EFFECT OF TREATED SLUDGE AND CHITOSAN ON GROWTH AND YIELD OF NERICA RICE 10 IN AUS SEASON

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CERTIFICATE

This is to certify that the thesis entitled " EFFECT OF TREATED SLUDGE AND CHITOSAN ON GROWTH AND YIELD OF NERICA RICE 10 IN AUS SEASON" **submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of** MASTER OF SCIENCE (M.Sc.) IN SOIL SCIENCE, **embodies the results of a piece of bona fide research work carried out by** SUKANTO HALDER, **Registration No.09-03682, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.**

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

Dated:

(Prof. Dr. Alok Kumar Paul)
Supervisor

Dhaka, Bangladesh

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The Author

ABSTRACT

A field experiment was conducted to assess the effect of treated sludge and chitosan on the growth and yield of NERICA 10 rice at the research farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during Aus season (mid March-June), 2014.With the RCBD designFifty kilogram $Nha^{-1}$from urea and then recommended dose of P, K, S, Zn and foliar spray of chitosan(T_8 Treatment) produced the maximum yield and yield attributing characters of NERICA 10. But the effect of sludge along with chitosan was the most pronounced than that ofcowdung or nitrogenous fertilizer alone. Similar effects were also observed on P, K, S, Zn content and their uptake by NERICA 10. The effect of 50kg $Nha^{-1}$from urea with recommended dose of P, K, S, Zn and foliar spray of chitosan(T_8 Treatment) was statistically identical to 100kg N from urea with recommended dose of P, K, S, Zn (T_1 Treatment), 75 kg N from urea 25 kg N from supplemented sludge and recommended dose of P, K, S, Zn fertilizer (T_2Treatment)), 50 kg N from urea 50 kg N from supplemented sludge and recommended dose of P, K, S, Zn fertilizer (T_3Treatment), 25 kg N from urea 75 kg N from supplemented sludge and recommended dose of P, K, S, Zn fertilizer (T_4), whole N from supplemented sludge (T_5Treatment), foliar spray of chitosan along with recommended N, P, K, S, Zn fertilizer (T_6Treatment)), foliar spray of double chitosan along with recommended dose of N, P, K, S, Zn (T_7Treatment)). The effect of 50kg Nha^{-1} from urea with recommended dose of P, K, S, Zn and foliar spray of chitosan (T_8 Treatment)wasnot similar to Control (T_0 Treatment), 100% recommended N i.e.100 kg nitrogen / ha (T_1 Treatment), 75 kg N from urea with 25kg N substituted by sludge (T_2 Treatment) and 25 kg N from urea with 75 kg N substituted by sludge (T_4 Treatment). In post harvest soils, the contents of total nitrogen, available phosphorus, exchangeable potassium and available sulphur and zinc increased due to application of treated sludge and chitosan compared to initial soil. In the contrary, soil pH value increased slightly as compared to that of initial soil. The overall results indicate that 50kg Nha^{-1} from urea with recommended dose of P, K, S, Zn and foliar spray of chitosan (T_8 Treatment) was the best treatment in producing higher rice yield with sustenance of soil fertility.

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CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important food for the people of Bangladesh and it is the staple food for more than two billion people in Asia (Hien *et al.*, 2006). In Bangladesh, the geographical, climatic and edaphic conditions are favorable for year round rice cultivation. However, the national average rice yield in Bangladesh (4.2 t ha^{-1}) is very low compared to those of other rice growing countries, like China (6.30 t ha^{-1}), Japan (6.60 t ha^{-1}) and Korea (6.30 t ha^{-1}) (FAO, 2008). Sonarbangla-1 produced a 20% higher rice yield (7.55 t ha^{-1}) than the check variety, BRRI Dhan29, (6.26 t ha^{-1}) in Bangladesh (Parvez *et al.*, 2003).

Bangladeshi officials say NERICA 10 (line code WAB 450-11-1-1-P41-HB and parents WAB 56-104/CG 14/2*WAB 56-104) the new rice for Africa, developed around a decade ago by an institute in Ivory Coast, could boost the food security in Bangladesh as global weather patterns make that task more challenging.

The country initially trialed NERICA, which is drought-resistant and fast-growing, in 2009 and after better than expected field results last year a nationwide trial has been rolled out involving 1,500 farmers. In Aus season, sufficient rainfall is not available for rice cultivation. Maximum high-yielding rice varieties require 140 to 160 days to fulfill their life cycle. NERICA is a drought tolerant short duration crop usually requires 90-100 days. So it can be cultivated in Aus season in between boro and T. aman season and can save irrigation cost as well as time which is a good sign for ensuring food security of the nation as well as to increase the cropping intensity also.

Chitosan is produced commercially by deactylation of chitin, which is the structural element in the exoskeleton of crustaceans (such as crabs and shrimp) and cell walls of fungi. The degree of deacetylation (%DD) can be determined by NMR spectroscopy, and the %DD in commercial chitosans ranges from 60 to 100%. On average, the molecular weight of commercially produced chitosan is between 3800 and 20,000 Daltons. A common method for the synthesis of chitosan is the deacetylation of chitin using sodium hydroxide in excess as a reagent and water as a solvent. This reaction pathway, when allowed to go to completion (complete deacetylation) yields up to 98% product (Jabeen *et al.*, 2013).

Land application of sludge are supplying nutrients (N, P, secondary nutrients, and micronutrients), improving of soil physical conditions, and elevating of soil organic matter level. Heavy metals and organic pollutants concentration limits the use of sludge as organic fertilizer. Biological composting of sludge stabilizes its organic content and decreases the pathogens population less than 17% of the total amount of Cu, Zn, Pb, and Cd in sludge and approximately 22% (Chopra *et al*.,2004).

Chitosan has strong effects on agriculture such as acting as the carbon source for microbes in the soil, accelerating of transformation the process of organic matter into inorganic elements. The amino group in chitosan has leads to a protonation in acidic to neutral solution with a charge density dependent on pH. This makes chitosan water soluble and a bioadhesive which readily binds to negatively charged surfaces such as mucosal membranes (Jadav *et.al.*,1997). Chitosan enhances the transport of polar drugs across epithelial surfaces, and is biocompatible and biodegradable.

Sludge affects both the chemical and physical properties of the soil and its overall health. Properties influenced by sludge include: soil structure; moisture holding capacity; aeration; diversity and activity of soil organisms and nutrient availability. It also influences the effects of chemical amendments, fertilizers,

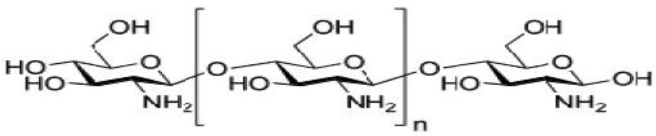


Fig.: Chitosan

pesticides and herbicides. The organic manures viz. sludge and spray of chitosan may be used as an alternative source of N which increases efficiency of applied N (Saravanan *et al.*, 1987)
Integrated use of organic manures with the combination of inorganic fertilizers can contribute to increase N content of rice soil as well as to increase long term productivity and enhancement of ecological sustainability (Gill and Meelu, 1982).

Combined application of sludge and spray of chitosan along with chemical nitrogen fertilizer improves soil health and soil productivity but only use of nitrogenous fertilizer for a long period causes deterioration of physical condition and organic matter status and reduces crop yield. When sludge and spray of chitosan are applied along with chemical fertilizers for efficient growth of crop, decline in organic carbon is arrested and the gap between potential yield and actual yield is bridged to large extent (Rabindra *et al.*, 2005). Keeping these facts in mind the following objectives undertaken:

- To observe the performance of NERICA 10 rice variety under different sources of nitrogen.
- To study the effect of treated sludge on the yield of NERICA 10 rice.
- To find out the efficacy of chitosan solution on the growth and yield of rice.

CHAPTER II
REVIEW OF LITERATURE

A number of research works relating to the application of organic manures and chemical fertilizers to rice crop have been carried out in different rice growing countries of the world including Bangladesh. A better understanding of the effects of the nutrients supplied from manures and fertilizers on rice will obviously facilitate the development of some agronomic practices for production of other crops. Since review of literature forms a bridge between the past and present research works related to problem, which helps an investigator to draw a satisfactory conclusion, an effort was thus made to present some research works related to the present study in this section. This chapter includes the available information regarding the effect of sludge and chitosan along with chemical nitrogenous fertilizers on NERICA 10.

2.1 Effects of chemical fertilizers on the growth and yield of rice

2.1.1 Nitrogenous fertilizers

Atera *et al*. (2011) conducted an experiment on field evaluation of selected NERICA rice cultivars in Western Kenya and reported that the highest plant height (103.8 cm) was obtained from 100 kg N ha^{-1}.

Kamara *et al*. (2011) conducted an experiment on the influence of nitrogen fertilization (0, 30 and 100 kg N ha^{-1}) on yield and yield components of rain-fed low land NERICA rice and reported that nitrogen application influenced number of spikelets $panicle^{-1}$ significantly by 19 to 22% over the control. In both years, number of spikelets increased with increasing nitrogen rates.

