijay *et al.* (1996) reported that in a field trial in 1987-1989 in Ludhiana, Punjab, India, irrigated rice cv. PR106 was given 60, 120 or 180 kg N/ha/year as poultry manure, urea or poultry manure + urea. In the first year, poultry manure did not perform better than urea but by the third year, 120 and 180 kg N/ha as poultry manure produced significantly higher grain yield of rice during three years while the yield decreased with urea. Apparent N recovery by rice decreased from 45 to 18% from

1987 to 1989 in the case of urea, but it remained almost the same (35, 33 and 37%) for poultry manure. Thus urea N values of poultry manure calculated from yield or N uptake data following two different applications averaged 80, 112 and 127% in 1987, 1988 and 1989, respectively. Poultry manure and urea applied in a 1:1 ratio basis produced yields in between the yields from the two sources applied alone.

Singh *et al.* (1996) conducted a field experiment in India where irrigated rice was given 60, 120 or 180 kg N/ha/year as poultry manure or poultry manure + urea. In the first year, poultry manure did not perform better than urea but in the third year, 120 kg and 150 kg N as poultry manure produced significantly higher grain yields than the same rates of urea. Poultry manure sustained the grain of rice during the three years while the yield decreased with urea.

Yamagata (2000) carried out a field experiment to determine the growth response of upland rice (*Oryza sativa* L.) and maize (*Zea mays*) to organic nitrogen by amending the soil with an inorganic N source (ammonium sulfate) and with an organic N source. N uptake was highest under the RBS treatment, but the inorganic N concentration in soil was lower when organic and inorganic N was applied together as compared to inorganic N alone. Upland rice also took up more N than maize in a pot experiment with RBS without differences in root spread. A study was also conducted to determined the N uptake mechanism of upland rice by determining the protease activity in pot soils of the crops and measuring 15 N abundance in pot trails with 15 N-labelled RBS. Results show the possibility of different protein uptake by upland rice which is attributed to the high response of upland rice to organic N fertilizer, since N in protein form was taken up resulting in less competition for soil N by microorganisms.

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

Rajni Rani *et al.* (2001) conducted a pot experiment in a glasshouse of Varanasi, Uttar Pradesh, India during kharif season to assess the response of rice to different treatment combinations of vermicompost (VC), poultry manure (PM) and nitrogen fertilizers. Results showed that all integrated treatments significantly increased plant height, number of effective panicles per pot and dry weight/panicle over the treatment heaving full N dose (T_1) through urea. Grain yield ranged from 6.5-20.0 g/pot among the combinations tried but T_2 was the most effective treatment for having the highest grain yield. They further proposed that agronomical efficiency was higher in case of integrated treatments than using fertilizer alone. Finally they concluded that the combined application of 2/3 N through fertilizer + 1/3 N through manure has a greater potential management for rice crops.

Singh *et al.* (2001) studied the effect of poultry manure under irrigated condition with nitrogen in rice-wheat cropping system in an Alfisol of Bilapur, Madhya Pradesh, India. The treatment consisted of poultry manure alone and in combination with nitrogen fertilizer. Root and shoot biomass at different growth stages increased with the application of N and poultry manure alone and combination. Root and shoot biomass was higher in 100% N through poultry manure, followed by 75% N through poultry manure and 25% through urea.

Keeling *et al.* (2003) determined the effect of green waste compost and provided with additional fertilizers on rice and showed consistently that the response of rice to compost and fertilizer applied together than the response to the individual additives, but only very stable compost was used (> 10 months processing). Experiments with 15 N-labeled fertilizer showed that rice was able to utilize the applied N-more efficiently when cultivated with the stable compost.

Aal *et al.* (2003) measured the usefulness of supplementing different organic materials viz., water hyacinth compost (HC), town refuse compost (TR) to minimize consuming chemical fertilizers. The results showed that the application of organic materials either alone or in combination with chemical fertilizer caused a substantial increase in total N, available P, K and micronutrients (Fe, Mn, Cu, Zn) as well as wheat yield (straw and grain). The importance of organic farming practices in desert sandy soils was emphasized to minimize chemical fertilizer consumption and to avoid environmental pollution.

Mahavisha *et al.* (2004) investigated the effect of organic fertilizer sources on the growth and yield of rice. The crop growth and yield were higher with 125% recommended fertilizer + poultry manure and 100% RDF + poultry manure compared to the other treatments.

Reddy *et al.* (2004) carried out a field study for two years (2001 and 2002) on the farmers fields in Kolar district (eastern dry zone, Karnataka, India) to study the effect of different organic manures on growth and yield of paddy under tank irrigation. Poultry manure and sewage sludge produced better growth components, viz., plant height, number of tillers/hill, total dry matter/plant and yield components like number of panicle/hill and panicle length.

Do Thi Thanh Ren *et al.* (2004) reported that both organic and inorganic nitrogen had a positive effect on the rice yield . Compared with the treatments being fertilized at the same doses of N, a significantly higher yield was obtained in the treatment of mixed organic N fertilizer and manure. The effect was found only in the first crop. From the second crop onward rice yield were not different among treatments (mixed fertilizers, inorganic N fertilizer and manure only). The manure only treatment resulted in rice yield equal to the treatment with 120 kg N/ha in the form of urea. Supplying N in both organic and inorganic forms over several years resulted in an accumulation of nitrogen in the soil, which became available for rice grown.

Davarynejad *et al.* (2004) conducted an experiment to investigate the effect of manure and municipal compost and their enrichment with chemical fertilizers on growth and yield of rice. Results showed that compost alone did not increase grain yield. However, when enriched with different levels of chemical fertilizer the highest amount of grain yield was produced. The yield was comparable to the yield obtained from 40 t/ha of compost. This indicated that compost might be an appropriate substitute for manure and half of chemical fertilizer needed for soil.

Vijay and Singh (2006) conducted a field experiment during kharif season of 2003 and 2004 at J.V. college, Baraut, Uttar Pradesh, India, to study the effect of organic manures and fertilizer treatments on growth, yield and yield attributes of rice (*Oryza sativa* cv. Pusa Bashmati). The manure treatment comprises of compost and fertilizer treatments included N at 0, 40, 80 and 120 kg/ha. Application of compost significantly improved the growth, yield and yield attributes of rice during the years of experimentation. However, the organic manure compost did not show marked variation among the other treatments. Each unit increase in N levels led to significant increase in growth, yield and yield attributing characters of rice up to 80 kg N/ha over the during study.

2.5 Changes in soil fertility and properties due to integrated use of fertilizers with manure

Organic materials are widely used to maintain soil fertility and improve soil properties in intensive cropping systems especially in traditional agriculture. Studies at IRRI showed that the total N, exch. K and available P in soil increased by green manuring. The application of FYM increased organic C, total N, available P, Exch, K and CEC than GM (IRRI, 1979). Application of NPK at 100-150% based on the initial soil test showed appreciable improvement in available soil N, P, and K. Organic C content was highest under FYM treatment. Depletion of P was highest under 100% treatment and K under 100% N and P treatment (Singh and Nambiar, 1984).

Bair (1990) stated that sustainable production of crop can not be maintained by using chemical fertilizers only and similarly it is not possible to obtain higher crop yield by using organic manure alone. Sustainable crop production might be possible through the integrated use of organic manure and chemical fertilizers.

Prasad and Kerketta (1991) conducted an experiment to assess the soil fertility, crop production and nutrient removal under different cropping sequences in the presence of recommended doses of fertilizers and cultural practices along with 5 t/ha compost applied to the crops. There was an overall increase in organic C, increase in total N (83.9%), available N (69.9%), available P (117.3%) and CEC (37.7%).

Bhandari *et al.* (1992) reported that an application of fertilizers or their combined use with organic manure increased the organic C status of soil. The NPK fertilizers at 100% level and their combined use with organic N sources also increased the available N and P by 5.22 kg and 0.8-3.8 kg/ha from their initial values.

Meelu *et al.* (1992) reported that organic C and total N increased significantly when *sesbania* and *crotalaria* were applied in the preceded rice crop for two wet seasons. More (1994) reported from 3-years study that application of 25 t/ha FYM + 20 t/ha press mud decreased the soil pH and increased organic matter content and available N, P and K in soil. Medhi *et al.* (1996) reported that incorporation of organic and inorganic sources of N increased soil solution NH_4-N to a peak and then declined to very low levels.

Nahar *et al.* (1995) examined the soil condition after one crop cycle (rice wheat) with addition of organic matter. Addition of organic matter during the rice crop doubled the organic C content compared to its original status. Total and available N contents were also significantly improved by addition of organic matter, but had less impact on soil exchangeable cations.

Palm *et al.* (1996) stated that organic materials influence nutrient availability through mineralization – immobilization pattern as an energy sources for microbial activities and as precursors to soil organic matter and by reducing P sorption of the soil.

Mathew and Nair (1997) reported that cattle manure when applied alone or in combination with chemical fertilizer (NPK) increased the organic C content, total N, available P and K in rice soils. Sarker and Singh (1997) reported that organic fertilizers when applied alone or in combination with inorganic fertilizers increase the level of organic carbon in soil as well as the total N, P and K contents of soil.

Ravankar *et al.* (1999) reported that organic carbon, total N and available P_2O_5, K_2O, S and Zn in the soil were higher in the plots where nutrients were applied through organics than the inorganic sources.

Santhi *et al.* (1999) observed that application of 100% NPK plus FYM decreased the bulk density and increased the water holding capacity of soil. The decreased in bulk density in FYM treated plots might be ascribed to better aggregation. The water holding capacity was increased due to the improvement in structural condition of soil that was brought about mainly by the application of FYM in combination with NPK fertilizers.

Hemalatha *et al.* (2000) reported that green manure significantly increased the soil fertility status, organic carbon, available soil N, P and K at post harvest soil. Zaman *et al.* (2000) opined that chemical properties like organic matter content CEC, total N, exchangeable K, available P and S were favorably influenced by the application of organic sources of nitrogen and potassium while the organic sources mostly did not show positive effect. Soil pH decreased slightly compared to the initial status.

