COMBINED EFFECT OF CHEMICAL NITROGENOUS FERTILIZER AND TREATED SLUDGE ON THE GROWTH AND YIELD OF BRRI dhan62

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CERTIFICATE

This is to certify that thesis entitled, **"COMBINED EFFECT OF CHEMICAL NITROGENOUS FERTILIZER AND TREATED SLUDGE ON THE GROWTH AND YIELD OF BRRI dhan62"** submitted to the Department of Soil Science, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN SOIL SCIENCE,** embodies the result of a piece of *bona fide* research work carried out by **NIRANJAN BANDOPADDHYA, REGISTRATION NO. 09-03541** under my supervision and guidance. No part of the 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: **(Dr. Alok Kumar Paul)**
Place: Dhaka, Bangladesh **Professor**
Supervisor

Dedicated to

My

Beloved Parents

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ABSTRACT

An experiment was carried out at Soil Science farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka to study the combined effect of chemical nitrogenous fertilizer (urea) and treated sludge on the growth and yield of BRRI dhan62 during the period from July to October, 2014. The experiment was laid out in a randomize block design with three replications. Seven treatments of the experiment including control were as T_1 = Absolute Control, T_2 = 100% Recommended Field Dose (RFD) of Urea, T_3 = 80% RFD of Urea + 20% sludge, T_4 = 60% RFD of Urea + 40% sludge, T_5 = 40% RFD of Urea + 60% sludge, T_6 = 20% RFD of Urea + 80% sludge and T_7 = 100% sludge. Here it can be mentioned that recommended fertilizer dose (RFD) per hectare = Urea 150kg + TSP 71kg + MP 71kg + Gypsum 41.1kg + $ZnSO_4$ 11.2kg + sludge 0.0kg and 1kg urea = 10 kg sludge. The results from the study revealed that the highest plant height (99.93 cm), the highest number of tiller per hill (14.95) and the longest panicle (23.99 cm) was recorded from T_2 (100% RFD of urea); the maximum number of grain per panicle (98.21) and the highest number of filled grain per panicle (91.95) was recorded from T_4 (60% RFD of urea + 40% sludge). The maximum number of effective tiller per hill (14.56), the highest weight of 1000 seeds (24.23g), Seed yield t/ha^{-1} (4.36), and Straw yield t/ha^{-1} (5.66) were achieved from T_3 (80% RFD of urea + 20% sludge). Chemical fertilizer in combination with sludge performed better in respect of almost all parameters studied.

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BARI	=	Bangladesh Agricultural Research Institute
CBR	=	Cost Benefit Ratio
cm	=	Centimeter
^{0}C	=	Degree Centigrade
DAS	=	Days after sowing
et al.	=	and others *(at elli)*
Kg	=	Kilogram
Kg/ha	=	Kilogram/hectare
g	=	gram (s)
LER	=	Land Equivalent Ratio
LSD	=	Least Significant Difference
MP	=	Muriate of Potash
m	=	Meter
P^{H}	=	Hydrogen ion conc.
RCBD	=	Randomized Complete Block Design
TSP	=	Triple Super Phosphate
t/ha	=	ton/hectare
%	=	Percent

CHAPTER I

INTRODUCTION

Rice (*Oryza sativa*) belonging to the family Poaceae; is the staple food for at least 62.8% of planet inhabitants and it contributes on an average 20% of apparent caloric intake of the world population and 30% of population in Asia. This contribution varies from 29.5% for China to 72.0% for Bangladesh (Begum *et al*., 2001). Ninety per cent of this crop is grown and consumed in South and Southeast Asia, the major centers of the world's population.

Rice is the most important food for majority of people around the world. It is the staple food for more than two billion people in Asia. In Bangladesh, the geographical, climatic and edaphic conditions are favorable for year round rice cultivation. However, the national average rice yield (2.34 t ha^{-1}) is very low compared to that of other rice growing countries. For instance, the average rice yield in China is about 6.30 t ha^{-1}, Japan is 6.60 t ha^{-1} and Korea is 6.30 t ha^{-1} (FAO, 2008). The population of Bangladesh is increasing at an alarming rate and the cultivable land is reducing due to urbanization and industrialization resulting in more shortage of food. As it is not possible to have horizontal expansion of rice area, rice yield $unit^{-1}$ area should be increased to meet this ever-increasing demand of food in the country. At present in Bangladesh, rice is occupied by 28101 thousand acres of land with production of 34357 thousand metric ton (BBS, 2014). In Bangladesh, rice dominates over all other crops and covers 75% of the total cropped area of which around 79% is occupied by high yielding rice varieties (BBS, 2008). According to Begum *et al*. (2001) and Islam *et al*. (1989) 62.8% and 27-100% respectively is occupied by high yielding rice varieties.

Zinc, iron and Vitamin-A are the three most important elements, deficiency of which hampers children's natural growth and decrease their disease prevention capability. In Bangladesh, over 40 percent children under five are stunted while an estimated 44 percent children of the same age group are at risk of zinc deficiency. BRRI has released the world's first zinc-enriched rice variety BRRI dhan62, capable of fighting diarrhoea and pneumonia-induced childhood deaths and stunting. Moreover, Bangladesh also contributed from the forefront in shaping up the still under-trial world's first vitamin A enriched rice, popularly known as Golden Rice (BRRI, 2012).

Sewage sludge is one of the cheap and important sources of organic matter and plant nutrients, influencing plant growth and yield (Parat *et al.* 2005). Its use is not new in agricultural land. Its application to soils not only improves organic matter and essential nutrient contents, but also improves soil structure, aeration, water-holding capacity and microbial activities (Webber *et al.* 1996 and Parat *et al.* 2005). It has been widely used in cropped land in many countries especially Europe, America and some parts of Asia. But, this may cause a potential hazard, especially heavy metal pollution to soil, if undesirable industrial sludge is incorporated in the sewage pipe line and substantial amounts of heavy metals (Cd, Ni, Cu, Zn and others) are not removed from the sludge (Fliebbach 1991).

The compositions of sewage sludge vary from one city to another and even from one day to the next in the same city (Tisdale *et al.* 1995). Approximately 54,750 tons of sewage sludge containing about 1,000 to 1,400 tons of nitrogen and 350 to 500 tons of phosphorus are produced per year in Dhaka city, Bangladesh (BARC 1997). In Bangladesh, sewage sludge application is not extensive in agricultural land. Moreover, research regarding the potential use of sewage sludge on agricultural land and its consequences on soils as well as in grain and vegetable crops is inadequate in Bangladesh. Therefore, the present investigation was conducted to find out the yield and mineral contents in rice grains under different levels of sewage sludge and nitrogen fertilization.

Nitrogen is the main nutrient associated with yield, but N management responds differently to rice type, cultivar, geographic zone, and other crop practices (Jing et al., 2008; Hirzel et al., 2011a). Similarly, fertilization management and genotype and environment interaction generate differences in plant nutrient composition (Mengel and Kirkby, 1987); they affect crop extraction, rice plant yield components, and N use efficiency (Matsunami et al., 2009). At the same time, differences in nutrient compartmentalization in the rice plant (grain and residues) produce positive or negative effects on the nutrient balance of the soil-plant system for those productive systems in which plant residues are incorporated or extracted.

Proper fertilization is an important management practice which can increase the yield of rice. Judicious and proper use of fertilizers can markedly increase the yield and improve the quality of rice (Yousida, 1976). Among the fertilizers nitrogenous fertilizers has immense effect on the yield of rice. Nitrogen not only enhances the yield of rice but also reduce the spikelet sterility. Nitrogen is required in adequate amount at early, at midtillering and panicle initiation stage for better grain development (Ahmed *et al.* 2005). BRRI (1990) reported that nitrogen has a positive influence on the production of effective tillers. However, heavy application of nitrogen does not always give higher yield. Application of heavy nitrogen increased tillering and spikelet number per plant and this, in turn, reduced the number of engorged pollen grains per anther, leading into increased spikelet sterility (Gunawardena *et al.* 2003). So it is necessary to know the best dose of nitrogenous fertilizer for optimum yield and to reduce spikelet sterility of rice.

Hence the present study was under taken to observe the combined effect of chemical nitrogenous fertilizer (urea) and treated sludge on the growth and yield of BRRI dhan62, so keeping this view in mind, the present experiment has taken with the following objectives -

1. To observe the effect of sludge on the growth and yield of rice
2. To find out the combined dose of urea and sludge for the better yield of BRRI dhan62 and
3. To study the interaction effect of nitrogenous fertilizer (urea) and treated sludge on the growth and yield of BRRI dhan62

CHAPTER 2

REVIEW OF LITERATURE

In abroad, great importance has given on the need of organic matter in soil. Waste materials could be a good source of organic matter. As a result a lot of research work has been done on this sector giving rise of huge literature. But in Bangladesh, though soil is severely suffering from organic matter deficiency this matter is not yet taken into great consideration. So literature in Bangladesh about this matter is limited. Some of the findings of relevant research work are reviewed under the following sequences.

2.1 Nutrient status of Bangladesh soil

The level of organic matter in the soil of Bangladesh is very low. About 45 per cent of the net cultivable area (NCA) of the country has less than 1 percent organic matter content. The districts of Dinajpur, Sherpur, Jamalpur, Tangali, Nawabgonj, Rajshahi, Pabna, Kushtia, Borga, Naogaon, Rangpur, Khagrachari, Bandarban and Chittagong consisting of 44.5% of net cultivable land contain organic matter below 1%. Adjoining area of Tista, Dharlus, Chandpur, Lakshimipur, Noakhali, Bhola, Barisal, Patuakhali, Narsingdi and Dhaka consisting of 17.1% of NCA contain 1-1.7% of organic matter, Shirajgonj, Mymensingh, Kishoregonj, Sherpur, Jamalpur, Sylhet, Moulvibazar, Feni and Cox's Bazer consisting of 21.3% NCA contain 1.7- 3.5% organic matter and Panchaghar, Natore, Naogaon, Khulna, Satkhira, Madaripur, Gopalgonj, Munshigonj, Habigonj, Sunamgonj and Neirokona consisting of 17.1% of NCA contain more than 3.5% organic matter (BARC. 1999).

Bhuiyan (1988) stated that 0.05-0.22% of total nitrogen was present in different soil series of Bangladesh. Moslehuddin (1993) reported that Bangladesh Agricultural University Farm soils contained 0.04-0.22% of total nitrogen.

2.2 Nutrient status of sludge or organic fertilizer as a source of nitrogen and their effect on soil

Yawalker *et al.,* (1981) reported that the urban compost had the nutrient status to the extent of 1.4% N, 1.0% P_2O_5 and 1.4% K_2O and night soil contained 5.5% N, 4.0% P_2O_5 and 2% K_2O. Sewage sludge reflected the status of 1.5-3.5% nitrogen, 0.78-4.0% phosphorus and 0.3-0.6% potash. Thorne *et al.* (1975) also reported that 1-6% of total nitrogen and on an average 5% nitrogen were present in fresh heated and anaerobically digested sewage sludge. Typical sludge contained 1-8% Ca, 2-5% Mg, 0.3- 1.5% S.

Ahmed *et al.*, (1996) found that the concentrations of total N, P, K in urban sewage sludge were 2.0%, 0.08%, 0.72% (Paulraj and Ramulu 1994). In non-irradiated sewage sludge, Ca and Mg content was 3.9% and 3%, and in irradiated sewage sludge was 3% and 3.5%, respectively.