Bahmanyar *et al.* (2010) found that maximum grain yield (75.46 g pot^{-1}) was found @ 23 kg N ha^{-1} in Aus rice.

Salahuddin *et al*. (2009) conducted an experiment to study the effect of nitrogen levels and plant spacing on the yield and yield contributing characters of T. aman rice (var. BRRI dhan31) and found that panicle length increased with the increase of nitrogen rate up to 150 kg N ha^{-1} and thereafter declined. The longest panicle (24.50 cm) was observed when 150 kg N ha^{-1} was applied and the shortest (18.15 cm) from control. Nitrogen nutrient takes part in panicle formation as well as panicle elongation and for this reason, panicle length increased with the increase of N-fertilization up to 150 kg N ha^{-1}.

Salahuddin *et al*. (2009) reported that the highest number of grains $panicle^{-1}$ (109.79) was obtained at 150 kg N ha^{-1}, which was significantly different from other N levels. Nitrogen helped in proper filling of seeds which resulted higher produced plump seeds and thus the higher number of grains $panicle^{-1}$. The lowest number of grains $panicle^{-1}$ (99.41) was obtained from 0 kg N ha^{-1}.

Oikeh *et al*. (2008) conducted experiment on the effect of nitrogen on the upland NERICA rice cultivars in Nigeria which indicated no significant influence of nitrogen on grain size but it is contrast with the result of Fageria and Baligar (2001) who reported that the weight of 1000-grain increased significantly and quadratically with increasing nitrogen rates in Brazil. Other studies reported that the weight of 1000-grain decreased with increasing nitrogen rates (Jadav *et al*., 2003).

Field experiments were conducted by Ravi *et al.* (2007) at Annamalai University Experimental Farm (Tamil Nadu, India) during Navarai and Kuruvai season to study the effect of foliar spray of phytohormones and nutrients on the yield and nutrient uptake of transplanted rice cv. ADT 36. The results revealed that foliar application of miraculan @1000 ppm recorded an added beneficial effect over other treatments.

Sarvanan *et al*. (2006) reported that the weight of 1000-grain was not affected significantly by crop management practices. Nitrogen application significantly increased 1000-grain weight (Singh *et al*., 2006).

Singh *et al.* (2006) showed that the nitrogen application significantly increased plant height.

Alam *et al.* (2006) reported that straw yield increased with increasing N levels in rice.

Mazumder *et al*. (2005) reported that different levels of nitrogen influenced grain, straw and biological yields with the application of 100% recommended dose (RD) of N (99.82 kg N ha^{-1}) which was statistically followed by other treatments in descending order. The highest grain yield (4.86 t ha^{-1}) was obtained with 100% RD of N and the lowest (3.80 t ha^{-1}) from no application of nitrogen.

Chopra and Chopra (2004) showed that nitrogen had significant effects on yield attributes such as plant height, panicle $plant^{-1}$and 1000-grain weight.

Singh *et al*. (1999) stated that each incremental dose of N gave significantly higher grain and straw yields of over pre-seeding dose, consequently the crop fertilized with 100 kg N ha^{-1} gave maximum grain yield.

2.1.2 Phosphatic fertilizers

Tang *et al*. (2011) conducted a field experiment on winter wheat (*Triticum aestivum* L.) rice (*Oryza sativa* L.) crop rotations in Southwest China to investigate phosphorus (P) fertilizer utilization efficiency, including the partial factor productivity (PFP), agronomic efficiency (AE), internal efficiency (IE), partial P balance (PPB), recovery efficiency (RE) and the mass (input–output) balance. This study suggests that, in order to achieve higher crop yields, the P fertilizer utilization efficiency should be considered when making P fertilizer recommendations in wheat–rice cropping systems.

Islam *et al*. (2010) conducted a field experiment with five phosphorus rates (0, 5, 10, 20 and 30 kg P ha^{-1}) with four rice genotypes in Boro (BRRI dhan36, BRRI dhan45, EH_1 and EH_2) and T. Aman (BRRI dhan30, BRRI dhan49, EH_1 and EH_2) season. Phosphorus rates did not influence grain yield irrespective of varieties in T. aman season while in Boro season P response was observed among the P rates. Application of P @ 10 kg ha^{-1} significantly increased the grain yield. But when P was applied @ 20 and 30 kg P ha^{-1}, the grain yield difference was not significant. The optimum and economic rate of P for T. Aman was 20 kg P ha^{-1} but in Boro rice the optimum and economic doses of P were 22 and 30 kg ha^{-1}, respectively. Hybrid entries (EH_1 and EH_2) used P more efficiently than inbred varieties. A negative P balance was observed up to 10 kg P ha^{-1}.

Das and Sinha (2006) showed a field experiment on sandy loam soil during the kharif season of 2000 to study the effects of the integrated use of organic manures and various rates of N (urea) on the growth and yield of rice cv. IR 68. Among the different sources of organic amendments, farmyard manure (FYM; 10 t ha^{-1}) was superior, followed by the incorporation of wheat straw (5 t ha^{-1}) along with the combined application of phosphates rock (40 kg P_2O_5 ha^{-1}) and N. Grain and straw yields were highest when FYM was applied with 90 kg N ha^{-1}, although this treatment was comparable with combined application of wheat straw, phosphate rock and 90 kg N ha^{-1}.

Moula *et al.* (2005) conducted an experiment on T. aman rice with different phosphorus rates. He found that when four treatments (P_0, 60 kg ha^{-1} phosphate rock, 60 kg ha^{-1} TSP and 210 kg ha^{-1} phosphate rock) were applied, 210 kg phosphate rock (PR) showed better performance on yield contributing characters and nutrient content as well as nutrient uptake by rice over other treatments.

Thakur and Patel (1998) conducted a field experiment to assess comparative efficiency of super phosphate and PR (34/74) at different levels in the yield characters and composition of rice. The treatments were 30 and 45 kg P_2O_5 ha^{-1} in the form of superphosphate and PR (34/74) with and without organic matter (6 t ha^{-1}), green manure (10 t ha^{-1}) and iron pyrites (10% by weight). The results showed that high grade phosphate rock (M, 34/74) with organic manure performed well and were followed by PR (34/74) with iron pyrites and green manure. Thus, PR (34/74) performed well with organic matter, FeS_2 and green manure in deciding growth and yield of rice. Higher contents of N, P, K, Ca and Mg of grain and straw were obtained at higher levels of 45 kg P_2O_5 ha^{-1} treatment.

2.1.3 Potassic fertilizers

Wang *et al*. (2011) carried out a field experiment to study the effects of N, P and K fertilizer application on grain yield, grain quality as well as nutrient uptake and utilization of rice to elucidate the interactive effects among N, P and K in a field experiment with four levels of nitrogen (N), phosphorus (P) and potassium (K) fertilizers. The results showed that the application of N, P and K fertilizer significantly increased grain yield, and the highest yield was found under the combined application of N, P and K fertilizer.

Wan *et al*. (2010) conducted an experiment to evaluate the effects of application of fertilizer, pig manure (PM), and rice straw (RS) on rice yield, uptake, and usage efficiency of potassium, soil K pools, and the non-exchangeable K release under the double rice cropping system. The field treatments included control (no fertilizer applied), NP, NK, NPK, and NK + PM, NP + RS, NPK + RS. The application of K fertilizer (NPK) increased grain yield by 56.7 kg ha^{-1} over that obtained with no K application (NP).

Mostofa *et al*. (2009) conducted a pot experiment in the net house at the Department of Soil Science, Bangladesh Agricultural University, Mymensingh. Four levels of potassium (0, 100, 200, and 300 kg ha^{-1}) were applied. They observed that the yield contributing characters like plant height, tiller number, and dry matter yield were the highest in 100 kg ha^{-1} of K.

Vijay *et al.* (2006) reported that increasing K rates increased paddy yields. Potassium applied in split dressings were more effective than when applied at transplanting time. Application of potassium fertilizer with organic manure increased soil K availability, K content and the number of grains $panicle^{-1}$.

Hu h. *et al.* (2004) conducted a field experiment in Zhejiang, China, to investigate the K uptake, distribution and use efficiency of hybrid and conventional rice under different low-K stress conditions. The grain yield and total K uptake by rice increased, while the K use efficiency of rice decreased significantly. The interaction effect between cropping history and K application was also significant. The phase from panicle initiation to flowering was critical for K uptake by rice and more than half of the total plant K was accumulated during this phase.

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

Shen *et al*. (2003) studied the effects of N and K fertilizer on the yield and quality of rice. Potassium fertilizer significantly improved all quality parameters and yield at 150 kg N ha^{-1} and equal amounts of K fertilizer applied to rice fields are optimum to obtain high yield.

Saha and Singh (2002) conducted a field experiment to determine the effect of potassium and sulphur. They applied 110 kg N: 90 kg P: 70 kg K: 20 kg S ha^{-1}. They observed that the number of tillers m^{-2}, 1000-grain weight, paddy and straw yield significantly increased with the application of N, P, K and S.