Seki *et al.* (1989) reported that with successive application of wheat and rice straw, the top soil pH was lowered markedly. The amount of exchangeable potassium of top soil increased gradually with successive application of straw but that of exchangeable calcium and magnesium decreased. Thakur *et al.* (1999) reported no significant changes in soil pH due to green manuring in field in rice-wheat system. However, Lal *et al.* (1999) observed that incorporation of organic wastes significantly increased pH and nutrient status of an acid soil. Sharma *et al.* (2000) reported a significant increase in cation exchange capacity, N and P status of soil along with slight reduction in pH on addition of crop residues, while the available K decreased markedly. The DTPA extractable Zn, Fe, Mn and Cu enhanced significantly due to crop residues as compared to chemical fertilizers alone.

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

Chapter 3
Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from February to July, 2009 to study the influence of crop residues, press mud and tannery waste on the growth and yield of aus rice. This chapter includes materials and methods that were used in conducting the experiment. The details are presented below under the following headings -

3.1 Experimental site and soil

The experiment was conducted in typical rice growing silt loam soil at the Sher-e-Bangla Agricultural University Farm, Dhaka during the aus season of 2009. The morphological, physical and chemical characteristics of the soil are shown in the Tables 1 and 2.

3.2 Climate

The climate of the experimental area is characterized by high temperature, high humidity and medium rainfall with occasional gusty winds during the *kharif* season (March-September) and a scanty rainfall associated with moderately low temperature in the *rabi* season (October-February). The weather information regarding temperature, rainfall, relative humidity and sunshine hours prevailed at the experimental site during the cropping season February to July 2009 have been presented in Appendix II.

3.3 Planting material

BRRI dhan27 was used as the test crop in this experiment. This variety was developed at the Bangladesh Rice Research Institute. Average plant height of the variety is 90-95 cm at the ripening stage. The grains are medium fine and white. It requires about 150-155 days completing its life cycle with an average grain yield of 5.5-6.5 t/ha (BRRI, 2004).

Table 1. Morphological characteristics of the experimental field

Morphology	Characteristics
Locality	SAU farm, Dhaka.
Agro-ecological zone	Madhupur Tract (AEZ 28)
General Soil Type	Deep Red Brown Terrace Soil
Parent material	Madhupur Terrace.
Topography	Fairly level
Drainage	Well drained
Flood level	Above flood level

(FAO and UNDP, 1988)

Table 2. Initial physical and chemical characteristics of the soil

Characteristics	Value
Mechanical fractions:	
% Sand (2.0-0.02 mm)	22.55
% Silt (0.02-0.002 mm)	56.70
% Clay (<0.002 mm)	20.75
Textural class	Silt Loam
Consistency	Granular and friable when dry.
pH (1: 2.5 soil- water)	6.2
CEC (cmol/kg)	17.9
Organic C (%)	0.686
Organic Matter (%)	1.187
Total N (%)	0.032
Exchangeable K (cmol/kg)	0.12
Available P (mg/kg)	19.85
Available S (mg/kg)	14.40

3.4 Land preparation

The land was first opened on 25 February, 2009 by a tractor and prepared thoroughly by ploughing and cross ploughing with a power tiller followed by country plough. Laddering helped breaking the clods and leveling the land followed every ploughing. Before transplanting each unit of plot was cleaned by removing the weeds, stubbles and crop residues. Finally each plot was prepared by puddling.

3.5 Experimental design and layout

The experiment was laid out in a randomized complete block design (RCBD), where the experimental area was divided into three blocks representing the replications to reduce soil heterogeneity effects. Each block was divided into eight unit plots as treatments with raised bunds around. Thus the total number of unit plot size was 2.5 m × 2 m and ails separated plots from each other. The distance maintained between two blocks and two plots were 1.5 m and 0.75 m, respectively.

3.6 Initial soil sampling

Before land preparation, initial soil samples at 0-15 cm depth were collected from different spots of the experimental field. The composite soil sample were air-dried, crushed and passed through a 2-mm (8 meshes) sieve. After sieving, the soil samples were kept in a plastic container for physical and chemical analysis of the soil.

3.7 Treatments

Crop residues, press mud and tannery wastes composted with or without enrichment of nutrients were used as treatments in the study. The experiment consisted of 10 treatments as follows-

T_1: No chemical fertilizer, no organic amendment (control)

T_2: 100% recommended N, P, K and S (100 kg N, 60 kg P_2O_5, 40 kg K_2O and 25 kg S/ha)

T_3: Decomposed crop residues (rice straw) without nutrient enrichment

T_4: Decomposed crop residues (rice straw) with nutrient enrichment

T_5: Decomposed tannery waste without nutrient enrichment

T_6: Decomposed tannery waste with nutrient enrichment

T_7: Decomposed sugar mill waste (press mud) without nutrient enrichment

T_8: Decomposed sugar mill waste (press mud) with nutrient enrichment

T_9: Decomposed crop residues (rice straw) + tannery waste with nutrient enrichment

T_{10}: Decomposed crop residues (rice straw) + press mud with nutrient enrichment

3.8 Fertilizer application

The amounts of N, P, K and S fertilizers required per plot were calculated as per the treatments. Full amounts of TSP, MOP and gypsum 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 5 days before panicle initiation stage (55 DAT).

3.9 Composting of crop residues, press mud and tannery waste and their incorporation

Three different types of organic manure crop residues, press mud and tannery waste with or without enrichment were used for the experiment. Crop residues (rice straw), press mud and tannery wastes were composted by traditional pit method with or without nutrient enrichment for 3 months. Sufficient amount of water was added with occasional stirring for proper decomposition of organic materials. Crop residues were cut into pieces before composting. About 500 kg of rice straw was composted as such without any nutrient enrichment. Another 500 kg of rice straw was composted with nutrient enrichment. For nutrient enrichment 2 kg N, 1.2 kg P and 0.8 kg K were mixed per 100 kg of rice straw before composting. Press mud and tannery wastes were also composted similarly as crop residues. A mixture of crop residues and press mud (1:1) and another mixture of crop residues and tannery waste (1:1) were also composted with or without nutrient enrichment. The composts were incorporated into soil before final land preparation at the rate of 20 t/ha.

3.10 Raising of seedlings

The seedlings of rice were raised wet-bed methods. Seeds (95% germination) @ 5 kg/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.

3.11 Transplanting

Forty days old seedlings of BRRI dhan27 were carefully uprooted from the seedling nursery and transplanted on 05 March, 2009 in well puddled plot. Two seedlings per hill were used following a spacing of 20 cm × 20 cm. After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings whenever required.

3.12 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.

3.12.1 Irrigation

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

3.12.2 Weeding

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

3.12.3 Insect and pest control

There was no infestation of diseases in the field but leaf roller (*Chaphalocrosis medinalis*, Pyralidae, Lepidoptera) was observed in the field and used Malathion 57EC @ 1.12 L ha^{-1}.

3.13 Crop harvest

The crop was harvested at full maturity when 80-90% of the grains were turned into straw colored on 24 June, 2009. The crop was cut at the ground level and plot wise crop was bundled separately and brought to the threshing floor.

3.14 Yield components

3.14.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 30, 50, 70, 90 days and at harvesting stage. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the base of the panicle.

3.14.2 Number of tillers/hill

The number of tillers/hill was recorded at the time of 30, 50, 70 and 90 days by counting total tillers. Data were recorded as the average of 10 hills selected at random from the inner rows of each plot.

3.14.3 Effective tillers/hill

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

3.14.4 Non-effective tillers/hill

The total number of in-effective tiller/hill was counted as the number of non-panicle bearing hill/plant. Data on non effective tiller/hill were counted from 10 selected hills and average value was recorded.

3.14.5 Total tillers/hill

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

3.14.6 Length of panicle

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

3.14.7 Filled grain per panicle

The total numbers of filled grain was collected randomly from selected 10 plants of a plot on the basis of grain in the spikelet and then average numbers of filled grain per panicle was recorded.

3.14.8 Unfilled grain per panicle

The total numbers of unfilled grain was collected randomly from selected 10 plants of a plot on the basis of not grain in the spikelet and then average numbers of unfilled grain per panicle was recorded.

3.14.9 Total grain per panicle

The total numbers of grain was collected randomly from selected 10 plants of a plot by adding filled and unfilled grain and then average numbers of grain per panicle was recorded.

3.14.10 Weight of 1000 seeds

One thousand seeds were counted randomly from the total cleaned harvested seeds and then weighed in grams and recorded.

3.14.11 Grain yield

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of central 1 m^2 area and five sample plants were added to the respective unit plot yield to record the final grain yield/plot and finally converted to t ha^{-1}.

3.14.12 Straw yield

Straw obtained from each unit plot were sun-dried and weighed carefully. The dry weight of straw of central 1 m^2 area and five sample plants were added to the respective unit plot yield to record the final straw yield/plot and finally converted to ton/ha.

3.14.13 Biological yield

Grain yield and straw yield together were regarded as biological yield. the biological yield was calculated with the following formula:

Biological yield = Grain yield + Straw yield.

3.14.14 Harvest index

Harvest index was calculated from the grain and straw yield of rice for each plot and expressed in percentage.

$$HI = \frac{\text{Economic yield (grain weight)}}{\text{Biological yield (Total dry weight)}}$$

3.15 Chemical analysis of plant samples

3.15.1 Collection of plant samples

Grain and straw samples were collected after threshing. The samples were finely ground by using a Wiley-Mill with stainless contact points to pass through a 60-mesh sieve. The samples were stored in plastic vial for analyses of N, P, K and S.