An experiment was conducted by Datta *et al.* (2000) at IARI farm New Delhi, India, to study the effect of continuous irrigation with sewage sludge effluents on heavy metal build-up in soils and their uptake by various crops. They found that pH and organic C content of sewage effluent irrigated soils ranged from 7.1 to 8.4 and 3.5 to 7.7 g/kg, respectively, while in the tube-well water-irrigated soils the corresponding values were 7.3-8.4 and 3.7-5.8 mg/kg. Accumulation of available P occurred in the sewage-effluent-irrigated soils with an increase of 180% and 20% decrease was discernible in available K status. DTPA- Extractable Zn, Cu, Fe, Mn, Ni and Pb contents were increase by 127, 200, 22, 247, 100 and 29% due to long-term use of sewage effluents over adjacent soils irrigated through tube-well water. The concentration of metals in all crops was below the generalized critical levels of phytotoxicity except Fe.

Kumaraswamy *et al.,* (1998) conducted a long-term filed experiment for 29 years in Cuddalare, Tamil Nadu, India found that no marked change on EC and pH of soil, organic C content had increased markedly, particularly in the treatment that received press mud for every crop of sugarcane. There was no appreciable buildup N and K in the soil in spite of application of these nutrients to each crop over year. So, there was a significant buildup of P in the soil in treatments receiving P every year. Available P status was appreciably higher in treatment receiving press mud then in treatment without press mud.

A field experiment was conducted by Yang *et al.* (1999) in Jiangsu province, China, to study the feasibility of irradiated and non-irradiated sewage sludge as a fertilizer for the growth of rice. The irradiated and non-irradiated sewage sludge was applied at rates of O (control), 112.5, 225 kg N ha^{-1} respectively. Irradiation stimulated mineralization of organic nitrogen in the sludge and improved seedling growth. The addition of irradiated sludge could reduce the leaching loss of chemical nitrogen fertilizer. Both irradiated and no irradiated sewage sludge could increase the content of soil nitrogen.

Chhonkar *et al.* (2000) conducted an experiment on the impact of tannery effluent on soil health and agriculture. They reported that tannery effluents are characterized by high BOD (Bio-chemical Oxygen Demand), COD (Chemical Oxygen Demand), Na, and total dissolved solids. These effluents also contained several major, primary and secondary nutrients (N, P, K, Ca, Mg, S etc.) as well as micro-nutrients and heavy metals. Addition of tannery effluents was reported to the cause DE flocculation of soil particles and increase in the N, P and K levels of soils. The adverse effects of tannery effluents as progressively reduced with their dilution and the database is not adequate to indicate the effect of long-term use of tannery effluents on soil health.

Tannery waste and effluent increased total N, P and S associated with the presence of high organic matter content was observed by Bremner and Bundy (1974). Stomberg *et al.* (1984) found that the tannery waste could provide significant amount of N and lime for crops but application at high rates may limit salt content, heavy metal accumulation or potential movement of NO_3-N ratio into ground water.

Portch and Islam (1984) conducted an experiment on 63 sewage sludge and drainage wastes using Agro-Services International methodology and found that 14.21% sewage sludge and 68% drainage waste treated samples were below critical level of Ca, Mg and S respectively.

2.2 Effect of sludge or organic fertilizer as an organic source of nitrogen on yield and chemical composition of crop

Chung *et al.,* (1992) stated that the application rates of sludge and city refuse were 5, 10, 120% and 5, 10%, respectively and there was a slow releasing N-fraction in sewage sludge which was not exhausted by the first soybean crop but was able to continue to be utilized by the rice crop.

Datta *et al.,* (1995) conducted an experiment about the effect of sludge, industrial waste and molasses on rice crop and revealed that plant height; number of tillers hill^{-1}; number of effective tillers hill^{-1}; length of panicle and test weight were increased in several dosage. Yield of grain and straw did not show any significant increase.

Yang *et al.* (1999) applied the irradiated and non-irradiated sewage sludge at the rates of 0 (control), and 225 kg N ha^{-1} and found that the irradiated of sewage sludge by gamma ray at a dosage of 5 KGy increased, crop yield by 11-27% as compared to the non-irradiated treatment.

Rajan and Ramulu (1984) conducted a laboratory experiment to study the influence of sewage wastes (@ 40, 80, 120 and 160 mt ha^{-1}) on the dry matter yield of three crops viz. sorghum, maize and ragi. At the highest rate of sewage sludge application the reduction in dry matter yield was maximum in sorghum. But the same dose of sludge produced maximum dry matter yield of maize. Only the solid sewage treatments up to 120 t ha^{-1} produced greater dry matter yield of plants than the control. The liquid sewage (without dilution) and solid sewage (160 t ha^{-1}) treatments resulted in poor dry matter of ragi as compared to all other treatments.

Prasad *et al.*, (1989) investigated the relative efficiency of Fe enriched organic wastes and found the yield of Pusa-2.21 rice *(Orvza sativa)* was increased in the order, Sewage sludge = poultry manure > municipal wastes > press mud > farmyard manure > $FeS0_4$ and that of "BR 25" lentil (*Lens culinaris***):** sewage sludge > municipal wastes = poultry manure > press mud > farmyard manure > $FeS0_4$. The highest DTPA extractable Fe was in the treatment of sewage sludge (14.8mg kg^{-1}), followed by municipal waste, press mud, poultry manure, farmyard manure and $FeS0_4$ (7.6mg kg^{-1}).

Singh *et al.* (1995) conducted a field experiment during l988-91 in Uttar Pradesh in India and found that Sugarcane cv. cos 8118 applied with press mud 30 ton ha^{-1} + N fertilizer or 2 different NPK rates. The application of 30 ton press mud + 120kg N produced the highest mean plant and ratoon cane yield of 79.0 and t ha^{-1} respectively and the highest commercial cane sugar yield and net return.

In a field experiment in Madhya Pradesh, India, Tiwri *et al.*, (1998) found that continuous application press mud and nitrogenous fertilizer significantly increased sugarcane and sugar yield and also increased available nitrogen. Town refuse compost raised the yield of grain by 37.1 and lower the yield of straw by 18.3%

(Abdalla *et al.,* 1992).

Effects of plant growth regulators, triacontanol, cypermetrin, sludge, industrial waste and molasses were investigated in a field on rice cv. IR 50. Plant height, number of tillers hill^{-1}, number of effective tillers hill^{-1}, length of panicle and test weight increased in several doses. Yield of grain and straw did not show any significant increase (Datta *et al.,* 1995).

Mirshra *et al.*, (1987) applied waste @ 5 tons and nitrogen @ 100 kg ha^{-1} brought about the maximum grain yields of 9.6 ton in 5 crop seasons. The lower level of waste application in combination with fertilizer nitrogen had little effect on the yield. The grain yields due to 100 kg and 50 kg nitrogen ha^{-1} were increased by 122% and 78% respectively over control. The increase in grain yields due to application of organic waste in absence of fertilizer nitrogen was marginal and due to unavailability of nutrients to microbial immobilization.

Kamrul (2000) studied with management and utilization of cowdung, sewage sludge, tannery waste, drainage waste, press mud and dustbin refuse, carried out to prepare compost. The effect of five wastes on growth, yield and chemical composition of grain and straw of rice (Binasail) was observed. Composted waste were applied @ 5 t ha^{-1} and 10 t ha^{-1} with half and full doses of chemical fertilizer. Press mud **@** 10 t ha^{-1} in combination with full dose of chemical fertilizer produced highest straw yield.

Talashilkar, 1989 and Vleeschauwer *et al.*, (1980) applied compost consisting of sewage sludge, saw dust and rice husk were twice in a year for maize in summer and barley in winter. The control plot received chemical fertilizer. Depressed plant growth with nutritional disorder symptoms resembling K deficiency was noticed.

Extractable K levels decreased significantly ($p > 0.05$) in the surface soil of the S plot but not the H plot, although plant growth was repressed in both the S and H plots. However, the difference in extractable K concentration between these S and H plots was insignificant ($P > 0.05$) (Miah *et al.*, 1999).

In a field trial in the rainy season of 1989 - 90 at Sehore, Madhya pradesh, India, Jain and Tiwarii (1995) reported that soyabean cv. Punjab was given 0.4 or 6 t FYM, 0.3, 4 or 5 t press mud ha^{-1} or a combination the two. Seed yield, P and k. contents in seeds and straw and N content in straw were highest with 5 t FYM + 5 t mud.

Filipek *et al.*, (2000) carried out an experiment and they treated orchardgrass with NPK fertilizer, FYM, tannery waste, vermicomposted tannery waste + straw or vermicomposted urban waste + straw and found that treatment with vemicompost had a more beneficial effect on plant content of total N, Ca, Mg and Na than FYM. They also found that untreated tannery waste was a source of more easily available P than vermicompost and vemicompost cause an excessive accumulation of heavy metals in the above-ground parts of orchard grass, but a higher accumulation in the root system.

The maximum S content in seed and straw was recorded in the treatment receiving dustbin refuse @ 10 t ha^{-1} and sewage sludge 5 t ha^{-1} respectively. Phosphorus concentration was always higher in grain than of straw. It was observed Na content in plant and grain was comparatively less affected by the treatment unlike other elements. The concentration of Na in tannery wastes was adequately higher as compared to other wastes but due less generalization plant uptake was not remarkable (Kamrul, 2000).

Nurunnabi (2001) investigated an experiment and found that the maximum removal of Ca was noticed due to treatment presumed @ 10 t ha^{-1} and the minimum in control. The maximum amount of S was recorded by TW @ 5 t ha^{-1} + full dose of chemical fertilizer and the lowest was in control. The highest P uptake (17.90 kg ha^{-1}) was found due to treatment sewage sludge @ 10 t ha^{-1} + half dose of chemical fertilizer. The highest Ca content in grain and straw were recorded with the treatment PM @ 10 t ha^{-1}+ CF V_2, TW @ 5 t ha^{-1} + CF 1/2 and lowest with DW @ 10 t ha^{-1} + CF, PM @ 5 t ha^{-1} + CF, respectively.

Ali (1994) conducted experiment with rice at several locations of Bangladesh during 1989-90 showed fertilizer use efficiency of over 20 kg ha^{-1} nutrient supplies. Improving the soil condition with organic manure and appropriate fertilization had further increased the production level of rice to more than 6 tons grain ha^{-1}.

In Philippines, Maskina *et al.*, (1992) obtained 0 9 t ha^{-1} mungbean grain and considerable N saving with incorporation of mungbean straw before rice transplanting. The mungbean residue supplemented 25 kg ha ^{1} of inorganic N. This result suggests that mungbean or a similar short duration crop is an alternative to GM (Green manure). In this case, a farmer should consider growing leguminous crop that would produce a cash income. The crop residues should be incorporated in to the soil for its contribution of N and other nutrients.

Zaman *et al.*, (1995) reported that the application of Sesbania @ 5 t ha^{-1} (oven dry basis) once a year prior to wet season planting along with 140 kg urea N ha^{-1} yr^{-1} (80 kg for dry season and 60 kg for wet season) and recommended doses of P, K and S gave a yield of about 11 t ha^{-1} yr^{-1} in a rice-rice cropping pattern on a moderate fertile soil. This practice allowed a saving of 150 kg urea ha^{-1} yr^{-1}.