Peng *et al*. (2001) found that K application improved yield of rice grown on an alluvial soil. Overall quality of crops was improved with K application though there was no generally accepted indicator according to which fertilizer effects on quality can be measured.

Singh *et al.* (1999) evaluated the effect of levels of K application on rice at different places. Results indicated that K application significant enhanced the growth and yield of rice over no application. The highest grain and straw yields of rice was obtained at 90 kg K_2O ha^{-1} all the cropping seasons.

2.1.4 Sulphur fertilizers

Ji-ming *et al.* (2011) conducted a field experiment to study the effects of manure application on rice yield and soil nutrients in paddy soil. The results show that the long-term applications of green manure combined with chemical fertilizers (N, P, K, and S) are in favorable of stable and high yields of rice.

Patel *et al*. (1993) conducted a field experiment to study the performance of rice and a subsequent wheat crop along with changes in properties of a sodic soil treated with gypsum, press mud and pyrite under draining and nondraining conditions in a greenhouse experiment. The highest rice yield was obtained with press mud applied at a rate of 50 and 75% gypsum requirement.

Manivannan *et al.* (2008) conducted a field experiment in sulfur deficient soils to study the response of rice genotypes to sulfur fertilization. The treatments consisted of three levels of sulphur (0, 20 and 40 kg ha^{-1}) applied through gypsum and 10 rice genotypes (ADT 36, ADT 37, ADT 42, ADT 43, ADT 38, ADT 39, CO 43, CO 45, CO 47 and ASD 19). The results revealed that rice genotypes differed significantly among themselves to growth and yield on S addition. Rice genotypes CO 43 (5,090 kg ha^{-1}) and CO 47 (5,243 kg ha^{-1}) recorded the highest grain yield.

Azmi *et al.* (2004) studies on long-term influence of four fertility levels and management practices under rice-wheat-sorghum and rice-mustard-mungbean rotations on soil fertility build-up and the yield of crops are being carried out in a Calciorthent of Pusa, Bihar, India. Increasing fertility levels significantly increased the crop yield and S uptake under both rotations.

Chandel *et al.* (2003) conducted a study to see the effect of sulphur nutrient on growth and sulphur content in rice and mustard grown in sequence. The experiment was laid out in split plot design with four sulphur levels (0, 15, 30 and 45 kg S ha^{-1}) applied to rice as main plot treatments during rainy season and each plot further divided into three subplots (0, 20 and 40 kg S ha^{-1}) applied to mustard during winter season. They found that increasing sulphur levels in rice significantly improved leaf area index, tiller number, dry matter production, harvest index and sulphur content in rice up to 45 kg S ha^{-1}.

Singh and Singh (1999) carried out a field experiment to see the effect of different S levels (0, 20 and 40 kg ha^{-1}) on rice cv. Swarna and PR 108 in Varanasi, Uttar Pradesh, India. They reported that plant height, tillers m^{-2}, dry matter production, panicle length and grains $panicle^{-1}$ was significantly increased with increasing levels of S up to 40 kg ha^{-1}.

Peng *et al.* (2002) conducted a field experiment where one hundred and sixteen soil samples were collected from cultivated soils in Southeast Fujian, Chaina. Field experiments showed that there was a different yield increasing efficiency with application S at the doses of 20-60 kg ha^{-1} to rice plant. The increasing rate of rice yield was 2.9-15.5% over control. A residual effect was also observed.

Yang *et al. (*2001) studied the effects of sulphur fertilizer and nitrogen-sulphur fertilizers with rice cv. Weiyou 63 in Fujian, China and found that S treated pots (6.9 mg available S kg^{-1} soil) fertilized with 20 and 40 kg N ha^{-1} had a greater number of panicles and higher fertility than control plants. On the other hand, in NS treated plots (received N rate of 0, 150 and 210 kg ha^{-1} and S rate of 0, 30 and 60 kg ha^{-1}) the highest yield (6,850 kg ha^{-1}) was obtained with 150 kg N ha^{-1} + 60 kg S ha^{-1}.

Raju and Reddy (2001) conducted field investigations at Agricultural Research Station, Maruteru, Andhra Pradesh, India to study the response of both hybrid and conventional rice to sulphur (at 20 kg ha^{-1}) and zinc (at 10 kg ha^{-1}) applications. Significant improvement in grain yield was observed due to sulphur application.

Mandal *et al.* (2000) carried out a greenhouse experiment to evaluate the effect of N and S fertilizers on nutrient content of rice grains (cv. BR 3) at various growth stages (tillering, flowering and harvesting). Nitrogen was applied as urea and S as gypsum @ 0, 5, 10 and 20 kg S ha^{-1}. The combined application of these two elements increased the straw S content only at tillering stage. The uptake of nutrient by the straw and grain increased significantly, which was reflected in the straw and grain yields.

2.2 Effects of organic manure on the growth and yield of rice

Morteza *et al.* (2011) conducted an experiment in order to study the effect of organic fertilizer on growth and yield components in rice. The chicken manure, cow dung and paddy rice were mixed together in 1: 1: 0.5 ratios from organic fertilizer. The treatments of organic fertilizer were given in 5 levels (0.5, 1.0, 1.5, 2.0 and 2.5 t ha^{-1}). An increase in the grain yield at the above mentioned treatments may be due to the increase of 1000-seed weight, panicle number, number of fertile tiller, flag leaf length, number of spikelet, panicle length and decrease number of hollow spikelet per panicle.

Solaiman *et al.* (2011) conducted a field experiment at Bangabandhu Sheikh Mujibur Rahman Agricultural University Research Farm, Gazipur during boro season to evaluate and examine the effect of urea- nitrogen, cowdung, poultry manure and urban wastes on growth and yield of boro rice, cv. BRRI Dhan 29. The yield was significantly increased where urea, cowdung, poultry manure and urban wastes are applied together.

Yadav *et al.* (1998) conducted a field experiment to find the efficacy of substituting fertilizer N at different proportions (25%, 50% and 75% of total N) with organic N sources i.e., farm yard manure (FYM), green leaf manure (GLM), poultry manure and BGA on nutrient uptake (NPK) and yield of rice variety Sarju 52. In general the maximum uptake of the nutrients and grain yield were obtained with the application of 25% N through green manure + 75% through inorganic urea. GLM is more efficient than other organic sources at all the proportions of N.

Debiprasad *et al*. (2010) conducted a field experiment to investigate the effect of enriched pressmud compost on soil chemical properties like pH, EC, nutrient content. Application of 120 kg N ha^{-1} through chemical fertilizer and combination of press mud and cowdung increased effective tillers m^{-2} number of effective tillers m^{-2}, filled grains per panicle, 1000-grain weight.

Uddin *et al.* (2009) conducted a field experiment to study the effects of S, Zn and B supplied from chemical fertilizers and poultry manure on yield and nutrient uptake by rice (cv. BRRI Dhan-30). The different nutrients significantly increased plant height, effective tillers $hill^{-1}$, filled grains $panicle^{-1}$, 1000-grain weight, grain and straw yields of rice. The highest grain yield of 4,850 kg ha^{-1} was obtained when S, Zn and B were applied combination with poultry manure.

Kumar *et al.* (1998) conducted a field experiment on rice-wheat system revealed that the values of all yield attributes were improve significantly due to integrated use of press mud along with recommended doses of fertilizer (RDF). Rice received 10 t press mud ha^{-1} along with RDF produced significantly higher grain yield.

Verma *et* al. (1996) conducted a field experiment in rabi season to develop integrated N management practice for wet seeded rice (cv. ADT 38) + daincha dual cropping systems. They reported that 75% recommended dose of N fertilizer + 25% N as poultry manure increased growth, yield attributes and yield and nutrient uptake of rice higher soil available organic carbon, nitrogen and phosphorus.

Singh *et al.* (1999) conducted an experiment during kharif 2004, on an Inceptisol in Varanasi, Uttar Pradesh, India to evaluate the effects of chemical fertilizer (urea), cowdung and biofertilizer (*Azospirillum*) on the yield of rice and physicochemical properties of the soil. Application of chemical fertilizer, cowdung and *Azospirillum*, individually or in combinations, significantly increased the yield attributes (plant height, number of tillers, panicle length, grain yield and straw yield) over the control. The treatment comprising 80 kg N ha^{-1} + *Azospirillum* + 2.5 t cowdung ha^{-1} was superior over all other treatments in terms of rice yield.

Reddy *et al.* (2006) carried out a field experiment for two years (2001 and 2002) on the farmers field in Koler district (eastern dry zone, Karnataka, India) to study the effect of different organic manures on growth and yield of paddy under tank irrigation. Application of poultry manure (9 t ha^{-1}) to paddy produced grain yields at recommended dose of fertilizers + 10 t ha^{-1} FYM but both were higher (67 and 69%) respectively than FYM. Poultry manure produced better growth components viz. plant height, number of tillers $hill^{-1}$, and total dry matter $plant^{-1}$ and yield components like number of panicle $hill^{-1}$ and panicle length.