3.15.2 Preparation of plant samples

The plant samples were dried in an oven at 70 ^{0}C for 72 hours and then ground by a grinding machine to pass through a 20-mesh sieve. The grain and straw samples were analyzed for the determination of N, P, K and S concentrations. The methods were as follows:

3.15.3 Digestion of plant samples with sulphuric acid for N

For the determination of nitrogen an amount of 0.2 g oven dry, ground sample were taken in a micro kjeldahl flask. 1.1 g catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se in the ratio of 100: 10: 1), and 5 ml conc. H_2SO_4 were added. The flasks were heated at 120^{0}C and added 2.5 ml 30% H_2O_2 then heated was continued at 180 ^{0}C until the digests became clear and colorless. After cooling, the content was taken into a 100 ml volumetric flask and the volume was made up to the mark with de-ionized water. A reagent blank was prepared in a similar manner. Nitrogen in the digest was estimated by distilling the digest with 10 N NaOH followed by titration of the distillate trapped in H_3BO_3 indicator solution with 0.01N H_2SO_4.

3.15.4 Digestion of plant samples with nitric-perchloric acid for P, K and S

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

3.15.5 Determination of P, K and S from plant samples

3.15.5.1 Phosphorus

Phosphorus was digested from the plant sample (grain and straw) with 0.5 M $NaHCO_3$ solutions, pH 8.5 (Olsen *et al.*, 1954). Phosphorus in the digest was determined by using 1 ml for grain sample and 2 ml for straw sample from 100 ml extract was then determined by developing blue color with reduction of phosphomolybdate complex and the color intensity were measured colorimetrically at 660 nm wavelength and readings were calibrated with the standard P curve (Page *et al.*, 1982).

3.15.5.2 Potassium

Five milli-liter of digest sample for the grain and 10 ml for the straw were taken and diluted 50 ml volume to make desired concentration so that the absorbance of sample were measured within the range of standard solutions. The absorbance were measured by atomic absorption flame photometer.

3.15.5.3 Sulphur

Sulphur content was determined from the digest of the plant samples (grain and straw) with $CaCl_2$ (0.15%) solution as described by (Page *et al.* 1982). The digested S was determined by developing turbidity by adding acid seed solution (20 ppm S as K_2SO_4 in 6N HCl) and $BaCl_2$ crystals. The intensity of turbidity was measured by spectrophotometer at 420 nm wavelengths (Hunter, 1984).

3.16 Nutrient Uptake

After chemical analysis of straw and grain samples the nutrient contents were calculated and from the value of nutrient contents, nutrient uptakes were also calculated by following formula:

Nutrient uptake = Nutrient content (%) × Yield (kg/ha)/100

3.17 Post harvest soil sampling

After harvest of crop soil samples were collected from each plot at a depth of 0 to 15 cm. Soil sample of each plot were air-dried, crushed and passed through a two mm (10 mesh) sieve. The soil samples were kept in plastic container to determine the physical and chemical properties of soil.

3.18 Soil analysis

Soil samples were analyzed for both physical and chemical characteristics viz. organic matter, pH, total N and available P, K, and S contents. These results have been shown in the Table 8. The soil samples were analyzed by the following standard methods as follows:

3.18.1 Soil pH

Soil pH was measured with the help of a glass electrode pH meter, the soil water ratio being maintained at 1: 2.5 (Jackson, 1962).

3.18.2 Organic matter

Organic carbon in soil sample was determined by wet oxidation method of Walkley and Black (1935). The underlying principle was used to oxidize the organic matter with an excess of 1N $K_2Cr_20_7$ in presence of conc. H_2SO_4 and conc. H_3PO_4 and to titrate the excess $K_2Cr_20_7$ solution with 1N $FeSO_4$. To obtain the content of organic matter was calculated by multiplying the percent organic carbon by 1.73 (Van Bemmelen factor) and the results were expressed in percentage (Page *et al.*, 1982).

3.18.3 Total nitrogen

Total N content of soil were determined followed by the Micro Kjeldahl method. One gram of oven dry ground soil sample was taken into micro kjeldahl flask to which 1.1

gm catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se in the ratio of 100: 10: 1), and 6 ml H_2SO_4 were added. The flasks were swirled and heated 200 ^{0}C and added 3 ml H_2O_2 and then heating at 360 ^{0}C was continued until the digest was clear and colorless. After cooling, the content was taken into 100 ml volumetric flask and the volume was made up to the mark with distilled water. A reagent blank was prepared in a similar manner. These digests were used for nitrogen determination (Page *et al.*, 1982).

Then 20 ml digest solution was transferred into the distillation flask, Then 10 ml of H_3BO_3 indicator solution was taken into a 250 ml conical flask which is marked to indicate a volume of 50 ml and placed the flask under the condenser outlet of the distillation apparatus so that the delivery end dipped in the acid. Add sufficient amount of 10N-NaOH solutions in the container connecting with distillation apparatus. Water runs through the condenser of distillation apparatus was checked. Operating switch of the distillation apparatus collected the distillate. The conical flask was removed by washing the delivery outlet of the distillation apparatus with distilled water. Finally the distillates were titrated with standard 0.01 N H_2SO_4 until the color changes from green to pink. The amount of N was calculated using the following formula:

$$\% N = (T-B) \times N \times 0.014 \times 100 / S$$

Where,

T = Sample titration (ml) value of standard H_2SO_4

B = Blank titration (ml) value of standard H_2SO_4

N = Strength of H_2SO_4

S = Sample weight in gram

3.18.4 Available phosphorus

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

3.18.5 Exchangeable potassium

Exchangeable K was determined by 1N NH_4OAc (pH 7) extraction methods and by using flame photometer and calibrated with a standard curve (Page *et al.*, 1982).

3.18.6 Available sulphur

Available S content was determined by extracting the soil with $CaCl_2$ (0.15%) solution as described by (Page *et al.*, 1982). The extractable S was determined by developing turbidity by adding acid seed solution (20 ppm S as K_2SO_4 in 6N HCl) and $BaCl_2$ crystals. The intensity of turbidity was measured by spectrophotometer at 420 nm wavelengths.

3.19 Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference of different treatments on yield and yield contributing characters of BRRI dhan27. The mean values of all the characters were calculated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

Chapter 4
Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

The experiment was conducted to determine the influence of crop residues, press mud and tannery waste on the growth and yield of rice. Data on different growth parameters and yield were recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix II-VIII. The results have been presented and possible interpretations given under the following headings:

4.1 Yield contributing characters and yield of rice

4.1.1 Plant height

Plant height of BRRI dhan27 showed statistically significant variation due to the influence of crop residues, press mud and tannery waste (Appendix II) at 30, 50, 70, 90 DAT and at harvest. The tallest plant height (23.96 cm, 31.29 cm, 44.23 cm, 66.84 cm and 88.87 cm) was recorded from T_2 (100% recommended dose of N, P, K and S/ha) at 30 DAT,50 DAT,70 DAT,90 DAT and harvest respectively, which was statistically similar with T_8 (decomposed sugar mill waste (press mud) with nutrient enrichment). On the other hand, at the same DAT the shortest plant (16.47 cm, 21.60 cm, 30.23 cm, 47.13 cm and 61.95 cm) was obtained from T_1 as control at 30 DAT,50 DAT,70 DAT,90 DAT and harvest (Table 3). From the data it was revealed that all the treatments produced significantly taller plants compared to the control. Rajani Rani *et al.* (2001), Hossain *et al.* (1997) and Sharma and Mitra (1991) also observed similar results.

Table 3. Effect of crop residues, press mud and tannery waste on plant height of aus rice BRRI dhan27

Treatments	Plant height (cm)				
	30 DAT	50 DAT	70 DAT	90 DAT	Harvest
T_1	16.47 d	21.60 d	30.23 d	47.13 e	61.95 f
T_2	23.96 a	31.29 a	44.23 a	66.84 a	88.87 a
T_3	19.80 bcd	24.91 cd	39.88 c	57.28 d	75.81 e
T_4	21.73 abc	28.70 ab	42.22 b	62.73 bc	83.97 c
T_5	19.27 cd	26.20 bc	40.26 c	60.75 cd	79.50 d
T_6	22.47 abc	29.53 ab	43.25 ab	65.33 ab	86.80 ab
T_7	21.53 abc	29.63 ab	42.39 ab	64.10 abc	85.94 bc
T_8	23.53 a	31.07 a	44.15 ab	66.50 ab	86.01 bc
T_9	22.87 ab	29.17 ab	43.38 ab	64.43 abc	85.33 bc
T_{10}	22.93 ab	30.13 ab	43.33 ab	65.65 ab	86.06 bc
$LSD_{(0.05)}$	3.193	3.541	1.773	3.590	2,506
CV(%)	8.67	7.31	6.50	9.37	5.78

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

T_1: No chemical fertilizer, no organic amendment (control)

T_2: 100% recommended N, P, K and S

T_3: Decomposed crop residues (rice straw) without nutrient enrichment

T_4: Decomposed crop residues (rice straw) with nutrient enrichment

T_5: Decomposed tannery waste without nutrient enrichment

T_6: Decomposed tannery waste with nutrient enrichment

T_7: Decomposed sugar mill waste (press mud) without nutrient enrichment

T_8: Decomposed sugar mill waste (press mud) with nutrient enrichment

T_9: Decomposed crop residues (rice straw) + tannery waste with nutrient enrichment

T_{10}: Decomposed crop residues (rice straw) + press mud with nutrient enrichment

4.1.2 Number of total tillers

Statistically significant variation was recorded in number of total tillers of BRRI dhan27 due to the influence of crop residues, press mud and tannery waste(Appendix III). The number of total tillers of rice at 30, 50, 70 and 90 DAT the maximum number of tillers per hill (5.41, 11.18, 20.87 and 17.71) was recorded from T_2 which was followed by or statistically similar (5.10, 10.90, 20.65 and 17.13) with T_8 at 30, 50, 70 and 90 DAT, respectively. Again, at the same DAT the minimum number of tillers per hill (2.60, 4.67, 10.31 and 7.29) was obtained from T_1 as control (Table 4). It revealed that all the treatments produced significantly greater number of tillers compared to the control treatment.