Gupta (1995) conducted field trial on different organic manure in India and reported that the application of green manure (10 t ha ') produced the highest grain yield (4 5 t ha ') followed by PM (Poultry Manure) and FYM (Farm Yard Manure) which produced yield of 41 and 39 t ha^{-1} of rice grain, respectively. The increase in rice yield with organic manure was 34 to 55% higher over control and 5 to 22% higher over NPK fertilizer.

Hama Singh and Sing (1995) showed that microbial biomass C, N and P were ***66***, 77 and 49% grater, respectively in the straw + fertilizer treated plots than in the control Total crop biomass ranged from 6.79 - 9.91 t ha^{-1} and grain yield ranged from 1 08 -1 46 t ha^{-1} both in order control < Straw < fertilizer + straw. There were strong positive relationships between grain yield and microbial biomass, N-mineralization and available P.

Jeon *et al.*, (1996) studied the effect of PM (Poultry Manure) application on rice growth and grain yield quality. They reported that 5 t fermented chicken manure ha^{-1} in rice field increased N content in rice.

Singh *et al.,* (1996) carried out a field experiment in India where irrigated rice was given 60 80 or 120 kg ha^{-1} yr^{-1} as poultry manure, urea, poultry manure + urea. In the first year poultry manure did not perform better than urea but in the fourth year 120 and 1 50 kg N as poultry manure produced significantly higher grain yield than the same rates as urea. The PM helped to sustain the grain yield of rice during the 3 years while the yield decreased with urea application.

Mishra and sharma (1997) stated that the continuous addition of NPK fertilizers showed no deteriorating effect on soil physical properties; rather it significantly increased aggregation and water transmission characteristics and reduced bulk density and penetration resistance of the soil. The effectiveness of manures on aggregation, water transmission and hardness of the soil was observed. Grain yield of rice, wheat and winter maize crops were also enhanced significantly with continuous application of NPK fertilizer, farmyard manure and cyanobacteria separately as well as in combination.

Muthukrishnan *et al.*, (1998) reported that the application of 100% or 133% of the recommended mineral fertilizer (150 60 60 NPK) and 10 t farmyard manure with or without adjustment with mineral fertilizer, 21 kg ZnSO4 and foliar spraying of 1% KCl in irrigated rice. The maximum rice (cv ADT 38) yield was recorded with normal plant populations of 500000 plants ha^{-1} (20 x 10 cm spacing) and application of organic manure adjusted with mineral fertilizer.

Aulakh *et al.,* (2000) found that integrating fertilizer Nitrogen (FN) with legume green manures (GM) application @ 60 kg FN ha^{-1} (FN 60) and 20 kg GM ha^{-1} (GM 20) rice yield was double the control yield and 6% greater than the FN 120 treatment. Nitrogen utilization by rice was greater for GM 20 than FN, as indicated by greater fertilizer N equivalents and an apparent N recovery by rice of 79 vs. 63%.

Rahaman (2001) conducted experiment with rice (Boro and T Aman) with N, P. K. S and Zn fertilizers alone and with organic manures (Cow dung and Green Manure). The finding of his experiment suggest that the integrated use of fertilizers with manure (viz Sesbania, cow dung) can be an efficient practice for ensuring higher crop yields without degradation of soil fertility.

Singh *et al.,* (2001) reported the integrated effect of chemical fertilizer (NPK) with farm-yard manure (FYM) and Blue Green Algae (BGA) on grain yield and nutrient availability in tropical area Both rice and wheat yields continued significantly with increasing NPK level up to 100% of the recommended rale.

However, maximum yields of rice and wheat were obtained where recommended rate of NPK was applied along with FYM and BGA Available soil nutrients were enhanced up to rates of 75% of the recommended NPK dosage alone or with FYM, BGA or FYM + BGA, compared with initial 66 t ha^{-1} was incorporated into the soil and then wheat was grown The results indicated that the various application rates were significantly correlated with improvement in physical properties of soil as well as straw and grain yields of rice.

2.3 Effect and importance of organic manure/crop residues on rice

Vijaya and Balasubramamian (2002) reported that 28 days old rice seedlings were treated with different organic amendments (Farm Yard Manure, at 50 kg N ha^{-1} + Urea at 50 kg N ha green manure and 50 kg N ha^{-1} + Urea at 50 kg N ha^{-1} , neem cake at 50 kg N ha^{-1} + urea at 50 kg N ha'^{1}, press mud cake at 50 kg N ha^{-1} (Urea at 50 kg N ha^{-1} , and Urea at 100 kg N ha^{-1}) in a field experiment conducted in Rudrur, India, during seasons of 1996 and 1997 to develop a suitable integrated nutrient supply system to reduce blast (*Pyricularia orysae*) incidence in the crop. Substitution of nitrogen through FYM has a significant effect on reducing rice blast disease and increasing grain yield Statistical analysis of the data showed that supply of 50% of the required nitrogen through FYM and remaining 50% through urea reduced the blast disease severity to a maximum extent and produced maximum yield.

Sinha *et al.,* (2002) showed that application of BGA in combination with 90 kg N/ha recorded favorable results in all the three rice cultivars (Saryu-52, Swarna and Jaya) and was comparable with grain and straw yield at recommended doses of 120 kg N ha^{-1}. The response of BGA in combination with green manure was very much pronounced at 30 kg N ha^{-1} and was comparable to individual application of inorganic N at 90 and 120 kg ha^{-1} while maximum yield was recorded at 60 kg N ha^{-1} Residual effect of green manure and BGA was also observed in wheat crops with Azotobacter at all levels of N Maximum yield was recorded at 90 kg N ha^{-1}.

Kalceswari and Subramanian (2004) found that organic manures at 12 5 t ha^{-1} and inorganic phosphatic fertilizer i.e, single super phosphate (SSP) and Udaipur rock phosphate (RUP) at 0, 30 and 60 kg ha^{-1} combined with organic manure at 12.5 t ha^{-1} and inorganic P fertilizers recorded the highest grain yields and N, P and K uptake by rice.

Gowda *et al.,* (2004) conducted experiment that consisted of eight treatment including control, 5 and 10 t of fresh Azolla before planting, 5 and 10 t fresh Azolla + 30 kg N ha^{-1}, and 30, 60 and 90 kg N ha^{-1} Rice varieties phalguna and Jaya were used in Kharif and Rabi**.** respectively The experimental results indicated that the application of 10 t fresh Azolla + 30 kg N $ha^{'1}$ and 90 kg N ha^{-1} recorded significantly maximum grain yield of 4719 kg $ha^{'1}$, height, tillers per hill and panicles /m^2 during Kharif as well as during Rabi season.

Singh *et al.,* (2005) stated the effect of integrated management of N fertilizer, vermicompost and Azolla on grain yield and nutrient uptake of rice and on soil fertility. The highest grain and straw yields were recorded with the application of 60 kg N ha^{-1} plus Azolla. They also found that the highest N, P and K uptake with the application of 60 kg N ha^{-1} plus Azolla treatment.

Chideshwari and Krishnawamy (2005) conducted a pot experiment with rice cv ADT 36, to study the effect of Zn-enriched organic manures on yield, transformation of Zn and their availability under submerged condition Five Zn levels (0 0, I 25. 2 50. 3 75 and 50 mg/kg) were enriched with 4 sources of organic manures at 1.0 t ha^{-1} (farmyard manure (FYM), composted coir pith (CCP), FYM + green leaf manure (GLM and CCP+ GLM) and was compared with the application of recommended dose of organic manures (without Zn- enrichment) at 12 t ha^{-1}. The application of Zn-enriched organic manures at 10 mg ha^{-1} was sufficient to get the maximum yield compared to the recommended dose of organic manures The enrichment of Zn at 1 25 mg/kg with organic manures increased the grain yield of rice by 26% over no Zn application Soil Zn fractions increased with increasing levels of enrichments. The complex organically bound and water soluble plus exchangeable fractions significantly affected the grain and dry matter yields, DTP A- Zn, Zn content and uptake at all stages of crop growth (maximum tillering, panicle initiation and harvest).

Bhandari *et al.*, (1992) observed from a 4-year study on integrated nutrient management in a rice-wheat system that both rice and wheat yields continued to increase significantly with increasing NPK levels up to 100% of recommended dose through fertilizer GM with 50% recommended dose of NPK to rice produced as much rice yield of 6.27 t ha^{-1} to 100% NPK dose through fertilizer produced 6.28 t ha^{-1}. They also reported that inclusion of short duration pulse crop (mungbean) in the system substituted 50% of recommended NPK fertilizers in rice Among different organic source of N for rice. GM was found significantly superior to FYM and wheat straw in increasing the crop yield and nutrient uptake.

Hundal *et al.*, (1992) studied the contribution of GM (Green Manure) to P nutrition of rice and showed that fertilizer P addition increased dry matter production and P uptake by rice. Grain yield and P uptake by rice were highest in cowpea plots followed by dhaincha and sun hemp.

Khan *et al.*. (1993) obtained rice yields of 3.2, 5.8 and 7.2 t ha^{-1} with 0, 60 and 120 kg N ha^{-1} when crop residues of mungbean were removed and 6.5, 7.5 t ha^{-1} residues were incorporated into the soil increased N and P uptake by rice.

Majid *et al.*, (1995) found that when chicken manure was applied @) 0. 4, 8.25 to 15 and 33 t ha^{-1} in wheat, the grain yields, grain quality and straw yields were increased with the rate of chicken manure. The greatest economic return was recorded by 8.25 t ha^{-1}. The N and P uptake increased with increasing manure rates.

Kumar and Yadav (1995) studied the effect of organic manure, fertilizers and their integrated use in rice-wheat cropping sequence. In the first year, 25-50% substitution of fertilizers through organic sources, FYM, GM and wheat straw reduced the rice yield by 6-23% compared with 100% chemical fertilizers alone. In the following year, 25-50% N through FYM or GM along with 50-75% fertilizers to rice gave either equal or more yields compared with 100% NPK. The FYM and GM were found superior to wheat straw with respect to grain yield and NPK uptake.

Zhu *et al.*, (1984) stated that the residual effect of GM was found to be more than those of urea as was evidenced by the increase in grain yields. N uptake and N recovery also showed positive effect of GM to the succeeding crops when applied to the preceding rice season.

Maskina *et al.*, (1986) conducted an experiment with different organic manure as a nitrogen source in rice-wheat rotation. They observed that yields with poultry manure and 80 kg urea- N ha^{-1} was as high as those were with 160 kg urea-N ha^{-1} alone. Yields with FYM or pig manure and 80 kg fertilizer N ha^{-1} were equal to 120 kg N ha^{-1} fertilizer alone. They also reported that application of any one of the manure added to rice had residual effect equivalent to 30 kg N and 13 kg P ha^{-1} in wheat. In trial with rice-wheat cropping sequence Yadav *et al.*, (1987) reported the highest yield with NPK as conventional fertilizers, intermediate yield with 50-

75% NPK as conventional fertilizer plus 25-50% NPK as FYM and the lowest with all NPK as FYM They found that the residual effect of NPK on wheat grain yield was in the order FYM> conventional 75% NPK fertilizers FYM> conventional NPK fertilizers.

Bouldin (1988) viewed that the residual effects of green manure on a second crop would be small when only one application of green manure is made, but the cumulative effects of several annual applications are expected to give appreciable residual effects These effects are important not only on N supply but also on long term improvement of soil fertility and crop productivity.