Mashkar and Jhora (2005) conducted a field experiment at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh, during August to December 1995 to study the transplanted aman rice. Four varieties, namely, BR10, BR11, BR22 and BR23 and five fertilizer application treatments namely, F_1= inorganic fertilizers (IF), F_2 = IF + cowdung 5t ha^{-1}, F_3 = IF + cowdung 10 t ha^{-1}, F_4= recommended doses N application + cowdung 5 t ha^{-1}, and F_5= IF with recommended doses N application + cowdung 10 t ha^{-1}. Cowdung up to 10 t ha^{-1} in addition to recommended inorganic N fertilizer application improved grain and straw yields and qualities of transplant rice over inorganic fertilizers alone.

Ogbodo *et al.* (2005) conducted a study to compare the response of rice to organic and inorganic manures at Abakaliki, Southeastern Nigeria between 2002 and 2003 cropping seasons (April-November). However organic manure application doses of over 20 t ha^{-1} reduced plant growth and grain yield.

Chettri *et al.* (2002) conducted a field experiment in a sandy clay loam soil of neutral reaction having 0.067, 17, 19.3 and 17.2 kg ha^{-1} available N, P, K and S, respectively in Nadia, West Bengal, India during 1994-95 and 1995-96. The highest number of effective tillers $hill^{-1}$, grains $panicle^{-1}$, percentage of filled grains, 1000-grain weight, grain yield (44.05 q ha^{-1}) of rice were obtained with the application of 60 kg N, 30 kg P_2O_5 and 30 kg K_2O ha^{-1} with 10 t cowdung ha^{-1}.

Azad and Leharia (2002) conducted a field experiment during Kharif of 1995 and 1996 in Jammu, India to investigate the effect to NPK application with and without poultry manure (PM at 10 t ha^{-1}) and Zn (as $ZnSO_4$ at 20 kg ha^{-1}) on growth and yield of rice cv. PC-19. Results indicated that application of poultry manure in combinations with different NPK levels exhibited a significant increase in effective tillers m^{-2} area in row, grain and straw yields over NPK, a significant increase in growth and straw yield (1,318 kg ha^{-1}) yields were recorded from T_7 and the lowest from T_4.

Saitoh *et al*. (2001) conducted an experiment to evaluate the effect of organic fertilizers (cowdung and chicken manure) and pesticides on the growth and yield of rice and revealed that the yield of organic manure treated and pesticide free plots were 10% lower than that of chemical fertilizer and pesticide-treated plot due to a decrease in the number of panicle.

Shrirame and Prasad (2000) reported that the application of FYM @ 10 t ha^{-1} produced 4.64 % higher grain yield than the control.

Channabasavanna and Biradar *et* al. (2003) conducted an experiment with four sources of organic manure (FYM 7 t ha^{-1}, rice husk 5 t ha^{-1}, poultry manure 2 t ha^{-1} and press mud 2 t ha^{-1}), one control and 3 levels of zinc (0, 25 and 50 kg $ZnSO_4$ ha^{-1}). Application of poultry manure with 25 kg $ZnSO_4$ ha^{-1} recorded significantly higher yields over rest of the treatments. The residual effect was more prominent when rice husk was applied. They also cited that organic manure increased panicle $hill^{-1}$ and seeds $panicle^{-1}$.

Mann *et al*. (2006) reported that manuring with cowdung up to 10 t ha^{-1} in addition to recommended inorganic fertilizer with late N application improved grain and straw yields and quality of transplant aman rice over inorganic fertilizers alone.

Ram *et al*. (2000) reported that the use of 30 or 60 kg N ha^{-1} from organic sources in a total application of 120 kg N ha^{-1} increased grain and straw yields, N uptake and recovery, grain nutritive value, decreased soil pH and increased soil fertility and economic returns.

2.3 Combined effects of manures and fertilizers on the growth and yield of rice and soil properties

Chun-yan *et al.* (2011) carried out an experiment to study the effect of fertilization on yield and nutrients absorption in japonica rice variety Zhejing 22. The results showed that rational combination of chemical fertilizers and manure showed better effect on rice yield, and the efficiency of fertilizers and absorption of nutrients increased.

Singh *et al.* (1999) conducted a experiment to study the effect of N, P and K fertilizers with or without FYM, lime, sulphur and boron on yield, nutrient uptake and fertility status of soil available N, P, K and S. The highest grain yield of rice and pea was recorded in the treatment receiving 50% of recommended dose NPK fertilizers along with application of 5 t FYM + 250 kg lime + 20 kg S + 1 kg B ha^{-1}. Application of lime @ 250 kg ha^{-1} in furrows along with 5 t FYM ha^{-1} and 50% RDF significantly improved the pH of soil after harvest of pea crops.

Kabir *et al.* (2009) conducted a experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh in transplanted *Aman* season 2008 to find out the effect of urea super granules (USG), prilled urea (PU) and poultry manure (PM) on the yield and yield attributes of transplant *Aman* rice varieties. Two transplant *Aman* rice varieties viz. BRRI dhan41 and BRRI dhan46 and ten levels of integrated nutrient management encompassing USG, PU and PM were tested following randomized complete block design with three replications. It was observed that combined use of chemical fertilizer and manure gave the higher yield of rice and improvement of soil fertility P, K and S content.

Ju-mei *et* al. (2008) conducted a field experiment to investigate the effects of chemical and organic fertilizers on rice yield, soil organic matter and soil nutrients. The combined use of chemical and organic fertilizers was an optimum way for high yield and improvement of soil fertility. Combined use of chemical fertilizer and manure were showed the higher yield of rice and improvement of soil fertility.

Saitosh *et al.* (2001) conducted a field experiment during 1997/98, in Srikakulam, Andhra Pradesh, India, to evaluate the effects of different integrated nutrient management (INM) components on the yield and nutrient uptake in mesta (*Hibiscus cannabinus*) **-** rice cropping system. Recommended fertilizer dose of 75 kg N ha $^{-1}$ with 5 t cowdung ha^{-1}, recorded the highest Mesta fiber yield of 25.32 q ha^{-1} as well as the highest rice grain and total (grain + straw) yields of 28.82 and 64.06 q ha^{-1} respectively. The result also showed that N, P and K content in soil were increased due to application of fertilizer and cowdung.

Singh *et al.* (2005) conducted multi-locational experiments at eight farmers field covering five villages (Pairaguri, Puturu, Gidhibill, Kuliyana and Deoli) of east Singhbhum, Jharkhand, India in kharif seasons of 2001 and 2002 to study the effect of integrated nutrient management (INM) practices on transplanted rice yield and nutrient uptake and soil fertility status. Results showed that the grain and straw yields of transplanted rice were significantly influenced by INM practices. NPK (80:60:30 kg ha^{-1}) + 5 t FYM ha^{-1} + cowpea as green manure recorded the highest grain yield. The total N, P and K uptake by rice was higher with INM practices over the farmers practice. Available N, P and K content in farmer’s field was improved under INM practices compared to its initial soil fertility.

Kumar *et* al. (1995) carried an experiment in Nigeria to determine the effect of goat manure on upland rice. The applications of 10 t ha^{-1} and 20 t ha^{-1} of goat manure produced 1.49 t ha^{-1} and 1.58 ton ha^{-1} grain yields, respectively in the second year. These yields were as good as those obtained with application of chemical fertilizer only or the application of 10 t ha^{-1} of goat manure + top-dressing with 30 kg N ha^{-1}. The application of 30 t ha^{-1} goat manure produced the highest grain yield increase but resulted in more weed and stem borer infestation in those plots.

Abro and Abbasi (2002) conducted a field experiment in randomized complete block design with six replication on rice variety DR-82 at Agriculture Research Institute, Dokri. The result indicated that highest grain yield 5,525 kg ha^{-1} was obtained when green manuring applied with chemical fertilizer at the rate of 90-60 kg ha^{-1}.

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

2.4 Effect of chitosan on growth, yield and yield parameter

Hasegawa *et al.* (2005) reported that corms with an increased diameter and height are obtained as a result of rice cultivation in a substrate with an addition of chitosan.

According to Win *et al*. (2005), spraying *Dendrobium* 'Missteen' plants with chitosan significantly increased the length of the inflorescence but did not affect the size of flowers.

Ohta *et al.* (1999) conducted that a stimulating effect of chitosan on the number of flowers was observed in plants such as lisianthus.

Vanaja *et al.* (2002) conducted that the increase of the chlorophyll content as a result of application of chitosan may be caused by plants' enhanced uptake of nutrients, which occurred in the studies by Nguyen on coffee seedlings.

Mondal *et al*. (2012) showed that, when used in plants, chitosan can increase the yield.

Al-Hetar *et al*. (2011) conducted that Chitosan is harmless to crops, animals and humans, and is biodegradable and friendly to the environment.

Wanichpongpan *et al*. (2001) conducted that to introduced as a material to improve grain yield under unfavorable conditions due to their bioactivities to plants such as inducing the plants resistance against a wide range of diseases through antifungal, antibacterial, antivirus activities, stimulating the growth of plants and seed germination, improving soil fertility and enhancing the mineral nutrient uptake of plant, increasing the content of chlorophylls, photosynthesis and chloroplast enlargement.