4.1.3 Number of effective tillers/hill

Number of effective tillers per hill of BRRI dhan27 varied significantly due to the influence of crop residues, press mud and tannery waste (Appendix IV). The maximum number of effective tillers per hill was found from T_2 (13.43) which was statistically identical (12.90, 12.47. 12.37 and 12.17) with T_8, T_9, T_6 and T_{10}, respectively whereas the minimum number of effective tillers per hill was recorded from T_1 (5.90) (Figure 1). BRRI dhan27 responded significantly better to chemical fertilizers when applied at the recommended doses than the decomposed organic matter with or without nutrient enrichment.

Table 4. Effect of crop residues, press mud and tannery waste on number of total tillers per hill of aus rice BRRI dhan27

Treatments	Number of total tiller per hill			
	30 DAT	50 DAT	70 DAT	90 DAT
T_1	2.60 f	4.67 d	10.31 e	7.29 e
T_2	5.41 a	11.18 a	20.87 a	17.71 a
T_3	3.45 e	7.30 c	15.48 d	11.58 d
T_4	4.13 cd	9.31 ab	16.57 cd	13.54 cd
T_5	3.64 de	7.93 bc	16.49 cd	12.14 d
T_6	4.74 b	9.95 ab	19.26 ab	15.36 abc
T_7	4.59 bc	9.92 ab	18.18 bc	14.86 bc
T_8	5.10 ab	10.90 b	20.65 a	17.13 ab
T_9	4.65 bc	9.81 ab	19.31 ab	15.13 bc
T_{10}	4.88 ab	10.73 a	19.75 ab	16.86 ab
$LSD_{(0.05)}$	0.561	1.882	2.152	2.238
CV(%)	7.59	11.97	7.09	9.21

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

T_1: No chemical fertilizer, no organic amendment (control)

T_2: 100% recommended N, P, K and S

T_3: Decomposed crop residues (rice straw) without nutrient enrichment

T_4: Decomposed crop residues (rice straw) with nutrient enrichment

T_5: Decomposed tannery waste without nutrient enrichment

T_6: Decomposed tannery waste with nutrient enrichment

T_7: Decomposed sugar mill waste (press mud) without nutrient enrichment

T_8: Decomposed sugar mill waste (press mud) with nutrient enrichment

T_9: Decomposed crop residues (rice straw) + tannery waste with nutrient enrichment

T_{10}: Decomposed crop residues (rice straw) + press mud with nutrient enrichment

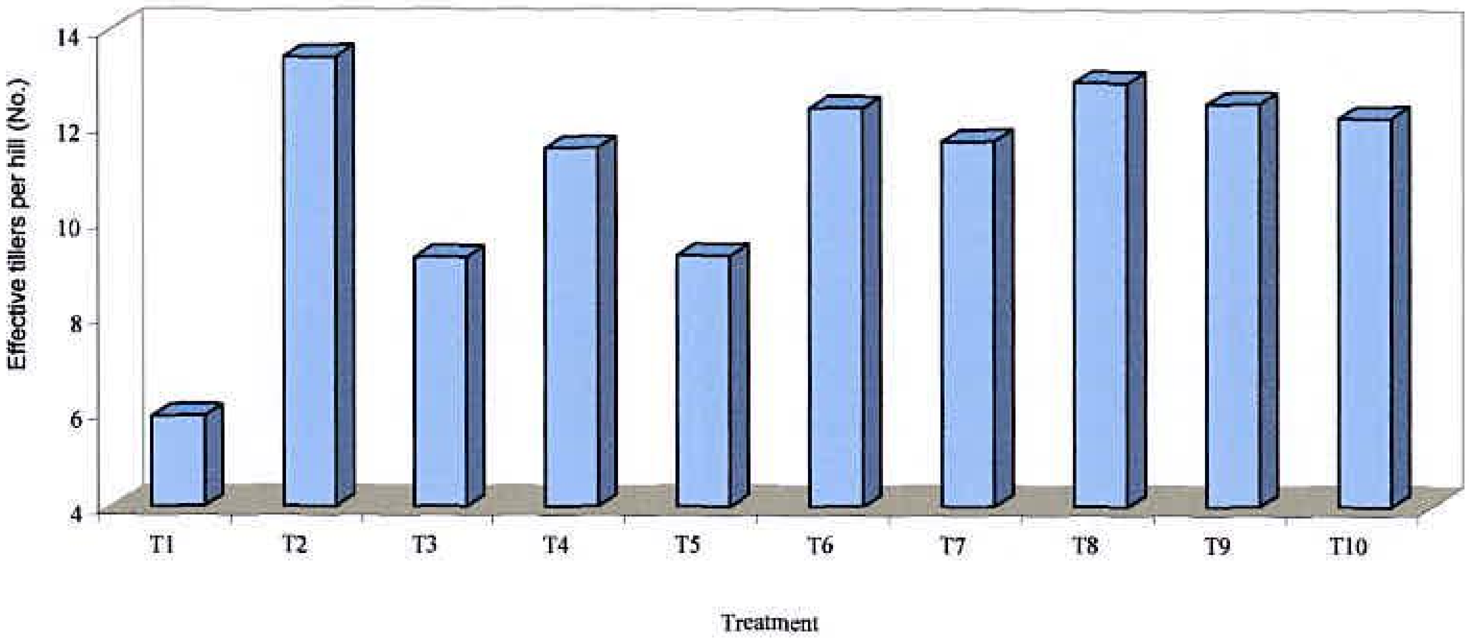

Figure 1. Effect of crop residues, press mud and tannery waste on number of effective tillers per hill of aus rice BRRI dhan27

4.1.4 Number of non-effective tillers/hill

Number of non-effective tillers per hill of BRRI dhan27 varied significantly due to the application of crop residues, press mud and tannery waste (Appendix IV). The maximum number of non-effective tillers per hill was obtained from T_1 (4.33) which was statistically similar to those obtained from T_2, T_8 and T_{10} (3.98, 3.71 and 3.43) respectively, while, the minimum number of non-effective tillers per hill was recorded from T_3 (2.21) (Figure 2).

4.1.5 Total tillers/hill at harvest

Crop residues, press mud and tannery waste showed statistically significant variation in terms of total number of total tillers per hill of BRRI dhan27 (Appendix IV). The maximum number of total tillers per hill at harvest was found from T_2 (17.41) which were statistically identical (16.61, 15.84, 15.61 and 15.59) with T_8, T_9, T_6 and T_{10}, respectively (Figure 3). On the other hand, the minimum number of total tillers was observed from T_1 (10.23).

4.1.6 Length of panicle

Length of panicle of BRRI dhan27 varied significantly due to the application of crop residues, press mud and tannery waste (Appendix IV). The highest length of panicle was recorded from T_2 (24.50 cm) which was statistically identical (23.66 cm, 23.31 cm, 23.16 cm, 22.75 cm and 22.67 cm) with T_8, T_{10}, T_6, T_7 and T_4, respectively. Conversely the lowest length of panicle (15.28 cm) was attained from T_1 (Table 5). Haque (1999) and Azim (1996) noted a significant increase in panicle length due to the application of organic manure and chemical fertilizers.

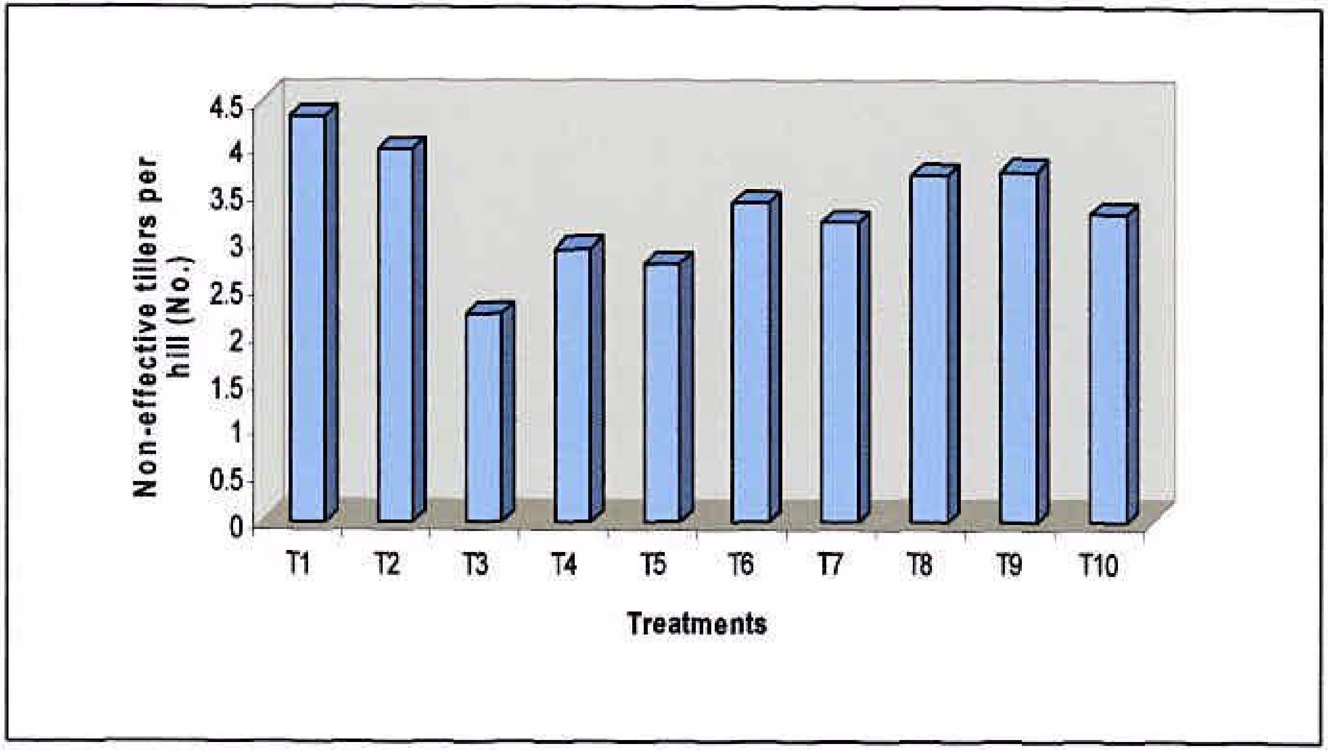

Figure 2. Effect of crop residues, press mud and tannery waste on number of non-effective tillers per hill of aus rice BRRI dhan27