Ishikawa (1988) observed that long-term (10-15 years) application of vetch green manure increased organic matter and N contents of soils.

Garrity and Flinn (1988) conducted a regional survey in South Southeast and East Asian countries regarding green manure management systems. They concluded that that green manuring is now viable practice for rice farmers in many parts of Asia.

Ahmed and Rahman (1991) reported the residual effect of cow dung In a treatment with cow dung and other sources of plant nutrients, they found significantly higher yield in the following crop from the plots which received cow dung in the previous rice.

Bhandari ***et al.,*** (1992) demonstrated the residual effect of FYM. In a 4-year study on integrated nutrient management in rice-wheat cropping sequence some residual effect of FYM on wheat was observed.

Benoi *et al.,* (1993) pointed out that the residual effect of FYM increased the grain yield of wheat by 230 to 520 kg ha^{-1} Rajput and Warsi (1992) examined the different levels of inorganic and organic sources of N in rice and residual effect of organic sources in the following wheat crop. They found that the residual effect of FYM alone increased the grain and straw yields significantly compared to the control.

Miah (1994) stated that only the first crop following the application of manure recovered one- fifth to one-half of the nutrients supplied by animal manure. The remainder was held as humus to very slow decomposition, 24% of nutrient element being released per annum. Islam (1994) found a significant yield increase with fertilizer-N plus cow dung compared to fertilizer-N alone in T. Aman rice.

In the following Boro rice, the yields with fertilizer-N + residual of cow dung were higher than the fertilizer-N alone. Santhi *et al.,* (1999) reviewing green manuring research in India reported that the residual effect of green manure applied to ricc was low.

Previous works, (Beri and Meelu, 1981; Ishikawa 1984, Mcclu *et al.,* 1992) have also shown that there is little or no cumulative (over 3 to 4 years) benefit of green manuring of rice to the succeeding crop Integrated use of fertilizers with manure-crop residues of rice.

Maskina *et al.,* (1986) studied the effect of N application on wetland rice in a loamy sand soil amended with cattle manure (60 kg N ha^{-1}) or PM (80 kg N ha^{-1}). In the absence of urea-N, PM increased the rice grain yield by 98% which was 2 6 times higher than cattle manure (37%). Rice yield increased linearly with N rates whether or not the soil was amended with organic manure. Urea-N equivalent to cattle and PM varied from 21 to 53 and 50 to 123 kg $ha^{'1}$, respectively. Apparent recovery of N from poultry manure ranged from 38 to 82% compared with 51 to 69% from urea and 20 to 25% cattle manure and pig manure. Besides chemical fertilizers, organic manure like poultry manure is another good source of nutrients in soil Experiments on the use and agronomic efficiency of poultry manure showed that 4 t ha^{-1} poultry manure along with 60 kg N ha^{-1} as urea produced grain yield of rice similar to that with 120 kg N ha^{-1} as urea alone (Meelu and Singh 1991).

Studies conducted by Ali (1994) with rice at several locations of Bangladesh during 1989-90 showed fertilizer use efficiency of over 20 kg per kg nutrient supply. Improving the soil condition with organic manure and appropriate fertilization had further increased the production level of rice to more than 6 tons grain ha^{-1}. Residual effect of GM was found to be more than those of urea as was evidenced by the increase in grain yields, N uptake and N recovery. Zhu *et al.,* (1984) also observed positive effect of GM to the succeeding crops when applied to the preceding rice season.

From the above report it is clear that, study on effect of organic and chemical sources of nitrogen on rice plant and their residual effect on soil, in Bangladesh is very limited. The present study was therefore, selected to investigate their effect on rice plant and soil.

CHAPTER III

MATERIALS AND METHODS

This chapter presents a brief description about the work which is related to the experiment. It represents a brief description about the experimental site, soil, climate, crops, treatments, experimental design followed, land preparation, seedling transplanting, intercultural operations, harvesting, data recording, collection and the methods for the chemical and statistical analysis.

3.1 Field trial

3.1.1 Experimental site and season

The experiment was laid out in the Non Calcareous Dark Grey Floodplain soil of Sher-e- Bangla Agricultural University, Sher-e- Bangla Nagar, Dhaka. This soil belongs to the Modhupur tract under AEZ 28. The site of the experimental plot was in the 23°74' latitude and 90°35' longitude with an elevation of 8.2 m above sea level (Anon, 1989).

3.1.2 Soil

The experimental soil was silt loam, a member of hyperthermic aeric haplaquept. The soil belongs to inceptisol order having only few horizons, developed under aquic moisture regime and variable temperature regime. A general characteristic of the soil is presented in Table 3.1. The selected plot was medium high land and the soil series was Tejgaon series. The soil characteristics were silty loam in texture with pH value 6.5 and C: N ratio was 8:1.

Table 3.1 Morphological, physical and chemical characteristics of soil under study

A. Morphological characteristics

Characteristics	Experimental field
Location	Sher-e-Bangla Agricultural University farm, Dhaka
AEZ	28
General soil type	Deep Red Brown Terrace Soil
Drainage	Erate
Topography	Medium high land
Flood level	Above flood level

B. Physical characteristics

Characteristics	Experimental field
% Sand	30.4
% Silt	40.0
% Clay	29.6
Textural class	Silty loam

C. Chemical characteristics

Characteristics	Experimental field
pH (soil: water = 1: 2.5)	5.70
Organic matter (%)	1.32
Total N (%)	0.06
Available P (ppm)	18.10
Available S (µg g^{-1})	13.10
Exchangeable K (meq/100gm soil)	0.10

3.1.3 Climate

The climate of the experimental area is characterized by sub-tropical accompanied by bright sunshine, high rainfall associated with moderately high temperature during Aman season from July to October, 2014.

3.1.4 Crop

BRRI dhan62 was the test crop. The life cycle of this variety is 100 days on average. Seed of the variety was collected from Breeding Division of Bangladesh Rice Research Institute (BRRI), Joydebpur, Gaipur.

3.1.5 Land preparation

The land was prepared by repeated ploughing and cross ploughing followed by laddering. After uniformly leaving and puddling, the experimental plots were laid out as per treatments and design of the experiment.

3.1.6 Raising of seedling

A well puddled land was selected for seedling rising and sprouted seeds were sown uniformly on 23 July, 2014 and covered with a thin layer of tine earth Proper care of the seedlings was taken in the nursery.

3.1.7 Experimental design

The experiment was laid out in a randomize block design. The size of the unit plot was 3.5 m × 3.0 m. There were seven treatments and three replications. The total numbers of plot were 21. There were 0.5 m drains between the blocks. The treatments were randomly distributed to each block.

3.1.8 Treatments

There were seven treatments including control are used in this study which were as follows

i) T_1 = Absolute Control

ii) T_2 = 100% Recommended Field Dose (RFD) of Urea

iii) T_3 = 80% RFD of Urea + 20% sludge

iv) T_4 = 60% RFD of Urea + 40% sludge

v) T_5 = 40% RFD of Urea + 60% sludge

vi) T_6 = 20% RFD of Urea + 80% sludge

vii) T_7 = 100% sludge

* RFD per hectare = Urea 150kg + TSP 71kg + MP 71kg + Gypsum 41.1kg + $ZnSO_4$ 11.2kg + sludge 0.0kg

* RFD per plot = Urea 223.18g + TSP 106.01g + MP 106.01g + Gypsum 61.37g + Zn 16.73g+ Zn 16.73gm + sludge 0.0gm

Detailed of the experiment

i) T_1 = Urea 0.0gm + TSP 0.0gm + MP 0.0gm + Gypsum 0.0gm + Zn 0.0gm + sludge 0.0gm; (per plot)

ii) T_2 = Urea 223.18gm + TSP 106.01gm + MP 106.01gm + Gypsum 61.37gm + Zn 16.73gm + sludge 0.0gm; (per plot)

iii) T_3 = Urea 178.50gm + TSP 106.01gm + MP 106.01gm + Gypsum 61.37gm + Zn 16.73gm + sludge 500.00gm; (per plot)

iv) T_4 = Urea 133.9gm + TSP 106.01gm + MP 106.01gm + Gypsum 61.37gm + Zn 16.73gm + sludge 900.00gm; (per plot)

v) T_5 = Urea 89.27gm + TSP 106.01gm + MP 106.01gm + Gypsum 61.37gm + Zn 16.73gm + sludge 1400.00gm; (per plot)

vi) T_6 = Urea 44.63gm + TSP 106.01gm + MP 106.01gm + Gypsum 61.37gm + Zn 16.73gm + sludge 1800.00gm; (per plot)

vii) T_7 = Urea 0.0gm + TSP 106.01gm + MP 106.01gm + Gypsum 61.37gm + Zn 16.73gm + sludge 2300.00gm; (per plot)

** 10kg sludge = 1 kg urea

3.1.9 Transplanting of seedling

24 days old seedlings of BRRI dhan62 were uprooted carefully from the seedbed and transplanted in the experimental plots with a spacing of 20cm × 15cm on 16 August 2014. Three seedlings were transplanted in each hill.

3.2 Intercultural operations

Intercultural operations were done for ensuring and maintaining the normal growth of the crop. The following intercultural operations were done as and when required.

3.2.1 Irrigation

After transplanting 5-6 cm water was maintained in each plot through the growth period of the crop.

3.2.2 Weeding

The crop was infested with some common weeds, which were controlled by uprooting and remove them three times from the field during the period of experiment. Weeding was done after 15, 32 and 52 days of transplanting.

3.2.3 Disease and insect pest control

There was some incidence in insects specially grasshopper, nee stem borer, rice ear cutting caterpillar, thrips and rice bug which was controlled by spraying Curatter 5 G and Sumithion. Narrow brown spot of rice was controlled by spraying Tilt.

3.3 Harvesting and threshing

The crop was harvested plot wise at maturity from 4th November, 2014. The harvested crop of each plot was bundled separately and brought to the threshing floor. The harvested crops were threshed, cleaned and processed Grain and straw yields were recorded plot-wise and moisture of grain and straw was calculated on oven dry basis. Grain and straw yields were converted into t ha^{-1}.

3.4 Data collection and recording

Five hills were selected randomly from each plot prior to harvest for recording data on crop parameters and the yield of grain and straw were taken plot wise. The following parameters were recorded at harvest:

a) **Plant height (cm):** Plant height was measured from the base of the plant to the tip of the tallest panicle.

b) **Number of tiller per hill:** Tillers which had at least one leaf visible were counted. Both productive and unproductive tillers were included.

c) **Number of effective tiller per hill:** The panicles that had at least one grain were considered as bearing tillers.

d) **Length of panicle (cm):** Panicle length was measured from the basal node of rachis to the tip of the panicle.

e) **Number of grains per panicle:** Number of grains of all the fertile tillers was counted.

f) **Number of unfilled grains per panicle:** Number of unfilled grain of all fertile tillers was counted.

g) **Number of filled grains per panicle:** Number of filled grain of all fertile tillers was counted.

h) **1000 seed weight (g):** One thousand grain was counted from the seeds obtained from the samples and weighed by using an electric balance.

i) **Straw yield and Grain yield (t/ha):** After harvesting of the crop, grain yield of each plot was dried and weighted. The result was expressed as t ha^{-1} on 14% moisture basis. After harvesting of the crop, straw yields obtained from each plot were dried and weighed carefully. The results were expressed as t ha^{-1} and expressed on oven dry basis.