Peng *et* al. (2002) conducted that chitosan which revealed that wheat plants treated with polymeric or oligomeric chitosan increased spike weight and grain yield

Balakrishnan et al. (2010) reported that seeds of no heading Chinese cabbage dressed with chitosan atthe rate 0.4-0.6 mg/g seed and leaf spraying with20-40 micro g/ml increased fresh weight.

Limpanavech et al. (2008) reported that tillers per plant significantly increased ($P<0.05$) with the increase in molecular weights of chitosan spray.

Hach *et al*. (2006) Using chitosan in agriculture with less use of chemical fertilizer increases the production, in different kinds of plant, by 15-20%.

CHAPTER III
MATERIALS AND METHODS

The experiment was conducted in the Sher-e-Bangla Agricultural University Farm, Dhaka, under the Agro Ecological Zone of Madhupur Tract, AEZ-28 during the *Aus*season of 2014. For better understanding the site, it is shown in the map of AEZ of Bangladesh (Fig. 1).

This chapter presents a brief description of the soil, crop, experimental design, treatments and intercultural operations, collection of soil and plant samples and analytic methods followed in the experiment. This chapter has been divided into a number of sub-heads describe as below:

3.1 Experimental details of site

3.1.1 Soil

The experiment was carried out in a typical rice growing soil of the Sher-e-Bangla Agricultural University (SAU) Farm, Dhaka, during *Aus* season of 2014. The farm belongs to Tejgaon series under the General soil type, **"**Deep Red Brown Terrace Soil**"**. The land was above flood level and sufficient sunshine was available during the experimental period. The morphological, physical and chemical characteristics of initial soil are presented in Tables 1 and 2.

3.1.2 Crop

NERICA 10 is a short duration rice variety first introduced in Bangladesh in 2009 from Africa, was used as a test crop. It is not only a drought tolerant but also drought avoidance variety and fast recovery with rains after drought.

3.1.3 Land preparation

The experimental field was first opened on 15th March 2014 with the help of a power tiller, later the land was saturated with irrigation water and puddled by three successive ploughing and cross-ploughing. Each ploughing was followed by laddering to have a good puddled field. All kinds of weeds and residues of previous crop were removed from the field. The experimental plots were laid out as per treatment and design.

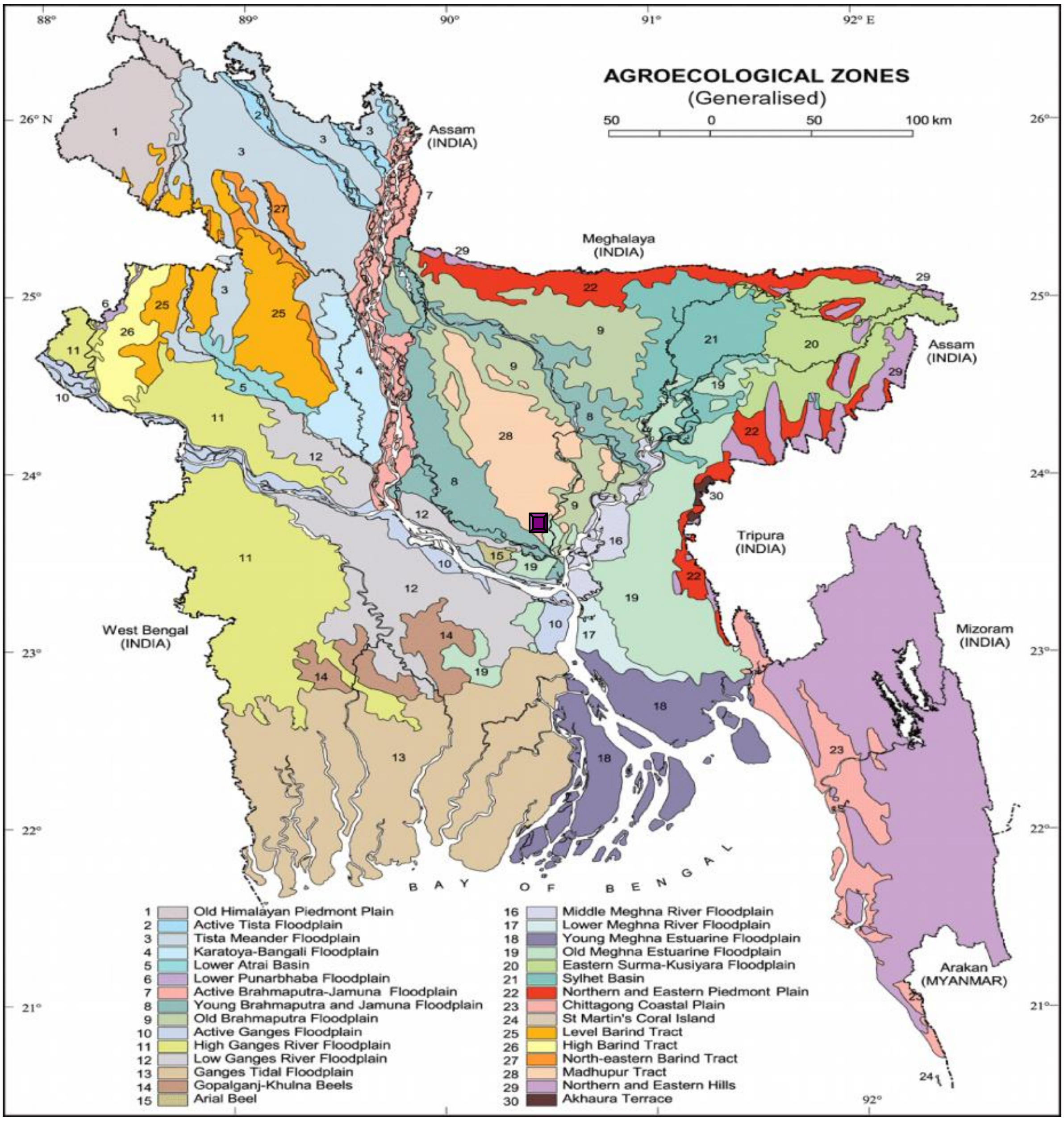


Figure 1. Map showing the experimental site under study

Table 1. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Sher-e-Bangla Agricultural University Farm, Dhaka
AEZ	Madhupur Tract (AEZ 28)
General Soil Type	Deep Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

Table 2. Physical and chemical properties of the initial soil sample

Characteristics	Value
Particle size analysis	
% Sand	28.27
% Silt	41.28
% Clay	30.45
Textural class	Silty-clay
pH	5.62
Bulk Density (g/cc)	1.48
Particle Density (g/cc)	2.54
Organic carbon (%)	0.49
Organic matter (%)	0.86
Total N (%)	0.06
Available P (ppm)	18.21
Exchangeable K (meq/100g soil)	0.13
Available S (ppm)	22

3.1.4 Experimental design

Design: Randomized Complete Block (RCB).

Treatment: 9

Replication: 3

Total number of plots: 27

Plot size: 3.5 m × 2.75 m

Block to block distance: 1 m

Plot to plot distance: 0.5 m

3.1.5 Layout of the experiment

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each block was sub-divided into eleven unit plots. The treatments were randomly distributed to the unit plots in each block. The total number of plots was 27 (9×3). The unit plot size was 3.5 m × 2.75 m. Block to block distance was 0.5 m and plot to plot distance was 1 m. The layout of the experiment has been shown in Fig. 2.

3.1.6 Seed sowing

A standard procedure of broadcasting was followed to sow the seeds of NERICA 10 rice in field. For this purpose, line sowing of seed was sown.

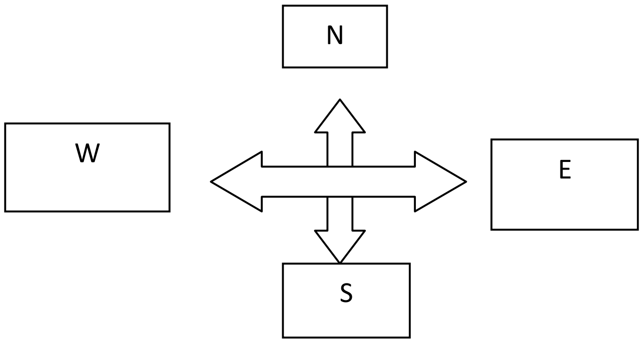
3.1.7 Collection and preparation of initial soil sample

The initial soil samples were collected before land preparation from a 0-15 cm soil depth. The samples were drawn by means of an auger from different location covering the whole experimental plot and mixed thoroughly to make a composite sample. After collection of soil samples, the plant roots, leaves etc. were picked up and removed. Then the samples were air-dried and sieved through a 10-mesh sieve and stored in a clean plastic container for physical and chemical analysis.