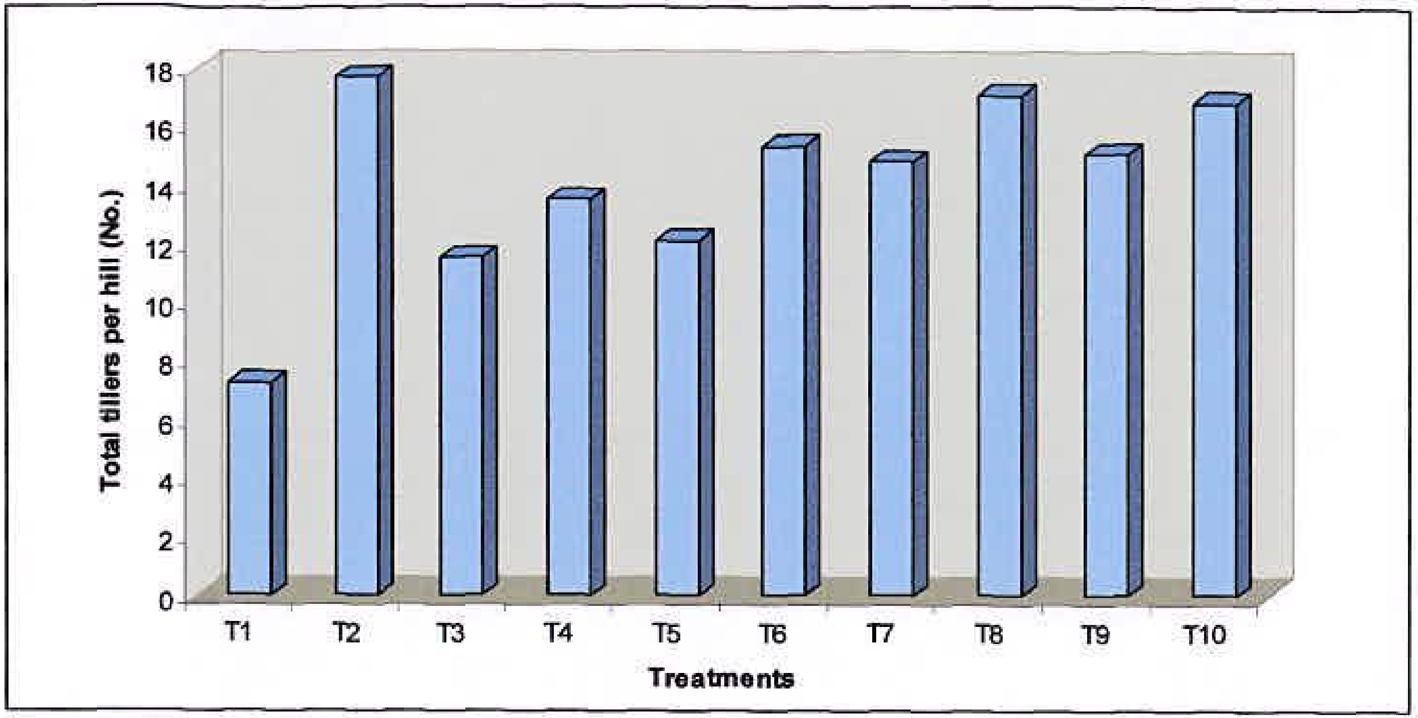

Figure 3. Effect of crop residues, press mud and tannery waste on number of total tillers per hill of aus rice BRRI dhan27

Table 5. Effect of crop residues, press mud and tannery waste on length of panicle and number of grains of aus rice BRRI dhan27

Treatments	Length of panicle (cm)	Number of filled grain/plant	Number of unfilled grain/ plant	Number of total grain/plant
T_1	15.28 d	52.63 h	13.53 a	66.17 d
T_2	24.50 a	91.40 a	6.10 f	97.50 a
T_3	21.06 c	73.70 g	9.44 b	83.14 c
T_4	22.67 abc	84.77 e	8.56 bc	93.33 a
T_5	21.14 c	78.93 f	9.39 b	88.33 b
T_6	23.16 ab	88.57 cd	6.49 ef	95.06 a
T_7	22.75 abc	87.90 d	8.21 cd	96.11 a
T_8	23.66 ab	90.17 b	7.33 de	97.49 a
T_9	22.52 bc	88.33 cd	7.17 def	95.50 a
T_{10}	23.31 ab	89.40 bc	7.96 cd	97.36 a
$LSD_{(0.05)}$	1.639	1.045	1.045	5.255
CV(%)	4.34	8.90	7.23	6.73

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

T_1: No chemical fertilizer, no organic amendment (control)

T_2: 100% recommended N, P, K and S

T_3: Decomposed crop residues (rice straw) without nutrient enrichment

T_4: Decomposed crop residues (rice straw) with nutrient enrichment

T_5: Decomposed tannery waste without nutrient enrichment

T_6: Decomposed tannery waste with nutrient enrichment

T_7: Decomposed sugar mill waste (press mud) without nutrient enrichment

T_8: Decomposed sugar mill waste (press mud) with nutrient enrichment

T_9: Decomposed crop residues (rice straw) + tannery waste with nutrient enrichment

T_{10}: Decomposed crop residues (rice straw) + press mud with nutrient enrichment

4.1.7 Number of filled grain/plant

Due to the application of crop residues, press mud and tannery waste statistically significant differences were recorded for number of filled grain per plant of BRRI dhan27 (Appendix IV). The maximum number of filled grain per plant was found from T_2 (91.40) which was closely followed (90.17 and 89.40) with T_8 and T_{10}, respectively (Table 5). Again, the minimum was recorded from T_1 (52.63).

4.1.8 Number of unfilled grain/plant

Number of unfilled grain per plant of BRRI dhan27 showed statistically significant variation due to the application of crop residues, press mud and tannery waste (Appendix IV). The minimum number of unfilled grain per plant was recorded from T_2 (6.10) which was statistically identical (6.49 and 7.17) with T_6 and T_9, respectively (Table 5). On the other hand, the maximum number of unfilled grain per plant was recorded from T_1 (13.53).

4.1.9 Number of total grain/plant

Significant variation was recorded in terms of number of total grain per plant of BRRI dhan27 due to the application of crop residues, press mud and tannery waste (Appendix IV). The maximum number of total grain per plant was found from T_2 (97.50) which were statistically identical with T_4, T_6, T_7, T_8, T_9 and T_{10}, whereas, the minimum number of total grain per plant was recorded from T_1 (66.17) which were shown in Table 5. These results are also in agreement with Hoque (1999) and Azim (1996).

4.1.10 Weight of 1000 Seeds

Application of crop residues, press mud and tannery waste showed significant variations for weight of 1000 seeds of BRRI dhan27 due to the application of crop residues, press mud and tannery waste (Appendix V). The highest weight of 1000 seeds was found from T_2 (21.80 g) which was statistically identical with T_6 (21.50 g), T_8 (21.33 g), T_{10} (21.30 g) and T_9 (21.07 g) respectively (Table 6). On the other hand, the minimum weight of 1000 seeds (15.50 g) was observed from T_1.

Abedin *et al.* (1999) reported that the combined application of organic manure and chemical fertilizers increased the 1000-grain weight of rice.

4.1.11 Grain yield

Due to the application of crop residues, press mud and tannery waste grain yield of BRRI dhan27 showed statistically significant differences (Appendix V). The highest grain yield was obtained from T_2 (recommended doses of NPKS) (7.23 t/ha) which was statistically identical (6.96 t/ha, 6.86 t/ha, 6.56 t/ha and 6.53 t/ha) with T_8, T_{10}, T_6 and T_9, respectively (Table 6). On the other hand, the lowest grain yield (2.75 t/ha) was found from T_1. These results revealed that nutrient enrichment of composting material produced better compost with more available nutrients than the compost produced without nutrient enrichment. The presence of mineral nutrient during composting might cause net mineralization instead of immobilization of nutrients. This is specially true for high C:N ratio material like rice straw. The compost made from the mixture of crop residues and press mud with nutrient enrichment performed better than that of crop residues only. However, the composts were not able to produce rice yield as good as the recommended doses of NPK indicating the requirement of chemical fertilizer supplement with composts. This is also in agreement with the findings of (Rajni Rani *et al.*, 2001), (Haque *et al.*, 2001), Ahmed and Rhaman (1991) and Laxminarayan (2000).

4.1.12 Straw yield

Straw yield of BRRI dhan27 varied significantly due to the application of crop residues, press mud and tannery waste (Appendix V). The highest straw yield was obtained from T_2 (7.60 t/ha) which was statistically identical (7.55 t/ha, 7.48 t/ha, 7.43 t/ha, 7.28 t/ha and 7.19 t/ha) with T_8, T_{10}, T_7, T_6 and T_9, respectively (Table 6). On the other hand, the lowest straw yield was found from T_1 (5.33 t/ha) as control condition. These findings are well corroborated with the work of Islam (1997) and Khan (1998).