3.5 Statistical analysis

The data obtained for yield contributing characters and yield were statistically analyzed to find out the significance of the differences among the treatments. The collected data from the experimental plot on morphology yield and yield contributing characters were compiled and analyzed using the Statistical, Mathematical Calculation and Data Management (MSTATC) package program. Morphological variation and yield performance among the treatments were studied by Analysis of Variance (ANOVA) by F-test. The significance of the difference between pairs of treatment means was evaluated by least significant difference (LSD) test at 5% and 1% level of probability (Gomez and Gomez, 1984).

3.6 Chemical Analysis of Soil Sample

Soil Samples were analyzed for chemical properties in the laboratory of Soil Resource Development Institute (SRDI) Farmgate, Dhaka. The properties studied included soil pH, Organic matter, Total Nitrogen, Available P, Exchangeable K, Available S and Available Zn.

3.6.1 Soil pH

Soil pH was measured with the help of a Glass electrode pH meter using soil and water at the ratio of 1:2.5 as described by Jackson (1962).

3.6.2 Organic matter

Organic matter in soil was determined by Walkley and Black's (1934) Wet Oxidation method. The underlying principle is to oxidize the organic carbon with an excess of 1N $K_2Cr_2O_7$ in presence of conc. H_2SO_4 and to titrate the residual $K_2Cr_2O_7$ solution with 1N $FeSO_4$ solution. To obtain the organic matter content, the amount of organic carbon was multiplied by the Van Bemmelen factor, 1.73. The result was expressed in percentage.

3.6.3 Total Nitrogen

Total Nitrogen of soil was determined by Micro Kjeldahl method where soil was digested with 30% H_2O_2, conc. H_2SO_4 and catalyst mixture (K_2SO_4: $CuSO_4.5H_2O$: Se powder in the ratio of 100:10:1). Nitrogen in the digest was estimated by the distillation with 40% NaOH followed by titration of the distillate trapped in H_3BO_3 with 0.01N H_2SO_4 (Bremner and Mulvaney 1982).

3.6.4 Available P

Available P was extracted from soil by shaking with 0.5M $NaHCO_3$ solition of pH 8.5 (Olsen *et al.*, 1954). The P in the extract was then determined by the developing blue color using $SnCl_2$ reduction of phosphomolybdate complex. The absorbance of the molybdophosphate blue color was measured at 660nm wave length by Spectrophotometer and available P was calculated with help of standard curve.

3.6.5 Exchangeable K

Exchangeable K was determined by 1N NH_4OAC (pH 7.0) extract of the soil by using Flame photometer (Black, 1965).

3.6.6 Available S

Available S in the soil was determined by extracting the soil samples with 0.15% $CaCl_2$ solution (Page *et al.*, 1982). The S content in the extract was determined turbidmetrically and the intensity of turbid was measured by Spectrophotometer at 420 nm wave length.

3.6.7 Available Zn

Available Zn in the soil was determined by 0.2% DTPA extracting method as described by Hunter (1984). The extractable Zn was measured by Atomic absorption spectrophotometer.

CHAPTER IV

RESULT AND DISCUSSION

This chapter presents the experimental results along with their possible interaction and discussion in relation to combined effect of chemical nitrogenous fertilizer (urea) and treated sludge on the growth and yield of BRRI dhan62. The results have been presented and discussed, and possible explanations have been given under the following headings:

4.1 Plant height (cm)

Combined application of chemical nitrogenous fertilizer (urea) and treated sludge significantly increased the plant height of BRRI dhan62 (Table 1 and appendix 2).Result revealed that the highest plant height (99.93 cm) was recorded from T_2 (100% RFD of urea) which was statistically identical with T_3 (80% RFD of urea + 20% sludge) and followed by T_4 (60% RFD of Urea + 40% sludge), T_5 (40% RFD of Urea + 60% sludge) and T_6 (20% RFD of urea + 80% sludge),where the lowest plant height (90.94 cm) was achieved from T_1 (Absolute Control) followed by T_7 (100% sludge).This is probably due to N released from sewage sludge. This finding is at par with Datta *et al.* (1995). Since sewage sludge contain sufficient N and S such type of results is expected in producing plant height. Thorne *et al.* (1975) found sufficient amount of essential nutrients in sew age sludge.

4.2Number of total tiller hill^{-1}

The studied experiment showed the significantly variation for combined application of chemical nitrogenous fertilizer (urea) and treated sludge on number of tiller per hill of BRRI dhan62 (Table 1 and appendix 2). The findings showed that the highest number of tiller per hill (14.95) was recorded from T_2 (100% Recommended Field Dose RFD of urea) which was statistically similar with T_3 (80% RFD of urea + 20% sludge), T_4(60% RFD of urea + 40% sludge) and

T_6(20% RFD of urea + 80% sludge), while the lowest number of tiller per hill (12.28) was achieved from T_1 (Absolute Control) followed by T_7 (100% sludge).The reason behind this may be the rapid N mineralization from sewage sludge and large amount of N and S present in this wastes (Throne, 1975).Yuging and Li (1999) observed that application of sulfur increased the number of tiller hill^{-1}.

4.3 Effective tiller hill^{-1}

Significant variation was found for combined application of chemical nitrogenous fertilizer (urea) and treated sludge on effective tiller per hill of BRRI dhan62 (Table 1 and appendix 2). The highest effective tiller per hill (14.56)was recorded from T_3 (80% RFD of urea + 20% sludge) followed by T_2 (100% Recommended Field Dose RFD of urea) and T_4 (60% RFD of urea + 40% sludge),where the lowest effective tiller per hill (11.62) was achieved from T_1 (Absolute Control) followed by T_7 (100% sludge).This finding is similar to Datta *et al* (1995) and they reported that sewage sludge increase number of effective rice tiller hill^{-1}. This may be due to N released by sewage sludge and also because S present in this waste. These two elements have great effect on effective tiller production. Chander and Pandey (1996) observed a significant increase of effective tiller m^{-2} due to application of higher doses of nitrogen. Islam and Hossain (1993) observed that S application increased the number of effective tillers of rice plants.

4.4 Length of panicle

There was highly significant variation for combined application of chemical nitrogenous fertilizer (urea) and treated sludge on length of panicle of BRRI dhan62 (Table 1 and appendix 2). The experimental findings showed that the highest length of panicle (23.99 cm) was recorded from T_2 (100% Recommended Field Dose RFD of urea) which was statistically same T_4 (60% RFD of urea +

40% sludge), while the lowest length of panicle(22.41 cm) was achieved from T_1 (Absolute Control) followed by T_7 (100% sludge).

Table.1 Growth and yield contributing parameters of BRRI dhan62 as influenced by combined effect of chemical nitrogenous fertilizer (urea) and treated sludge on

Treatments	Plant height (cm)	Number of tiller hill^{-1}	Number of effective tiller hill^{-1}	Length of panicle (cm)
T_1	90.94 c	12.28 d	11.62 e	22.41 d
T_2	99.93 a	14.95 a	13.95 b	23.99 a
T_3	98.70 a	14.56 ab	14.56 a	22.24 d
T_4	95.86 b	14.62 ab	13.89 b	23.22 a
T_5	95.39 b	13.95 b	13.28 c	23.17 b
T_6	94.13 b	14.17 ab	13.84 b	22.95 bc
T_7	91.25 c	13.12 c	12.44 d	22.71 c
$LSD_{0.05}$	2.158	0.7378	0.4068	0.2727
CV (%)	2.52	8.70	9.23	4.78

In a column same lettering indicate non-significant difference and different lettering indicate significant difference among the treatments

T_1 = Absolute Control
T_2 = 100% Recommended Field Dose (RFD) of Urea
T_3 = 80% RFD of Urea + 20% sludge
T_4 = 60% RFD of Urea + 40% sludge
T_5 = 40% RFD of Urea + 60% sludge
T_6 = 20% RFD of Urea + 80% sludge
T_7 = 100% sludge

4.5 Total number of grain panicle^{-1}

Combined application of chemical nitrogenous fertilizer (urea) and treated sludge influenced in significantly on total number of grain panicle^{-1} of BRRI dhan62 (Table 2 and appendix 3). Result showed that the highest total number of grain panicle^{-1} (98.21) was recorded from T_4 (60% RFD of urea + 40% sludge) followed by T_3 (80% RFD of urea + 20% sludge) and T_2 (100% (RFD) of urea), where the lowest total number of filled grain panicle^{-1} (84.58) was achieved from T_1 (Absolute Control) followed by T_7 (100% sludge).

4.6 Number of unfilled grain panicle^{-1}

The studied findings showed the highly significant variation for combined application of chemical nitrogenous fertilizer (urea) and treated sludge on number of unfilled grain panicle^{-1}of BRRI dhan62 (Table 2 and appendix 3). Result showed the highest number of unfilled grain panicle^{-1}(13.57) was recorded from T_1(Absolute Control),while the lowest number of unfilled grain panicle^{-1}(3.44) was achieved from T_5 (40% RFD of urea + 60% sludge) followed by T_7 (100% sludge).

4.7 Number of filled grain panicle^{-1}

Combined application of chemical nitrogenous fertilizer (urea) and treated sludge influenced in significantly on number of filled grain panicle^{-1}of BRRI dhan62 (Table 2 and appendix 3). Result showed that the highest number of filled grain panicle^{-1}(91.95) was recorded from T_4 (60% RFD of urea + 40% sludge) followed by T_3 (80% RFD of urea + 20% sludge) and T_2 (100% (RFD) of urea), where the lowest number of filled grain panicle^{-1}(76.95) was achieved from T_1 (Absolute Control) followed by T_7 (100% sludge).

Table. 2 Yield contributing parameters of BRRI dhan62 as influenced by combined effect of chemical nitrogenous fertilizer (urea) and treated sludge

Treatments	Total number of grain panicle^{-1}	Number of unfilled grain panicle^{-1}	Number of filled grain panicle^{-1}
T_1	84.58 c	13.5 a	76.95 d
T_2	94.28 b	8.00 b	85.73 b
T_3	95.46 b	7.94 b	87.50 b
T_4	98.21 a	7.36 c	91.95 a
T_5	85.06 c	3.44 e	81.28 c
T_6	94.73 b	7.11cd	86.78 b
T_7	86.61 c	6.72 d	79.89 c
$LSD_{0.05}$	2.284	0.5277	1.767
CV (%)	7.87	22.71	7.32

In a column same lettering indicate non-significant difference and different lettering indicate significant difference among the treatments

T_1 = Absolute Control
T_2 = 100% Recommended Field Dose (RFD) of Urea
T_3 = 80% RFD of Urea + 20% sludge
T_4 = 60% RFD of Urea + 40% sludge
T_5 = 40% RFD of Urea + 60% sludge
T_6 = 20% RFD of Urea + 80% sludge
T_7 = 100% sludge

4.8 Weight of 1000 seeds

Combined application of chemical nitrogenous fertilizer (urea) and treated sludge influenced in significant variation on weight of 1000 seeds of BRRI dhan62 (Table 3 and appendix 4). The experimental findings the highest weight of 1000 seeds (24.23g) was recorded from T_3 (80% RFD of urea + 20% sludge), where the lowest filled weight of 1000 seeds (22.20g) was achieved from T_1(Absolute Control).