Plot size: 3.5 m x 2.75 m

Plot to plot distance: 0.5 m

Block to block distance: 1 m



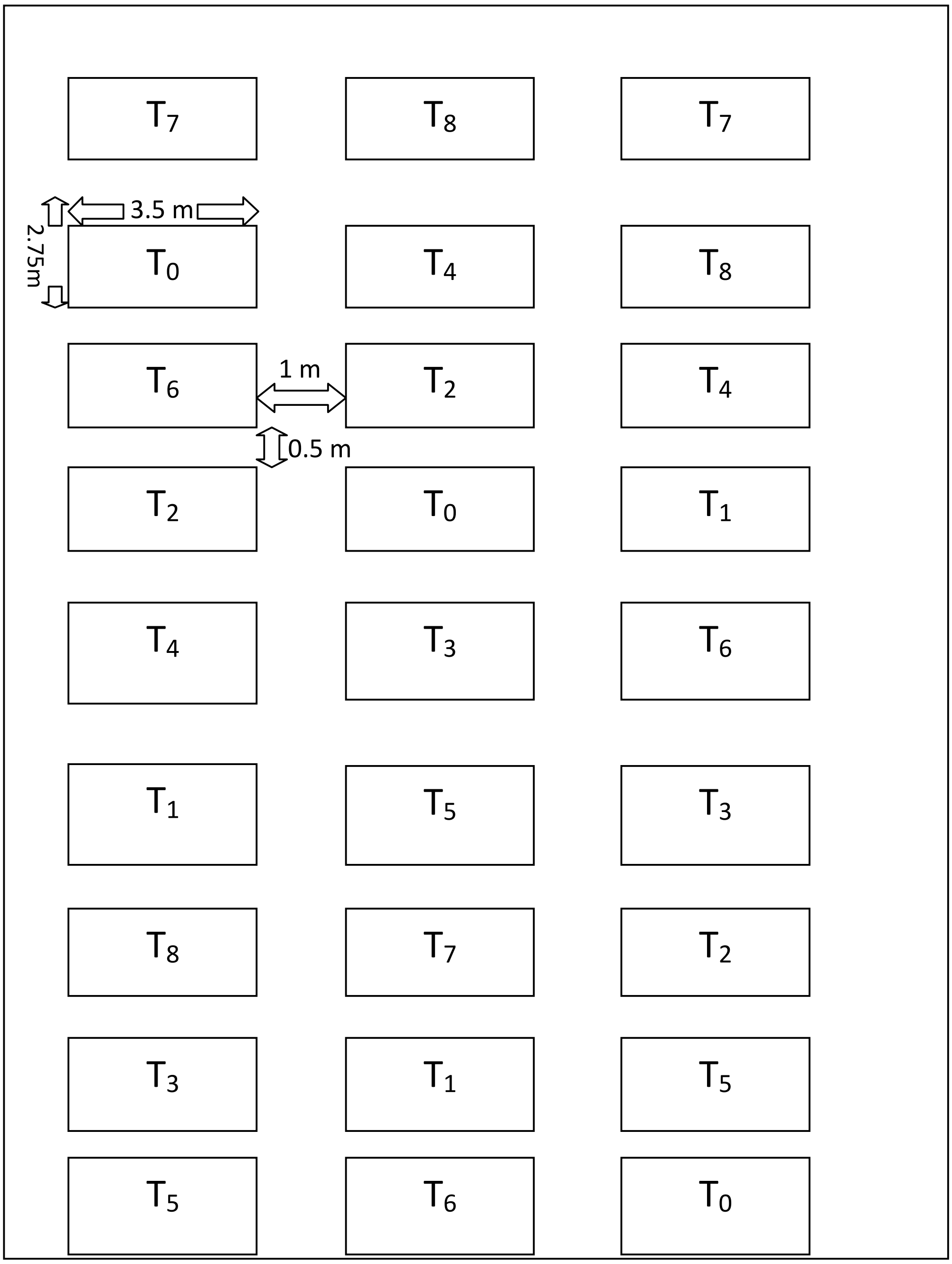


Figure 2: Layout of the experimental field

3.1.8 Treatments

There were 9 treatments. The treatments were as follows:

T_0: No chemical fertilizer, no organic manure (Control)

T_1: 100% recommended N (100 kg Nha^{-1}) + recommended PKSZn

T_2: 75 kg N from urea + 25kg N supplemented by sludge + recommended PKSZn

T_3: 50 kg N from urea + 50 kg N supplemented by sludge + recommended PKSZn

T_4: 25 kg N from urea + 75kg N supplemented by sludge + recommended PKSZn

T_5: Whole N supplemented by sludge

T_6: Foliar spray of chitosan (twice in week up to flowering) + recommended NPKSZn

T_7: Foliar spray of double chitosan + recommended NPKSZn

T_8: Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn

Note: Urea contain 46% N, Sludge contain 0.10% N

Table 3. Sources and rates of different elements in the experiment

Source	Rate ha^{-1}	Time of application
TSP	80 kg	Final land preparation
MP	90 kg	Final land preparation
Gypsum	55 kg	Final land preparation

3.1.9 Application of fertilizers

The amounts of nitrogen, phosphorus, potassium and sulfur fertilizers required per plot were calculated from fertilizers rate per hectare. A blanket dose of 16 kg P, 45 kg K and 10 kg S hectare^{-1} was applied to all plots in the forms of triple super phosphate (TSP), muriate of potash (MOP) and gypsum, respectively during final land preparation. Nitrogen was also applied as per treatment in the form of urea in three equal splits. The first split was applied after 15 days of sowing, the second split was applied after 35 days of sowing i.e. at active vegetative stage and the third split was applied at 60 days of sowing i.e. at panicle initiation stage.

3.1.10 Intercultural operations

The following intercultural operations were done for ensuring the normal growth of the crop. Top dressing of urea was done as per schedule and the normal cultural practices including weeding and insecticides spray were done as and when necessary.

3.1.11 Plant sampling at harvest

Plants from 1 m^2 were randomly selected from each plot to record the parameter and yield contributing characters like plant height (cm), number of tillers hill^{-1}, panicle length (cm), number of grains panicle^{-1}, and 1000-grain weight (g). The selected hills were collected before harvesting. Grain and straw yields were recorded plot-wise and expressed at t ha^{-1} on sundry basis.

3.1.12 Harvesting

The crop was harvested at maturity on 22 June, 2014. The harvested crop was threshed plot-wise. Grain and straw yields were recorded separately plot-wise and moisture percentage was calculated after sun drying. Dry weight for both grain and straw were also recorded

3.1.13 Data collection

The data on the following growth and yield contributing characters of the crop were recorded:

i) Plant height (cm)
ii) Number of effective and ineffective tillers hill^{-1}
iii) Panicle length (cm)
iv) Number of unfilled and filled grains panicle^{-1}
v) Total grain panicle^{-1}
vi) 1000-grain weight (g)
vii) Seed grain yield (t ha^{-1})
viii) Seed grain and straw yields (t ha^{-1})
ix) Straw yield (t ha^{-1})
x) Biological yield (t ha^{-1})
xi) Harvest index

3.1.13.1 Plant height (cm)

The plant height was measured from the ground level to the top of the panicle. Plants of 10 hills (1 m^2) were measured and average for each plot.

3.1.13.2 Number of effective and ineffective tillers hill^{-1}

Ten hills were taken at random from each plot and the number of tillers hill^{-1} was counted. The numbers of effective and ineffective tillers hill^{-1} were also determined.

3.1.13.3 Panicle length

Measurement was taken from basal node of the rachis to apex of each panicle. Each observation was an average of 10 panicles.

3.1.13.4 Filled and unfilled grain panicle^{-1}

Ten panicles were taken at random to count unfilled and filled grains and averaged.

3.1.13.5 Total number of grain panicle^{-1}

Total number of grain panicle^{-1}was the sum offilled and unfilled grain from the sample panicle.

3.1.13.6 1000-grain weight

The weight of 1000-grains from each plot was taken after sun drying by an electric balance.

3.1.13.7 Grain and straw yields

Grain and straw yields were recorded separately plot-wise and expressed as t ha^{-1} on 12% moisture basis.

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

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

$$\text{Biological yield (t ha}^{-1}\text{)} = \text{Grain yield (t ha}^{-1}\text{)} + \text{Straw yield (t ha}^{-1}\text{)}$$

3.1.13.9 Harvest Index (%)

It denotes the ratio of economic yield to biological yield and was calculated with following formula (Donald, 1963; Gardner *et al*., 1985).

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

3.1.14 Chemical analysis of soil samples

Soil samples were analyzed for both physical and chemical properties in the laboratory of Bangladesh Sugarcane Research Institute (BSRI), Ishwardi, Pabna. The properties studied included soil texture, pH, organic matter, total N, available P, exchangeable K and available S. The physical and chemical properties of the initial soil have been presented in Table 2. The soil was analyzed by standard methods:

3.1.14.1 Physical analysis

Soil physical analysiswas done by Hydrometer Method (Bouyoucos, 1926) and the textural class was determined by plotting the values for % sand, % silt and % clay to the "Marshall's Textural Triangular Coordinate" according to the USDA system.

3.1.14.2 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).