Table 6. Effect of crop residues, press mud and tannery waste on yield of aus rice BRRI dhan27

Treatments	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
T_1	2.75 f	5.33 c	8.08 d	34.03 d
T_2	7.23 a	7.60 a	14.83 a	48.76 a
T_3	4.53 e	5.74 b	10.28 c	44.14 c
T_4	5.60 cd	6.61 ab	12.21 b	45.82 bc
T_5	4.95 de	5.66 b	10.61 c	46.58 ab
T_6	6.56 ab	7.28 a	13.84 ab	47.38 ab
T_7	6.29 bc	7.43 a	13.72 ab	46.02 bc
T_8	6.96 ab	7.55 a	14.52 a	47.94 ab
T_9	6.53 ab	7.19 a	13.72 ab	47.53 ab
T_{10}	6.86 ab	7.48 a	14.34 a	47.85 ab
$LSD_{(0.05)}$	0.752	0.921	1.584	2.050
CV(%)	7.61	7.98	7.40	6.64

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

T_1: No chemical fertilizer, no organic amendment (control)

T_2: 100% recommended N, P, K and S

T_3: Decomposed crop residues (rice straw) without nutrient enrichment

T_4: Decomposed crop residues (rice straw) with nutrient enrichment

T_5: Decomposed tannery waste without nutrient enrichment

T_6: Decomposed tannery waste with nutrient enrichment

T_7: Decomposed sugar mill waste (press mud) without nutrient enrichment

T_8: Decomposed sugar mill waste (press mud) with nutrient enrichment

T_9: Decomposed crop residues (rice straw) + tannery waste with nutrient enrichment

T_{10}: Decomposed crop residues (rice straw) + press mud with nutrient enrichment

4.1.13 Biological yield

Biological yield of BRRI dhan27 showed statistically significant variation due to the application of crop residues, press mud and tannery waste (Appendix VI). The highest biological yield was recorded from T_2 (14.83 t/ha) which was statistically identical with T_8 (14.52 t/ha), T_{10} (14.34 t/ha), T_7 (13.72 t/ha), T_6 (13.84 t/ha) and T_9(13.72 t/ha) respectively (Table 6), whereas the lowest biological yield was obtained from T_1 (8.08 t/ha).

4.1.14 Harvest index

Harvest index of BRRI dhan27 showed statistically significant variation due to the application of crop residues, press mud and tannery waste (Appendix V). The highest harvest index was found from T_2 (48.76%) which was statistically identical (47.94%, 47.85%, 47.53%, 47.38% and 46.58%) with T_8, T_{10}, T_9, T_6 and T_5, respectively (Table 6). On the other hand, the lowest harvest index was observed from T_1 (34.03%).

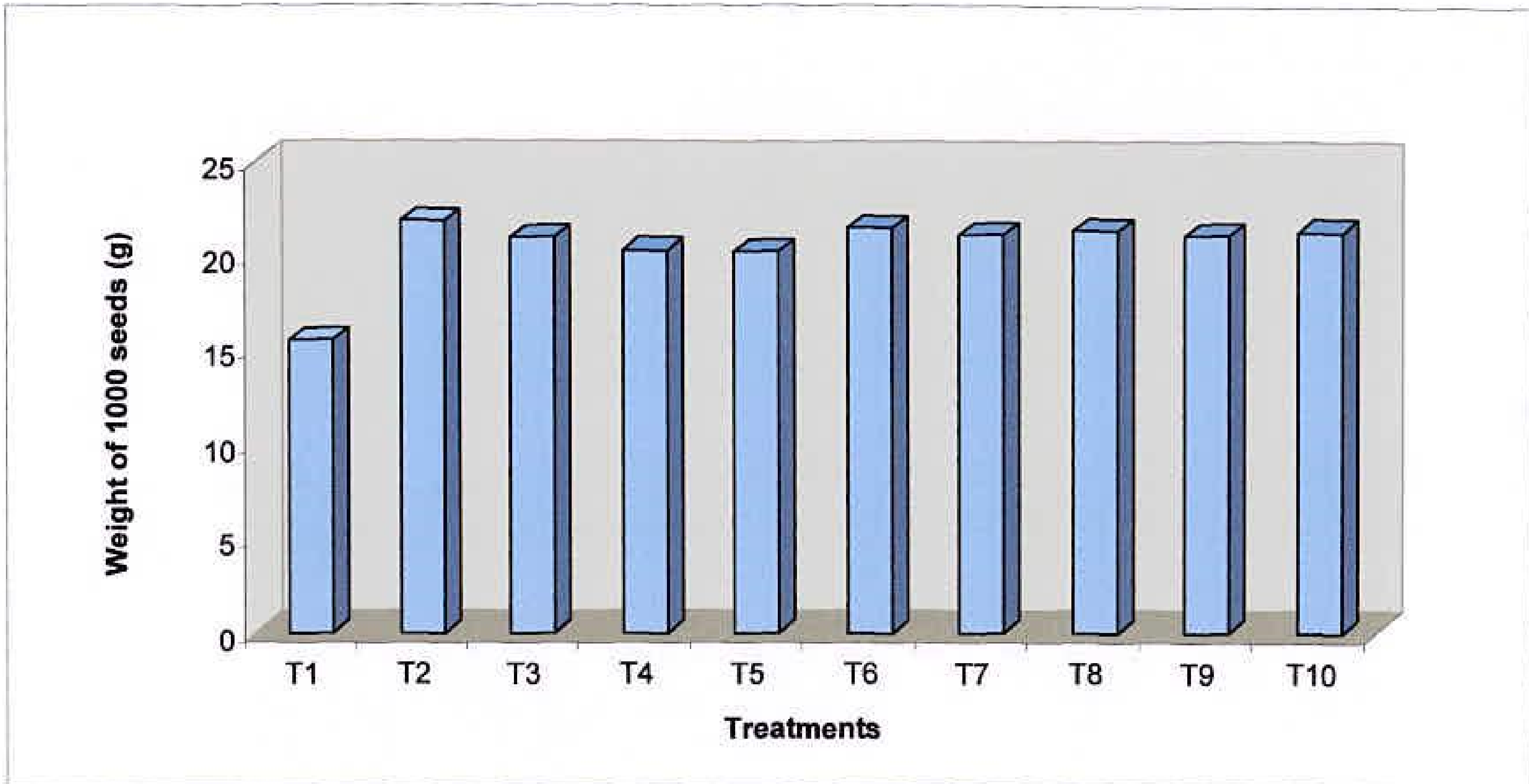

Figure 4. Effect of crop residues, press mud and tannery waste on weight of 1000 seeds of aus rice BRRI dhan27

4.2 NPKS concentration in grain and straw

4.2.1 NPKS concentration in grain

Statistically significant variation was recorded for NPKS concentration in grain of BRRI dhan27 due to the application of crop residues, press mud and tannery waste (Appendix VI). The maximum concentration of N (0.758%), P (0.293%), K (0.358%) and S (0.126%) in grain was recorded with T_2 and the minimum concentrations of N (0.566%), P (0.201%), K(0.265%) and S (0.075%) in grain were observed from T_1 (Table 7).

4.2.2 NPKS concentration in straw

Statistically significant variation was recorded for NPKS concentration in straw of BRRI dhan27 due to the application of crop residues, press mud and tannery waste (Appendix VI). The maximum concentration of N (0.505%), P (0.087%), K (1.175%) and S (0.098%) in straw was recorded with T_2 and the minimum concentrations of N (0.5334%), P (0.051%), K (0.778%) and S (0.058%) in straw were observed from T_1 (Table 7).

Table 7. Effect of crop residues, press mud and tannery waste on N, P, K and S concentrations in grain and straw of aus rice BRRI dhan27

Treatments	Concentration (%) in grain				Concentration (%) in straw			
	N	P	K	S	N	P	K	S
T_1	0.566 d	0.201 f	0.265 e	0.075 d	0.334 e	0.051 d	0.778 d	0.058 c
T_2	0.759 a	0.293 a	0.358 a	0.126 ab	0.505 a	0.087 a	1.175 a	0.098 a
T_3	0.637 c	0.237 cd	0.304 d	0.106 c	0.409 d	0.067 bcd	1.030 c	0.076 bc
T_4	0.681 bc	0.227 de	0.304 d	0.108 bc	0.413 d	0.065 bcd	1.043 bc	0.076 bc
T_5	0.657 bc	0.215 ef	0.301 d	0.104 c	0.401 d	0.064 cd	0.991 c	0.073 bc
T_6	0.688 bc	0.262 b	0.315 cd	0.109 bc	0.444 c	0.074 abc	1.137 ab	0.088 ab
T_7	0.668 bc	0.250 bc	0.322 c	0.108 bc	0.446 c	0.068 bcd	1.070 abc	0.079 ab
T_8	0.717 ab	0.284 a	0.344 ab	0.129 a	0.501 a	0.084 ab	1.149 a	0.091 ab
T_9	0.700 b	0.265 b	0.326 bc	0.111 abc	0.470 b	0.078 abc	1.140 ab	0.087 ab
T_{10}	0.700 b	0.285 a	0.331 bc	0.118 abc	0.489 a	0.078 abc	1.154 a	0.089 ab
$LSD_{(0.05)}$	0.054	0.017	0.017	0.017	0.017	0.017	0.094	0.017
CV(%)	9.44	5.46	8.62	5.02	7.76	6.53	4.80	5.44

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

T_1: No chemical fertilizer, no organic amendment (control)

T_2: 100% recommended N, P, K and S

T_3: Decomposed crop residues (rice straw) without nutrient enrichment

T_4: Decomposed crop residues (rice straw) with nutrient enrichment

T_5: Decomposed tannery waste without nutrient enrichment

T_6: Decomposed tannery waste with nutrient enrichment

T_7: Decomposed sugar mill waste (press mud) without nutrient enrichment

T_8: Decomposed sugar mill waste (press mud) with nutrient enrichment

T_9: Decomposed crop residues (rice straw) + tannery waste with nutrient enrichment

T_{10}: Decomposed crop residues (rice straw) + press mud with nutrient enrichment

4.3 NPKS uptake by grain and straw

4.3.1 NPKS uptake by grain

Statistically significant variation was recorded for NPKS uptake by grain of BRRI dhan27 due to the application of crop residues, press mud and tannery waste (Appendix VII). The maximum uptake by grain for N (54.94 kg/ha), P (21.20 kg/ha), K (25.89 kg/ha) and S (1.54 kg/ha) were recorded from T_2 and the minimum uptake by grain for N (15.64 kg/ha), P (4.13 kg/ha), K (5.46 kg/ha) and S (1.54 kg/ha) were observed from T_1 (Table 8). Rahman (2001); Duhan *et al.* (2002); Azim (1999) and Hoque (1999) also reported similar results.