4.9 Weight of fresh seed yield plot^{-1}

Highly significantly variation was observed for combined application of chemical nitrogenous fertilizer (urea) and treated sludge on weight of fresh seed yield plot^{-1} of BRRI dhan62 (Table 3 and appendix 4). Result explained that the highest weight of fresh seed yield plot^{-1} (6.78 kg) was recorded from T_3 (80% RFD of Urea + 20% sludge) which statistically similar with T_2 (100% RFD of urea) and followed by T_4 (60% RFD of urea + 40% sludge) and T_6 (20% RFD of urea + 80% sludge), where the lowest filled weight of fresh seed yield plot^{-1} (5.67 kg) was achieved from T_1 (Absolute Control) followed by T_7 (100% sludge).

4.10 Weight of dry seed yield plot^{-1}

Combined application of chemical Nnitrogenous fertilizer (urea) and treated sludge influenced in significant variation on weight of dry seed yield (kg) of BRRI dhan62 (Table 4 and appendix 4). Result showed that the highest weight of dry seed yield (4.58 kg) was recorded from T_3 (80% RFD of Urea + 20% sludge) which statistically similar with T_2 (100% RFD of urea) and followed by T_4 (60% RFD of urea + 40% sludge) and T_6 (20% RFD of urea + 80% sludge), while the lowest filled weight of dry seed yield (3.12k g) was achieved from T_1 (Absolute Control) followed by T_7 (100% sludge).Sewage sludge shows better performance in producing grain and grain yield increase with increasing dose of this waste. Nurunnabi (2001) also found same result. The highest concentration of P in sewage sludge is responsible for grain yield. Hussain *et al* (1994) found that grain and straw yield increased significantly with P application.

4.11 Dry seed yield ha^{-1}

Combined application of chemical nitrogenous fertilizer (urea) and treated sludge influenced in significant variation on dry yield ha^{-1} of BRRI dhan62 (Table 4 and appendix 4). Result showed that the highest dry yield ha^{-1} (4.36 t) was recorded from T_3 (80% RFD of Urea + 20% sludge) which statistically similar with T_2 (100% RFD of urea) and followed by T_4 (60% RFD of urea + 40% sludge) and T_6 (20% RFD of urea + 80% sludge), while the lowest dry yield ha^{-1} (2.97 t) was achieved from T_1 (Absolute Control) followed by T_7 (100% sludge).

Table. 3 Yield and yield contributing parameters of BRRI dhan62 as influenced by combined effect of chemical nitrogenous fertilizer (urea) and treated sludge

Treatments	Weight of 1000 seed (g)	Fresh seed yield $plot^{-1}$ (kg)	Dry seed yield $plot^{-1}$ (kg)	Dry seed yield ha^{-1} (ton)
T_1	22.20 e	5.67d	3.12 d	2.97 e
T_2	23.02c	6.61 ab	4.44 ab	4.23 b
T_3	24.23 a	6.78 a	4.58 a	4.36 a
T_4	24.02 ab	6.35 bc	4.34 bc	4.13 c
T_5	23.00 c	6.17 cd	4.19 c	3.99 d
T_6	23.4 d	6.36 bc	4.33 bc	4.12 c
T_7	23.58 cd	6.12 d	4.12 d	3.92 d
$LSD_{0.05}$	1.799	0.2698	0.2028	0.046
CV (%)	6.71	6.35	9.66	8.735

In a column same lettering indicate non-significant difference and different lettering indicate significant difference among the treatments

T_1 = Absolute Control
T_2 = 100% Recommended Field Dose (RFD) of Urea
T_3 = 80% RFD of Urea + 20% sludge
T_4 = 60% RFD of Urea + 40% sludge
T_5 = 40% RFD of Urea + 60% sludge
T_6 = 20% RFD of Urea + 80% sludge
T_7 = 100% sludge

4.12 Weight of raw straw plot^{-1}

The studied findings revealed that combined application of chemical nitrogenous fertilizer (urea) and treated sludge influenced in significantly on weight of raw straw plot^{-1}of BRRI dhan62 (Table 4 and appendix 5). Findings showed that the highest weight of raw straw plot^{-1}(13.77 kg) was recorded from T_3 (80% RFD of urea + 20% sludge) which statistically identical with T_2 (100% (RFD) of urea), T_4 (60% RFD of urea + 40% sludge) and T_6 (20% RFD of urea + 80% sludge), while the lowest weight of raw straw plot^{-1}(10.79 kg) was achieved from T_1 (Absolute Control) followed by T_7 (100% sludge).

4.13 Weight of dry straw plot^{-1}

Combined application of chemical nitrogenous fertilizer (urea) and treated sludge had a significantly variation on weight of dry strawplot^{-1} of BRRI dhan62 (Table 4 and appendix 5). Result revealed that the highest weight of dry straw plot^{-1}(5.94 kg) was recorded from T_3 (80% RFD of Urea + 20% sludge) which statistically same with T_2 (100%RFD of urea), T_4 (60% RFD of urea + 40% sludge) and T_6 (20% RFD of urea + 80% sludge),where the lowest filled weight of dry straw plot^{-1} (4.96kg) was achieved from T_1 (Absolute Control) followed by T_7 (100% sludge).

4.14 Dry straw yield ha^{-1}

Dry straw yield ha^{-1} BRRI dhan62 was significantly influenced by combined application of chemical nitrogenous fertilizer (urea) and treated sludge of (Table 4 and appendix III). Result signified that the highest dry straw yield ha^{-1} (5.66 t) was recorded from T_3 (80% RFD of Urea + 20% sludge) which statistically similar with T_2 (100% RFD of urea) and followed by T_4 (60% RFD of urea + 40% sludge) and T_6 (20% RFD of urea + 80% sludge), while the lowest dry straw yield ha^{-1} (4.71 t) was achieved from T_1 (Absolute Control) followed by T_7 (100% sludge).

4.15 Harvest index

The studied findings revealed that combined application of chemical nitrogenous fertilizer (urea) and treated sludge influenced the harvest index significantly for BRRI dhan62 (Table 4 and appendix 5). Findings showed that the highest harvest index (45.88%) was recorded from T_6 (20% RFD of Urea + 80% sludge) followed by T_5 (40% RFD of Urea + 60% sludge), where the lowest harvest index (38.67%) was achieved from T_1 (Absolute Control).

Table 4. Straw yield of BRRI dhan62 as influenced by combined effect of chemical nitrogenous fertilizer (urea) and treated sludge

Treatments	Weight of raw straw (kg plot^{-1})	Weight of dry straw (kg plot^{-1})	Dry straw yield (kg ha^{-1})	Harvest index (%)
T_1	10.79 c	4.95 c	4.71 g	38.67 e
T_2	13.53 ab	5.67 ab	5.40 b	43.93 c
T_3	13.77 a	5.94 a	5.66 a	43.51 d
T_4	12.34 a-c	5.53 a-c	5.27 c	43.94 c
T_5	11.90 bc	5.22 bc	4.97 e	44.53 b
T_6	12.22 a-c	5.10 a-c	4.86 f	45.88 a
T_7	11.32 c	5.25 bc	5.00 d	43.95 c
$LSD_{0.05}$	1.515	0.5337	0.106	0.157
CV (%)	6.94	8.88	9.49	8.361

In a column same lettering indicate non-significant difference and different lettering indicate significant difference among the treatments

T_1 = Absolute Control
T_2 = 100% Recommended Field Dose (RFD) of Urea
T_3 = 80% RFD of Urea + 20% sludge
T_4 = 60% RFD of Urea + 40% sludge
T_5 = 40% RFD of Urea + 60% sludge
T_6 = 20% RFD of Urea + 80% sludge
T_7 = 100% sludge

4.16. Effect of chemical nitrogenous fertilizer (urea) and treated sludge on pH, organic matter and N, P, K, S and Zn content in post harvest soil

4.16.1 Soil pH

Statistically non-significant variation was recorded for pH in post harvest soil due to the combined effect of chemical nitrogenous fertilizer (urea) and treated sludge on the growth and yield of BRRI dhan62 (Fig. 1). But the highest pH of post harvest soil (5.63) was found from T_2 (100% Recommended field dose of urea) and the lowest pH in post harvest soil (5.5) was recorded from T_1(Absolute control).

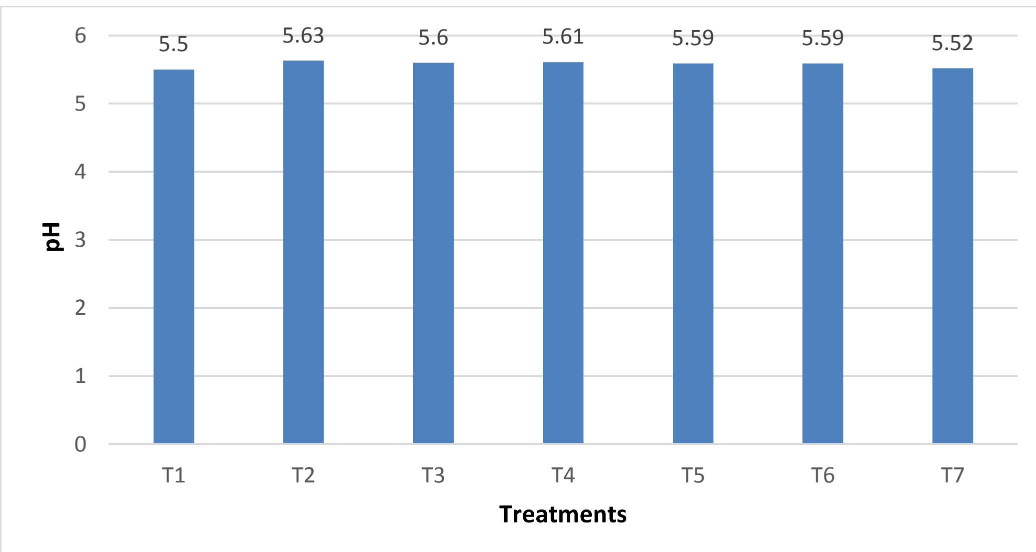

Fig. 1 pH status in soil of the experimental field after harvest of BRRI dhan62

T_1 = Absolute Control
T_2 = 100% Recommended Field Dose (RFD) of Urea
T_3 = 80% RFD of Urea + 20% sludge
T_4 = 60% RFD of Urea + 40% sludge
T_5 = 40% RFD of Urea + 60% sludge
T_6 = 20% RFD of Urea + 80% sludge
T_7 = 100% sludge

4.16.2 Organic matter

Organic manure in post harvest soil showed statistically non-significant differences due to the combined effect of chemical nitrogenous fertilizer (urea) and treated sludge on the growth and yield of BRRI dhan62 (Fig. 2). The highest organic matter in post harvest soil (1.15%) was recorded from T_3 (80% RFD of Urea + 20% sludge). On the other hand the lowest organic matter in post harvest soil (1.04%) was observed from T_2 (100% Recommended Field Dose (RFD) of Urea).