3.1.14.3 Organic carbon

Organic carbon in soil was determined by Walkley and Black (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.

3.1.14.4 Total nitrogen

Total nitrogenof 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 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).

3.1.14.5 Available phosphorus

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

3.1.14.6 Exchangeable potassium

Exchangeable potassium was determined by 1N NH_4OAc (pH 7.0) extract of the soil by using Flame photometer (Black, 1965).

3.1.14.7 Available sulphur

Available sulphur in soil was determined by extracting the soil samples with 0.15% $CaCl_2$ solution (Pang*et al.*, 2002) The S content in the extract was determined turbid metrically and the intensity of turbid was measured by Spectrophotometer at 420 *n*m wave length.

3.1.15 Chemical analysis of plant samples

3.1.15.1 Preparation of plant samples

Ten selected hills plot^{-1} were collected immediately after harvest of the crop. The selected hills were threshed. Both grain and straw were cleaned and dried in an oven at 65^0 C for 48 hours. The dried samples were grinded and put into small paper bags and kept into a desiccators till being used.

3.1.15.2 Digestion of plant samples with sulphuric acid

For N determination, an amount of 0.1 g plant sample (grain/straw) was taken into a 100 ml Kjeldahl flask. An amount of 1.1 g catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se = 100:10:1), 2 ml 30% H_2O_2 and 3 ml conc. H_2SO_4 were added into the flask. The flask was swirled and allowed to stand for about 10 minutes, followed by heating at 200^0C. Heating was continued until the digest was clear, and colorless. After cooling, the contents were taken into a 100 ml volumetric flask and the volume was made with distilled water. A blank digestion was prepared in a similar way except plant sample. This digest was used for determining the nitrogen contents on plant samples.

3.1.15.3 Digestion of plant samples with nitric-perchloric acid mixture

An amount of 0.5 g of plant sample was taken into a dry clean 100 ml Kjeldahl flask, 10 ml of di-acid mixture (HNO_3, $HClO_4$ in the ratio of 2:1) was added and kept for few minutes. Then, the flask was heated at a temperature rising slowly to 200^0C. Heating was instantly stopped as soon as the dense white fumes of $HClO_4$ occurred and after cooling, 6 ml of 6N HCl were added to it. The content of the flask was boiled until they become clear and colorless. This digest was used for determining P, K, S and Zn.

3.1.16 Statistical Analysis

All the data collected on different parameters were statistically analyzed following the analysis of variance (ANOVA) technique using MSTAT-C computer package program and the mean differences were adjudged by least significant difference (LSD) test at 5 % level of significance (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The results of the experiment conducted under field conditions are presented in several Tables and Figures. The experiment was conducted to study the effect of integrated nutrient management on the growth and yield of NERICA 10. The results are presented and discussed under the following parameters.

4.1 Growth and yield components

4.1.1 Plant height

Plant height was significantly influenced by different combination of treatment at 30, 60,80 days after transplanting (DAT) and at harvest (Table 4). At 30 DAT highest plant was found from T_8 (24.89 cm) which were statistically similar with T_7 (24.42 cm), T_6 (23.59 cm) and (23.56 cm). On the other hand lowest plant was found from at 30 DAT from T_0 (15.79 cm) which was statistically similar with T_4 (18.28 cm). At 60 DAT (80.49 cm), 80 DAT (84.57 cm) and at harvest (98.52 cm) the maximum plant height was observed in T_8. T_7 (79.78 cm) was statistically similar with T_8 at 60 DAT. The minimum plant height recorded at 60 DAT (57.01 cm), 80 DAT (66.58 cm) and at harvest (77.20 cm) from control (To). Plant height at harvest the treatments may be ranked in the order of T_8> T_7> T_6> T_5> T_1> T_2> T_3> T_4>T_0treatments where T8, T7, T6, T5,T1 werestatistically similar.Boonlertnirun *et al.*(1999)revealed that Seed soaking in chitosansolution before planting tended to stimulate plantheight. However, it did not show any statisticallysignificant differences from the others. Their treatment combination wereTr 1- no chitosan application(control), Tr 2- seed soaking with chitosan solution Tr 3 - seed soaking and soil application with chitosansolution and Tr4 - seed soaking and foliar spraying with chitosan solution.

The increased plant height through the application of FYM along with N, P, K and S was also reported by many other scientists (Kobayashi *et al.,* 1989;

Mashkar*et al.*,2005). Mostofa*et al.* (2009) observed that the yield contributing characters like plant height was the highest in 100 kg ha^{-1} of K

Table 4. Effect of treated sludge & chitosan onplant height over control of NERICA 10

Treatment	Plant height at different days after transplanting (DAT)			
	30 DAT	60 DAT	80 DAT	At harvest
T_0	15.79d	57.01e	66.58d	77.20d
T_1	21.14abc	68.63bcd	77.97abc	92.31abc
T_2	20.13bc	66.40cde	76.64abc	87.45bc
T_3	19.93bc	65.87cde	75.05bcd	87.03bc
T_4	18.28cd	63.53de	74.07cd	85.65c
T_5	23.56ab	74.99abc	79.97abc	93.57ab
T_6	23.59ab	77.49ab	82.80abc	97.02a
T_7	24.41a	79.78a	83.66ab	98.13a
T_8	24.89 a	80.49a	84.57a	98.52a
C.V (%)	**10.29%**	**8.30%**	**6.60%**	**4.30%**
LSD Value	**3.794**	**10.12**	**8.902**	**6.762**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability.

T_0: No chemical fertilizer, no organic manure (Control); **T_1:** 100% recommended N (100 kg Nha^{-1}) + recommended PKSZn**T_2:** 75 kg N from urea + 25kg N supplemented by sludge + recommended PKSZn**T_3:** 50 kg N from urea + 50 kg N supplemented by sludge + recommended PKSZn**T_4:** 25 kg N from urea + 75kg N supplemented by sludge + recommended PKSZn**T_5:** Whole N supplemented by sludge**T_6:** Foliar spray of chitosan + recommended NPKSZn**T_7:** : Foliar spray of double chitosan + recommended NPKSZn**T_8**: Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn

4.1.2 Length of flag leaf

Length of flag leaf was significantly influenced by different treatment (Fig 3). The maximum length of flag leaf was found in T8 (48.03 cm), which were statistically similar with T7(46.53 cm), To (46.69 cm), T1 (46.09 cm), T3 (45.97 cm) and T6 (45.23 cm).The lowest flag was observed in T2 (41.10 cm).

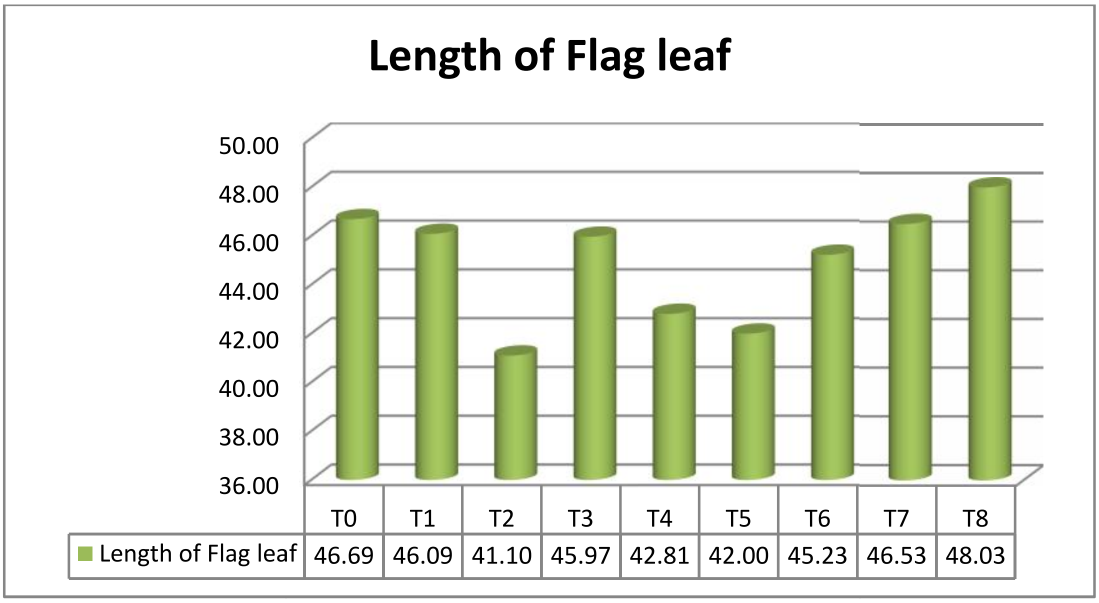


Fig 3 . Effect of treated sludge & chitosan on length of flag leaf over control of NERICA 10 (LSD value =3.86 and CV=4.97)

T_0: No chemical fertilizer, no organic manure (Control); **T_1:** 100% recommended N (100 kg Nha^{-1}) + recommended PKSZn**T_2:** 75 kg N from urea + 25kg N supplemented by sludge + recommended PKSZn**T_3:** 50 kg N from urea + 50 kg N supplemented by sludge + recommended PKSZn**T_4:** 25 kg N from urea + 75kg N supplemented by sludge + recommended PKSZn**T_5:** Whole N supplemented by sludge **T_6:** Foliar spray of chitosan + recommended NPKSZn**T_7:** : Foliar spray of double chitosan + recommended NPKSZn**T_8**: Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn

4.1.3 Length of panicle

Panicle length was significantly influenced among the treatments shown in (Fig 4). The tallest panicle length (31.27 cm) was found in T_8treatment which was statistically identical with almost all other treatments except T_0, T_1, $T_{2,}$ $T_{3,}$ and T_4 treatments. The longest panicle was recorded in T_8 (31.27 cm) whereas in T_7(30.74 cm) T_6 (30.74 cm)$_,$and T_5 (29.05 cm). The shortest panicle (22.28cm) was observed in T_0 (control). The treatments may be ranked in the order of T_8> T_7> T_6>T_5> T_1> T_2> T_3>T_4>T_0in terms of panicle length.Panicle numbers of rice were increased after spraying chitosan at the concentration of 0.4 g/50 cc of water (Li*et al.* 2011).Kobayashi*et al.* (1989) reported that increasing K rates increased panicle length.