4.3.2 NPKS uptake by straw

Statistically significant variation was recorded for NPKS uptake by straw of BRRI dhan27 due to the application of crop residues, press mud and tannery waste (Appendix VII). The maximum uptake by grain for N (38.35 kg/ha), P (6.62 kg/ha), K (89.12 kg/ha) and S (7.45 kg/ha) were recorded from T_2 and the minimum uptake by grain for N (15.80 kg/ha), P (2.43 kg/ha), K (36.79 kg/ha) and S (2.74 kg/ha) were observed from T_1 (Table 8).

Table 8. Effect of crop residues, press mud and tannery waste uptake by grain and straw of aus rice BRRI dhan27

Treatments	Uptake by grain (kg/ha)				Uptake by straw (kg/ha)			
	N	P	K	S	N	P	K	S
T_1	11.64 g	4.13 d	5.46 f	1.54 g	15.80 f	2.43 e	36.79 c	2.74 e
T_2	54.94 a	21.20 a	25.89 a	9.11 a	38.35 a	6.62 a	89.12 a	7.45 a
T_3	28.88 f	10.74 c	13.80 e	4.82 f	23.53 e	3.87 d	59.22 b	4.35 d
T_4	38.11 de	12.66 c	17.02 d	6.03 de	31.00 d	4.84 c	78.44 a	5.74 c
T_5	32.54 ef	10.60 c	14.90 de	5.16 ef	22.70 e	3.63 d	56.13 b	4.13 d
T_6	43.58 bcd	16.59 b	19.93 c	6.92 cd	32.36 cd	5.39 c	82.79 a	6.40 bc
T_7	42.04 cd	15.70 b	20.29 c	6.85 cd	33.11 bcd	5.06 c	79.33 a	5.87 c
T_8	49.92 ab	19.78 a	23.95 ab	8.97 a	37.85 ab	6.35 ab	86.72 a	6.87 ab
T_9	45.76 bc	17.25 b	21.34 bc	7.26 bc	33.84 abcd	5.59 bc	81.99 a	6.23 bc
T_{10}	48.01 bc	19.59 a	22.67 bc	8.08 ab	36.54 abc	5.80 abc	86.29 a	6.65 abc
$LSD_{(0.05)}$	5.900	1,973	2.689	1.104	4.637	0.866	12.08	0.861
CV(%)	8.70	7.76	8.46	9.94	8.86	10.19	9.56	8.89

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

T_1: No chemical fertilizer, no organic amendment (control)

T_2: 100% recommended N, P, K and S

T_3: Decomposed crop residues (rice straw) without nutrient enrichment

T_4: Decomposed crop residues (rice straw) with nutrient enrichment

T_5: Decomposed tannery waste without nutrient enrichment

T_6: Decomposed tannery waste with nutrient enrichment

T_7: Decomposed sugar mill waste (press mud) without nutrient enrichment

T_8: Decomposed sugar mill waste (press mud) with nutrient enrichment

T_9: Decomposed crop residues (rice straw) + tannery waste with nutrient enrichment

T_{10}: Decomposed crop residues (rice straw) + press mud with nutrient enrichment

Table 9. Effect of crop residues, press mud and tannery waste on the post harvest soil of aus rice BRRI dhan27

Treatments	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me /100 g soil)	Available S (ppm)
T_1	5.85 bc	1.01 c	0.024 c	19.42 d	0.103 e	12.45 e
T_2	6.05 b	1.03 c	0.054 a	25.53 a	0.166 a	20.66 a
T_3	5.67 c	1.18 a	0.038 ab	22.48 bc	0.132 d	16.30 d
T_4	5.85 bc	1.22 ab	0.041 ab	23.26 ab	0.135 cd	17.43 cd
T_5	5.80 bc	1.33 a	0.032 bc	21.09 cd	0.128 d	16.05 d
T_6	5.90 bc	1.22 ab	0.046 ab	24.05 ab	0.154 ab	18.00 bc
T_7	5.95 bc	1.21 ab	0.040 ab	23.66 ab	0.141 bcd	17.44 cd
T_8	6.47 a	1.29 a	0.053 a	25.58 a	0.158 ab	19.86 ab
T_9	6.13 b	1.29 a	0.050 ab	24.98 ab	0.156 ab	18.93 ab
T_{10}	5.83 bc	1.28 a	0.051 ab	25.09 ab	0.152 abc	19.99 ab
$LSD_{(0.05)}$	0.321	0.144	0.172	2.650	0.172	2.261
CV(%)	9.14	7.03	6.71	6.57	5.72	7.44

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

T_1: No chemical fertilizer, no organic amendment (control)

T_2: 100% recommended N, P, K and S

T_3: Decomposed crop residues (rice straw) without nutrient enrichment

T_4: Decomposed crop residues (rice straw) with nutrient enrichment

T_5: Decomposed tannery waste without nutrient enrichment

T_6: Decomposed tannery waste with nutrient enrichment

T_7: Decomposed sugar mill waste (press mud) without nutrient enrichment

T_8: Decomposed sugar mill waste (press mud) with nutrient enrichment

T_9: Decomposed crop residues (rice straw) + tannery waste with nutrient enrichment

T_{10}: Decomposed crop residues (rice straw) + press mud with nutrient enrichment

4.4 P^H, organic matter and NPKS in post harvest soil

Statistically non significant variation was recorded for pH, organic matter, total N, available P, exchangeable K, available S in post harvest soil due to the application of different organic manure and inorganic fertilizer in BRRI dhan27 (Appendix IX). The highest pH (6.05), total N (0.54%), available P (25.53 ppm), exchangeable K (0.166 me%) and available S (20.66 ppm) were recorded from T_2 and the lowest organic matter (1.01%), total N (0.24%), available P (19.42 ppm), exchangeable K (0.103 me%) and available S (12.45 ppm) were observed from T_1 (Table 9). However, the highest organic matter was recorded from T_5 (1.33%) and the lowest pH from T_3 (5.67).

Chapter 5
Summary and Conclusion

CHAPTER 5

SUMMARY AND CONCLUSION

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from February to July, 2009 to study the influence of crop residues, press mud and tannery waste on the growth and yield of rice. BRRI dhan27 was used as the test crop in this experiment. The experiment consisted of 10 treatments such as- T_1: No chemical fertilizer, no organic amendment (control); T_2: 100% recommended N, P, K and S (100 kg N, 60 kg P_2O_5, 40 kg K_2O and 25 kg S/ha); T_3: Decomposed crop residues (rice straw) without nutrient enrichment; T_4: Decomposed crop residues (rice straw) with nutrient enrichment; T_5: Decomposed tannery waste without nutrient enrichment; T_6: Decomposed tannery waste with nutrient enrichment; T_7: Decomposed sugar mill waste (press mud) without nutrient enrichment; T_8: Decomposed sugar mill waste (press mud) with nutrient enrichment; T_9: Decomposed crop residues (rice straw) + tannery waste with nutrient enrichment and T_{10}: Decomposed crop residues (rice straw) + press mud with nutrient enrichment. The experiment was laid out in a randomized complete block design (RCBD) with 3 replications.

The tallest plant (23.96 cm, 31.29 cm, 44.23 cm, 66.84 cm and 88.87 cm) was recorded from T_2 and the shortest plant (16.47 cm, 21.60 cm, 30.23 cm, 47.13 cm and 61.95 cm) was obtained from T_1 at 30, 50, 70, 90 DAT and at harvest, respectively. The maximum number of tillers per hill (5.41, 11.18, 20.87 and 17.71) was recorded from T_2 again, the minimum (2.60, 4.67, 10.31 and 7.29) was obtained from T_1. The maximum number of effective tillers per hill was found from T_2 (13.43) whereas the minimum from T_1. The maximum number of non-effective tillers per hill was obtained from T_1 (4.33), while, the minimum from T_6. The maximum number of total tillers per hill at harvest was observed from T_2 (17.41) and the minimum from T_1 (10.23). The highest length of panicle was recorded from T_2 (24.50 cm) and, the lowest length of panicle (15.28 cm) was observed from T_1. The maximum number of filled grain per plant was found from T_2 (91.40) again, the minimum from T_1 (52.63). The minimum number of unfilled grain per plant was recorded from T_2 (6.10) and the maximum number from T_1 (13.53). The maximum number of total grain per plant was found from T_2 (97.50), whereas, the minimum number of total grain per plant was recorded from T_1 (66.17). The highest weight of 1000 seeds was found from T_2 (21.80 g) and, the minimum weight of 1000 seeds (15.50 g) was observed from T_1. The highest grain yield was obtained from T_2 (7.23 t/ha) and, the lowest grain yield (2.75 t/ha) from T_1. The highest straw yield was obtained from T_2 (7.60 t/ha) and, the lowest from T_1 (4.73 t/ha). The highest biological yield was recorded from T_2 (14.83 t/ha) again, the lowest from T_1 (8.08 t/ha). The highest harvest index was found from T_2 (48.76%) and, the lowest from T_1 (34.03%).

The maximum concentration of N (0.758%), P (0.293%), K (0.358%) and S (0.126%) in grain was recorded with T_2 and the minimum concentrations of N (0.566%), P (0.201%), K (0.265%) and S (0.075%) in grain were observed from T_1. The maximum uptake by grain for N (54.94 kg/ha), P (21.20 kg/ha), K (25.89 kg/ha) and S (1.54 kg/ha) were recorded from T_2 and the minimum uptake by grain for N (11.64 kg/ha), P (4.13 kg/ha), K (5.46 kg/ha) and S (1.54 kg/ha) were observed from T_1. The maximum concentration of N (0.505%), P (0.087%), K (1.175%) and S (0.098%) in straw was recorded with T_2 and the minimum concentrations of N (0.5334%), P (0.051%), K (0.778%) and S (0.058%) in straw were observed from T_1. The maximum uptake by grain for N (38.35 kg/ha), P (6.62 kg/ha), K (89.12 kg/ha) and S (7.45 kg/ha) were recorded from T_2 and the minimum uptake by grain for N (15.80 kg/ha), P (2.43 kg/ha), K (36.79 kg/ha) and S (2.74 kg/ha) were observed from T_1. The highest pH (6.05), total N (0.54%), available P (25.53 ppm), exchangeable K (0.166 me%) and available S (20.66 ppm) were recorded from T_2 and the lowest organic matter (1.01%), total N (0.24%), available P (19.42 ppm), exchangeable K (0.103 me%) and available S (12.45 ppm) were observed from T_1. However, the highest organic matter was recorded from T_5 (1.33%) and lowest pH from T_3 (5.67).