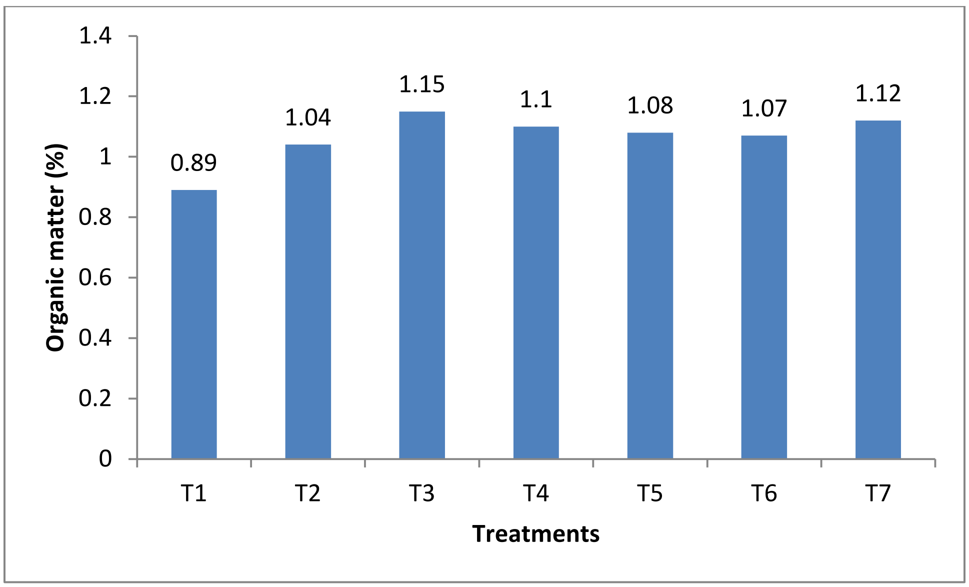

Fig. 2 Organic matter (%) in soil of the experimental field after harvest of BRRI dhan62

T_1 = Absolute Control
T_2 = 100% Recommended Field Dose (RFD) of Urea
T_3 = 80% RFD of Urea + 20% sludge
T_4 = 60% RFD of Urea + 40% sludge
T_5 = 40% RFD of Urea + 60% sludge
T_6 = 20% RFD of Urea + 80% sludge
T_7 = 100% sludge

4.16.3 Total Nitrogen

Total nitrogen in post harvest soil showed statistically non-significant differences due to the application of different levels of chemical nitrogenous fertilizer (urea) and treated sludge for BRRI dhan62 cultivation (Fig. 3). The highest total nitrogen in post harvest soil (0.055%) was recorded from T_3 (80% RFD of Urea + 20% sludge) where the lowest total nitrogen in post harvest soil (0.05%) was recorded from T_1 (Absolute Control).

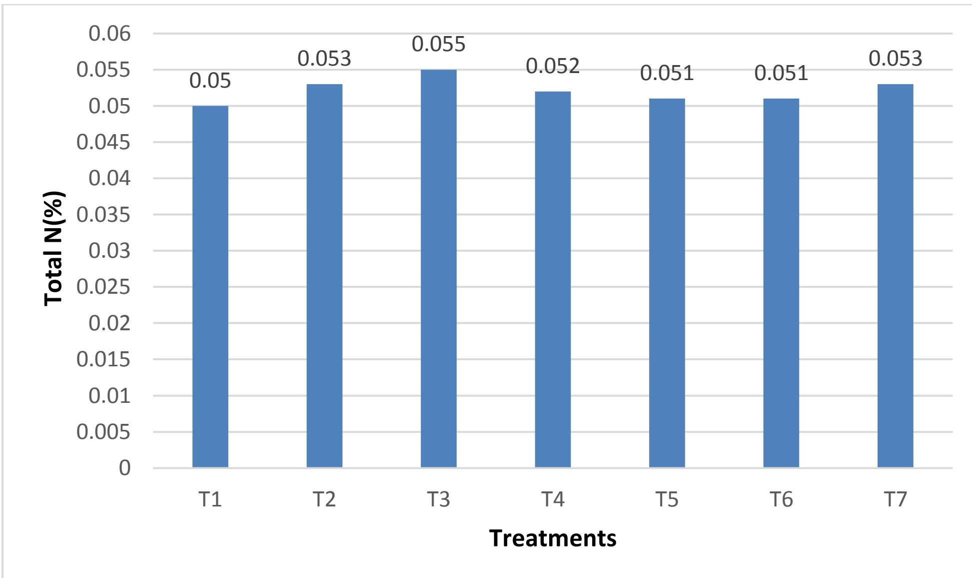

Fig.3 Total N (%)in soil of the experimental field after harvest of BRRI dhan62

T_1 = Absolute Control
T_2 = 100% Recommended Field Dose (RFD) of Urea
T_3 = 80% RFD of Urea + 20% sludge
T_4 = 60% RFD of Urea + 40% sludge
T_5 = 40% RFD of Urea + 60% sludge
T_6 = 20% RFD of Urea + 80% sludge
T_7 = 100% sludge

4.16. 4 Available P

Available P in post harvest soil showed statistically significant differences due to different levels of chemical nitrogenous fertilizer and treated sludge for BRRI dhan62 cultivation (Fig. 4). The highest available P in post harvest soil (24.89 ppm) was recorded from T_3 (80% RFD of Urea + 20% sludge) and the lowest available P in post harvest soil (18.78 ppm) was observed from T_1 (Absolute Control) (Table 5).

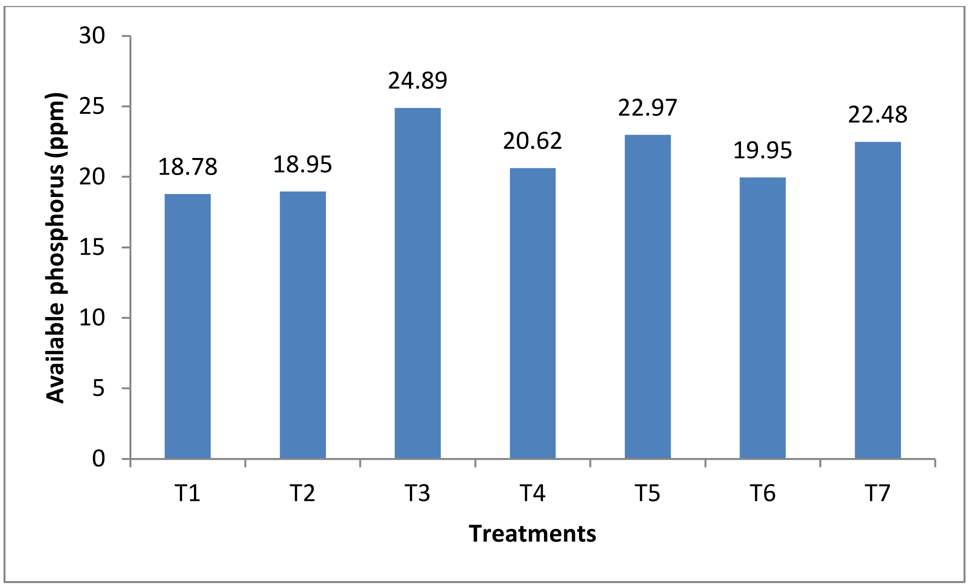

Fig. 4 Available phosphorus (ppm) in soil of the experimental field after harvest of BRRI dhan62

T_1 = Absolute Control
T_2 = 100% Recommended Field Dose (RFD) of Urea
T_3 = 80% RFD of Urea + 20% sludge
T_4 = 60% RFD of Urea + 40% sludge
T_5 = 40% RFD of Urea + 60% sludge
T_6 = 20% RFD of Urea + 80% sludge
T_7 = 100% sludge

4.16.5 Exchangeable K

Exchangeable K in post harvest soil showed statistically significant due to the different levels of chemical nitrogenous fertilizer and treated sludge for BRRI dhan62 cultivation (Fig. 5). The highest exchangeable K in post harvest soil (0.16 meq/100 g soil) was recorded from T_3 (80% RFD of Urea + 20% sludge). On the other hand, the lowest exchangeable K in post harvest soil (0.08 %) was obtained from T_1 (Absolute Control).

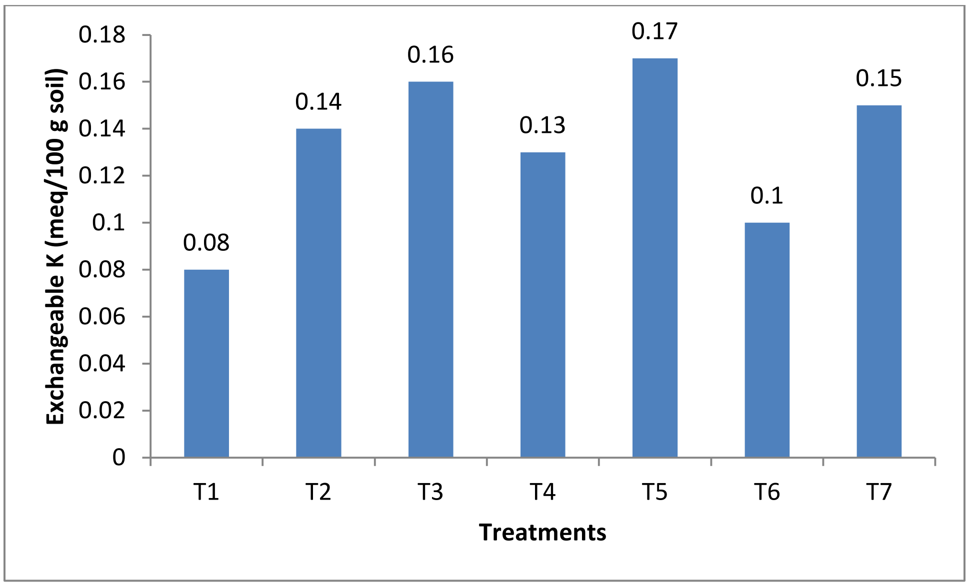

Fig. 5 Exchangeable K in soil of the experimental field after harvest of BRRI dhan62

T_1 = Absolute Control
T_2 = 100% Recommended Field Dose (RFD) of Urea
T_3 = 80% RFD of Urea + 20% sludge
T_4 = 60% RFD of Urea + 40% sludge
T_5 = 40% RFD of Urea + 60% sludge
T_6 = 20% RFD of Urea + 80% sludge
T_7 = 100% sludge

4.16.6 Available S

Available S in post harvest soil showed statistically significant differences different levels of chemical nitrogenous fertilizer and treated sludge for BRRI dhan62 cultivation (Fig. 6). The highest available S in post harvest soil (16.63 ppm) was recorded from T_4 (60% RFD of Urea + 40% sludge) where T_1 (Absolute Control) showed lowest (11.42) available Sulphur.

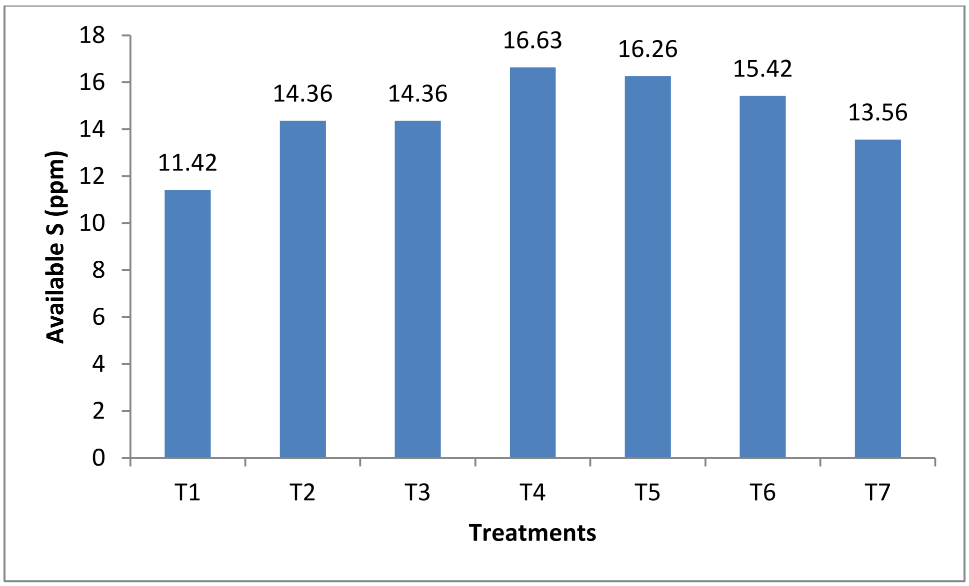

Fig. 6 Available Sulphur in soil of the experimental field after harvest of BRRI dhan62

T_1 = Absolute Control
T_2 = 100% Recommended Field Dose (RFD) of Urea
T_3 = 80% RFD of Urea + 20% sludge
T_4 = 60% RFD of Urea + 40% sludge
T_5 = 40% RFD of Urea + 60% sludge
T_6 = 20% RFD of Urea + 80% sludge
T_7 = 100% sludge

4.16.7 Available Zn

Available Zn in post harvest soil showed statistically non-significant due to the different levels of chemical nitrogenous fertilizer and treated sludge for BRRI dhan62 cultivation (Fig. 7). The highest available K in post harvest soil (1.10 ppm) was recorded from T_3 (80% RFD of Urea + 20% sludge). On the other hand, the lowest exchangeable K in post harvest soil (0.94%) was obtained from T_5 (40% RFD of Urea + 60% sludge).

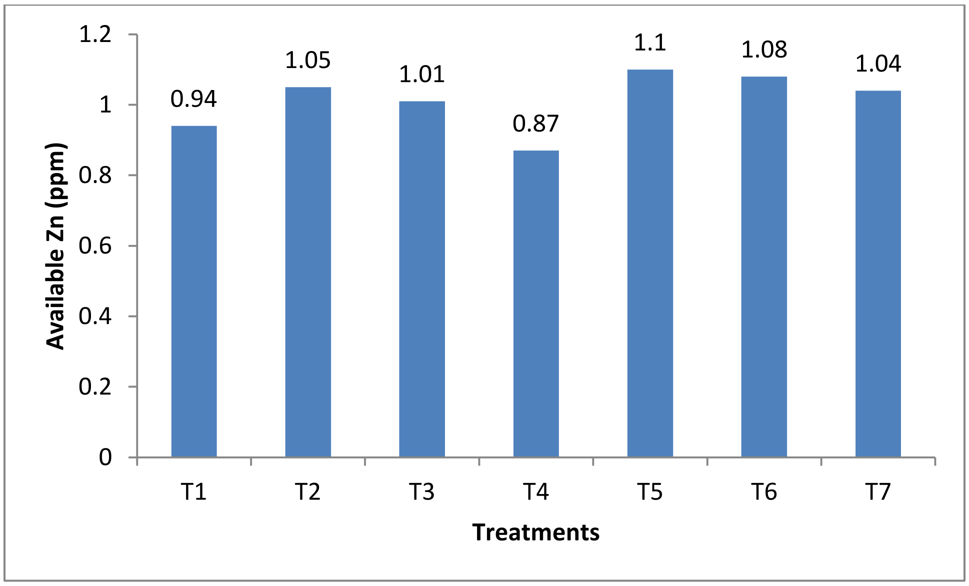

Fig. 7 Available Zn in soil of the experimental field after harvest of BRRI dhan62

T_1 = Absolute Control
T_2 = 100% Recommended Field Dose (RFD) of Urea
T_3 = 80% RFD of Urea + 20% sludge
T_4 = 60% RFD of Urea + 40% sludge
T_5 = 40% RFD of Urea + 60% sludge
T_6 = 20% RFD of Urea + 80% sludge
T_7 = 100% sludge

CHAPTER V

SUMMERYAND CONCLUSION

This experiment was conducted at Soil Science farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka to study the combined effect of chemical nitrogenous fertilizer (urea) and treated sludge on the growth and yield of BRRI dhan62. The experiment was laid out in a randomize block design with three replications. The size of the unit plot was 3.5 m × 3.0 m. There were seven treatments. Seven treatments of the experiment including control were as T_1 = Absolute Control, T_2 = 100% Recommended Field Dose (RFD) of Urea, T_3 = 80% RFD of Urea + 20% sludge, T_4 = 60% RFD of Urea + 40% sludge, T_5 = 40% RFD of Urea + 60% sludge, T_6 = 20% RFD of Urea + 80% sludge and T_7 = 100% sludge. Here it can be mentioned that RFD per plot = Urea 223.18g + TSP 106.01g + MP 106.01g + Gypsum 61.37g + Zn 16.73g+ Zn 16.73gm + sludge 0.0gm and 10kg sludge = 1kg urea. 24days old seedlings of BRRI dhan62 were uprooted carefully from the seedbed and transplanted in the experimental plots with a spacing of 20cm × 15cm on 16 August 2014.

Data were recorded on different yield and yield contributing parameters. Different parameters under the present study were significantly influenced by different treatments. The studied experiment showed that maximum vegetative growth parameter of BRRI dhan62increasedby applying 100% RFD urea; average combination of urea (60%) and sludge (40%) influenced to increase the filled grain per panicle and combination of high percentage (80%) of urea and low percentage (20%) of sludge positively provided the yield parameter as weight of 1000 seeds. Here, the highest plant height (99.93 cm), the highest length of panicle (23.99 cm) and the highest number of tiller per hill (14.95)ware recorded from T_2 (100% RFD of urea);the highest effective tiller per hill (14.56), the highest weight of row straw plot^{-1} (13.77 kg), the highest weight of dry straw plot^{-1} (5.94 kg), the highest weight of fresh seed yield plot^{-1} (6.78 kg), the highest weight of dry seed yield plot^{-1} (4.58 kg) and the highest weight of 1000 seeds (24.23g)ware recorded from T_3 (80% RFD of urea + 20% sludge); the highest total number of grain per panicle (98.21) and the highest number of filled grain per panicle (91.95) ware recorded from T_4 (60% RFD of urea + 40% sludge); and the highest unfilled grain per panicle (13.57) was recorded from T_1 (Absolute Control).

On the other hand, the lowest plant height (90.94 cm), the lowest number of tiller per hill (12.28), the lowest effective tiller per hill (11.62), the lowest length of panicle (22.41 cm), the lowest total number of grain per panicle (84.58), the lowest number of filled grain per panicle (76.95), the lowest weight of row straw plot^{-1} (10.79 kg), the lowest weight of dry straw plot^{-1} (4.96kg), the lowest weight of fresh seed yield plot^{-1} (5.67kg),the lowest weight of dry seed yield plot^{-1}(3.12kg)and weight of 1000 seeds weight (22.2) ware achieved from T_1 (Absolute Control) but the lowest unfilled grain per panicle (3.44) was achieved from T_5 (40% RFD of Urea + 60% sludge).

Again, the highest dry seed yield ha^{-1} (4.36 t), and dry straw yield ha^{-1} (5.66 t) ware achieved from T_3 (80% RFD of urea + 20% sludge) where the lowest dry seed yield ha^{-1} (2.97 t) and dry straw yield ha^{-1} (4.71 t) ware achieved from T_1 (Absolute Control). The highest harvest index (45.88%) was achieved from T_6 (20% RFD of Urea + 80% sludge) and the lowest harvest index (38.67%) was achieved from T_1 (Absolute Control).

From the above findings it can be concluded that only applying the doses of 100% urea cannot influence positive growth for all growth parameter of BRRI dhan62. The treatment of T_3 (80% RFD of urea + 20% sludge) gave the highest performance in respect yield. The treatment of T_2 (100% RFD of urea) and T_4 (60% RFD of Urea + 40% sludge) also gave promising result in respect of yield but significantly different from T_3 (80% RFD of urea + 20% sludge). So, under the present study, T_3 (80% RFD of urea + 20% sludge) can be treated as the best treatment. Further experiment may be established with more option along with the studied treatments for justification of the present study.

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APPENDICES

Appendix 1.Monthly records of Temperature, Rainfall, and Relative humidity of the experiment site during the period from July 2014 to October 2014

Year	Month	Air Temperature (^{0}c)			Relative humidity (%)	Rainfall (mm)	Sunshine (hr)
		Maximum	Minimum	Mean			
2015	July	35.80	29.60	32.70	75.70	2.70	230.50
2015	August	36.30	30.50	33.40	74.60	3.00	227.80
2015	September	34.30	28.60	31.45	68.40	2.00	222.60
2015	October	33.50	26.80	30.15	65.70	1.80	220.50

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

Appendix 2. Growth and yield contributing parameters of BRRI dhan62 as influenced by combined effect of chemical nitrogenous fertilizer (urea) and treated sludge on

Sources of variation	Degrees of freedom	Mean square of			
		Plant height (cm)	Number of tiller hill^{-1}	Number of effective tiller hill^{-1}	Length of panicle (cm)
Replication	2	0.173	4.060	4.319	0.756
Factor A	6	34.963	2.668	3.085	0.766
Error	12	5.740	1.472	1.523	1.203

Appendix 3. Yield contributing parameters of BRRI dhan62 as influenced by combined effect of chemical nitrogenous fertilizer (urea) and treated sludge

Sources of variation	Degrees of freedom	Mean square of		
		Total number of grain panicle^{-1}	Number of unfilled grain panicle^{-1}	Number of filled grain panicle^{-1}
Replication	2	3.677	1.371	2.730
Factor A	6	19.912*	12.028*	17.730*
Error	12	11.648	3.088	3.039

Appendix 4. Yield and yield contributing parameters of BRRI dhan62 as influenced by combined effect of chemical nitrogenous fertilizer (urea) and treated sludge

Sources of variation	Degrees of freedom	Mean square of			
		Weight of 1000 seed (g)	Fresh seed yield plot^{-1} (kg)	Dry seed yield plot^{-1} (kg)	Dry seed yield ha^{-1} (ton)
Replication	2	2.960	0.088	0.053	0.062
Factor A	6	10.272**	0.374*	0.161**	1.263*
Error	12	7.123	0.084	0.043	0.137

Appendix 5. Straw yield of BRRI dhan62 as influenced by combined effect of chemical nitrogenous fertilizer (urea) and treated sludge

Sources of variation	Degrees of freedom	Mean square of			
		Weight of raw straw (kg plot^{-1})	Weight of dry straw (kg plot^{-1})	Dry straw yield (kg ha^{-1})	Harvest index (%)
T_1	2	7.852	0.523	0.341	1.375
T_2	6	3.538*	0.360**	2.255*	6.239*
T_3	12	0.725	0.090	1.027	2.413

Appendix 6. Nutrient status in soil of the experimental field after harvest of BRRI dhan62

Sources of variation	Degrees of freedom	Mean square of						
		P^{H}	Organic matter (%)	Total N (%)	Availabl e P (ppm)	Exchange able K (meq/100 g soil)	Availab le S (ppm)	Availabl e Zn (ppm)
Replication	2	0.012	0.04	0.042	1.371	0.001	1.326	0.012
Factor A	6	0.107^{NS}	0.036^{NS}	0.376^{NS}	3.226^{S}	0.023^{NS}	4.215^{S}	0.064^{NS}
Error	12	0.014	0.006	0.057	4.141	0.004	3.266	0.011