These results revealed that nutrient enrichment of composting material produced better compost with more available nutrients than the compost produced without nutrient enrichment. The presence of mineral nutrient during composting might cause net mineralization instead of immobilization of nutrients. This is specially true for high C:N ratio material like rice straw. The compost made from the mixture of crop residues and press mud with nutrient enrichment performed better than that of crop residues only. However, the composts were not able to produce rice yield as good as the recommended doses of NPKS indicating the requirement of chemical fertilizer supplement with composts. Therefore, it may be concluded that-

(a) Nutrient enrichment of composting material produced better compost with more available nutrients than the compost produced without nutrient enrichment. Nutrient enrichment increased yield of rice compared to without enrichment.

(b) The compost made from press mud was better than that made from tannery waste or crop residues.

(c) The compost made from the mixture of crop residues and press mud with nutrient enrichment performed better than that of crop residues only.

(d) The composts were not able to produce rice yield as good as the recommended doses of NPKS indicating the requirement of chemical fertilizer supplement with composts.

Considering the situation of the present experiment, the following recommendations and suggestions may be made:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance.
2. Residual effect of crop residues on succeeding crop should have been investigated.
3. Organic manure and their combination and procedure of enrichment of nutrition may be included for further study

Chapter 6
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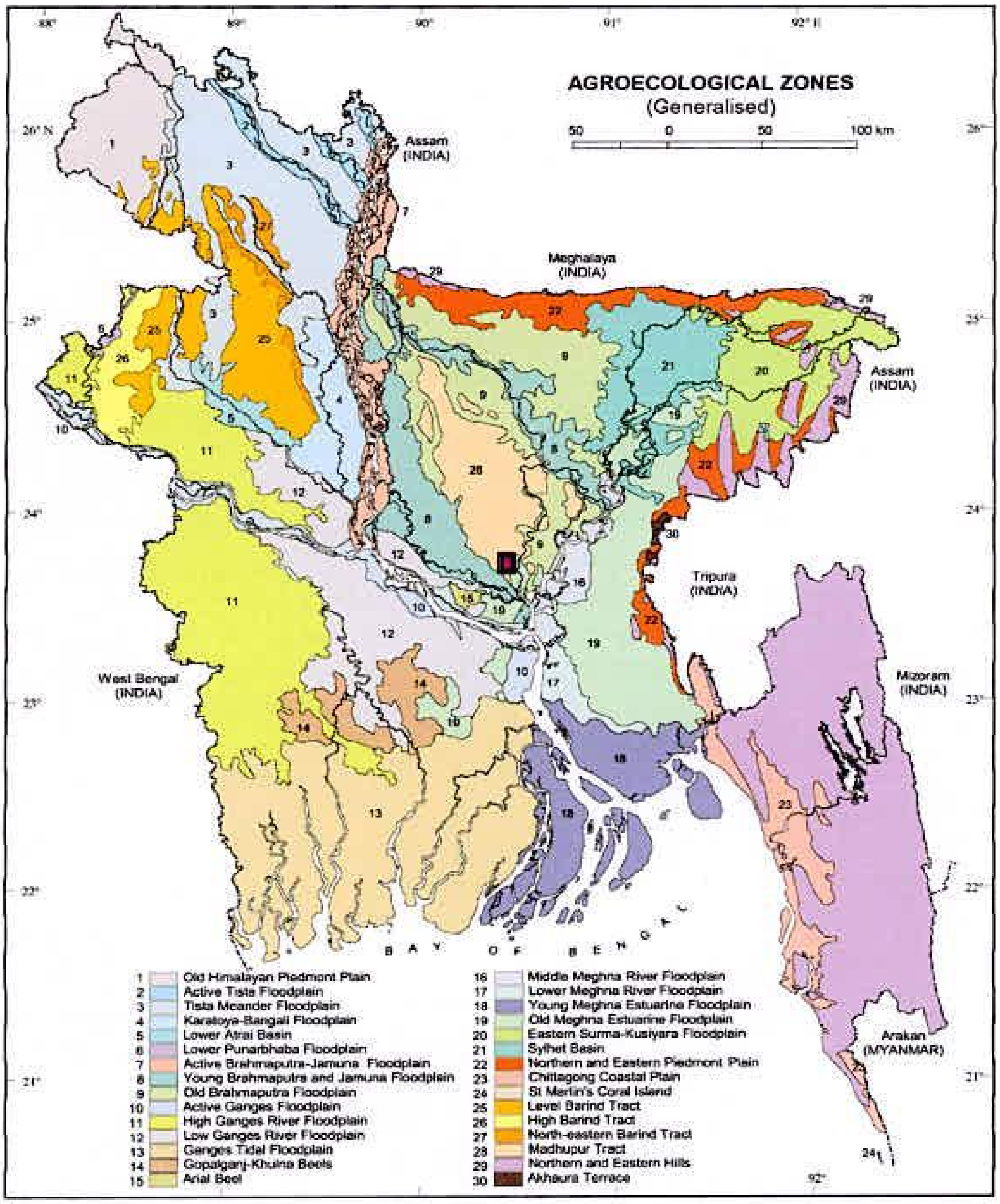
APPENDICES

Appendix 1. Map showing the location of experimental site



Appendix 2: Monthly record of air temperature, relative humidity and sunshine of the experimental site during the period from February to July, 2009

Month	Air Temperature (°C)		Relative* Humidity (%)	Rainfall** (mm)	Sunshine** (hr)
	Maximum	Minimum			
February	31.4	16.5	52	10	8.7
March	33.6	19.6	54	45	8.2
April	34.7	23.6	69	88	6.4
May	34.9	25.9	70	90	7.8
June	34.5	26.8	76	185	7.1
July	32.2	26.1	73	213	6.3

* Monthly average ** Monthly total

Source: Bangladesh Meteorological Department (Climate & water division) Agargaon, Dhaka-1207

Appendix 3: Mean Square values of analysis of variance of crop residues, press mud and tannery waste on plant height of aus rice BRRI dhan27

Sources of variation	Degree of freedom	Plant height(cm)				
		30 DAT	50 DAT	70 DAT	90 DAT	Harvest
Replication	2	0.168	0.016	0.141	2.618	2.387
Treatment	9	16.091**	28.306**	52.249**	107.920**	193.372**
Error	18	3.464	4.262	1.068	4.381	2.134

** 1% Level of Significance * 5% Level of Significance

Appendix 4: Mean Square values of analysis of variance of crop residues, press mud and tannery waste on number of total tillers per hill of aus rice BRRI dhan27

Sources of variation	Degree of freedom	Number of total tillers per hill			
		30 DAT	50 DAT	70 DAT	90 DAT
Replication	2	0.151	0.042	0.916	1.184
Treatment	9	2.218**	12.125**	30.150**	29.969**
Error	18	0.107	1.204	1.574	1.702

** 1% Level of Significance * 5% Level of Significance

Appendix 5: Mean Square values of analysis of variance of crop residues, press mud and tannery waste on length of panicle and number of grains of aus rice BRRI dhan27

Sources of variation	Degree of freedom	Length of panicle (cm)	Number of Filled grain/plant	Number of unfilled grain/plant	Number of total grain/plant
Replication	2	0.166	14.683	0.867	8.503
Treatment	9	20.057**	424.281**	13.421**	292.897**
Error	18	0.913	5.717	0.371	

** 1% Level of Significance * 5% Level of Significance

Appendix 6: Mean Square values of analysis of variance of crop residues, press mud and tannery waste on yield of aus rice BRRI dhan27.

Sources of variation	Degree of freedom	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest Index (%)
Replication	2	0.202	0069	0.475	1.045
Treatment	9	7.415**	3.043**	19.633**	87.279**
Error	18	0.192	0.288	0.853	1.428

** 1% Level of Significance * 5% Level of Significance

Appendix 7: Mean Square values of analysis of variance crop residues, press mud and tannery waste on N, P, K and S concentrations in grain and straw of aus rice BRRI dhan27

Sources of variation	Degree of freedom	Concentration (%) in grain				Concentration (%) in straw			
		N	P	K	S	N	P	K	S
Replication	2	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
Treatment	9	0.008**	0.003**	0.002**	0.001**	0.009**	0.000**	0.043**	0.000**
Error	18	0.001	0.000	0.000	0.000	0.000	0.000	0.003	0.000

** 1% Level of Significance * 5% Level of Significance

Appendix 8: Mean Square values of analysis of variance of crop residues, press mud and tannery waste uptake by grain and straw of aus rice BRRI dhan27

Sources of variation	Degree of freedom	Concentration (%) in grain				Concentration (%) in straw			
		N	P	K	S	N	P	K	S
Replication	2	6.443	0.522	0.870	0.395	0.186	0.145	0.541	0.001
Treatment	9	473.598**	83.746**	107.458**	15.211**	166.401**	5.118**	884.129**	6.377**
Error	18	11.829	1.323	2.457	0.414	7.306	0.255	49.605	0.252

** 1% Level of Significance   * 5% Level of Significance

Appendix 9. Mean Square values of analysis of variance of crop residues, press mud and tannery waste on the post harvest soil of aus rice BRRI dhan27

Sources of variation	Degree of freedom	Soil P^{H}	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me/100g)	Available S (ppm)
Replication	2	0.018/	0.010	0.000	0.634	0.000	0.667
Treatment	9	0.150**	0.037**	0.000**	12.348**	0.001**	17.535**
Error	18	0.035	0.007	0.000	2.387	0.000	1.738

** 1% Level of Significance   * 5% Level of Significance