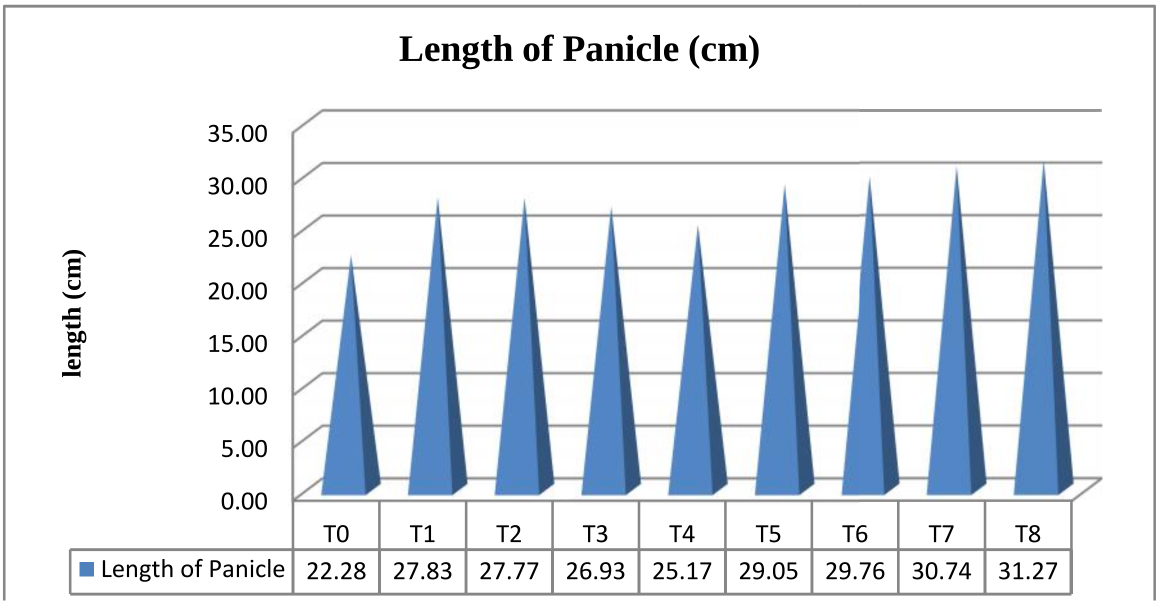


Fig 4 . Effect of treated sludge & chitosan on length of flag leaf over control of NERICA 10(LSD value = 2.825 and CV=5.86)

T_0: No chemical fertilizer, no organic manure (Control); **T_1:** 100% recommended N (100 kg Nha^{-1}) + recommended PKSZn**T_2:** 75 kg N from urea + 25kg N supplemented by sludge + recommended PKSZn**T_3:** 50 kg N from urea + 50 kg N supplemented by sludge + recommended PKSZn**T_4:** 25 kg N from urea + 75kg N supplemented by sludge + recommended PKSZn**T_5:** Whole N supplemented by sludge **T_6:** Foliar spray of chitosan + recommended NPKSZn**T_7:** : Foliar spray of double chitosan + recommended NPKSZn**T_8**: Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn

4.1.4 Effective tillers hill^{-1}

There was a significant effect of the treatments on number of effective tiller per hill (Fig 5). All the treatments significantly produced higher number of effective tiller per hill over control (T_0 treatment). The effective tiller per hill ranged from 7.583 to 12.87. The highest number of effective tiller hill^{-1} (12.87) was found in T_8receiving Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn and the lowest (7.853) was found in control (T_0)receiving No chemical fertilizer, No organic manure. The treatments may be ranked in the order of T_8> T_5> T_7>T_6>> T_1> T_3>T_2>T_4> T_0 in terms of effective tiller hill^{-1}.

These results were corroborated with the findings of Uddin *et al.* (2009) who found increased number of effective tiller hill^{-1} with the integrated use of manures and fertilizers

Boonlertnirun*et al.* (2012) showed different application methods significantly affected tiller number per plant, the maximum tiller numbers were obtained from application of chitosan in combination with mixed chemical fertilizer but did not differ from that of mixed chemical fertilizer application while their different treatment combination were Trl : chitosan at the concentration of 80 mg L' in combination with mixed chemical fertilizer between urea (46-0-0) and 16-20-0 at the rate of 312.5 kg ha", Tr2: mixed chemical fertilizer between urea (46-0-0) and 16-20-0 at the rate of 312.5 kg Tr3: chitosan spraying at the concentration of 80 mg L' and Tr4: no application of chitosan and mixed chemical fertilizer.

4.1.5Non-effective tillers hill^{-1}

Non-effective tillers hill^{-1}was significantly influenced by different combination of treatment (Fig 5). The highest number of non-effective tillers hill^{-1}was found from T_7 (3.28) which were statistically similar with T_8(3.27), T_6 (3.24). On the other hand lowest non-effective tillers hill^{-1}was recorded from control T_0 (2.05) which was statistically similar with T_2 (2.51), and T_4 (2.55).Ineffective tillers hill^{-1}the treatments may be ranked in the order of $T_7 > T_8 > T_6 > T_5 > T_1 > T_4 > T_2 > T_3 > T_0$ treatments where T8, T7, T6, T5,T1 arestatistically similar.

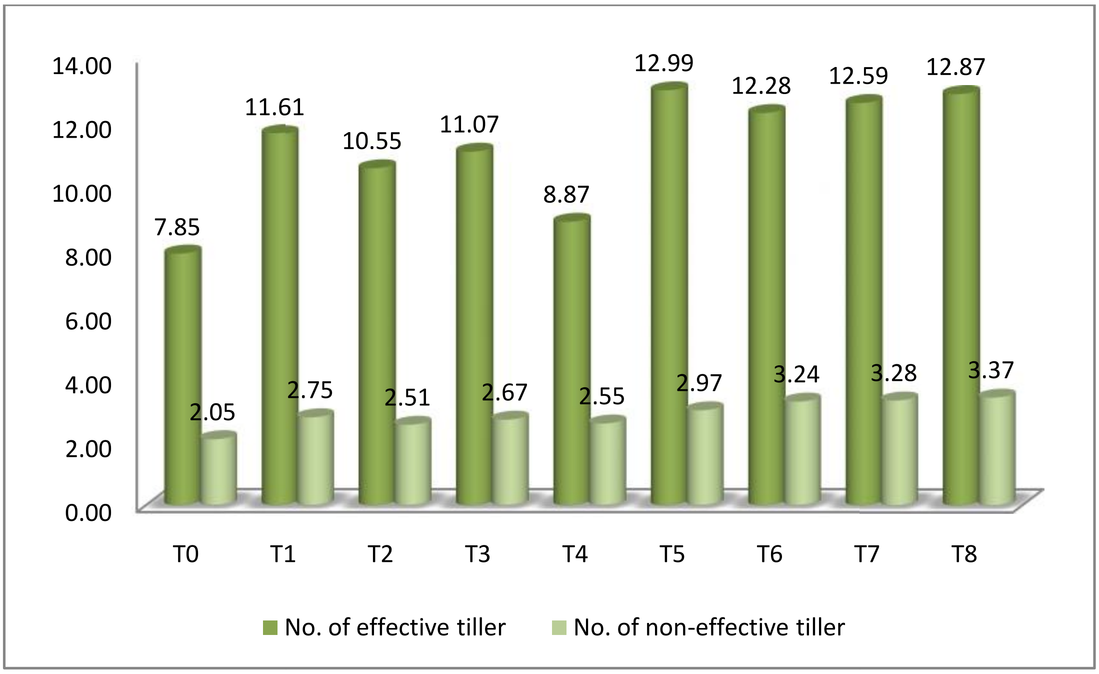


Fig 5 . Effect of treated sludge & chitosan on effective and non-effective tiller hill^{-1}over control of NERICA 10 (LSD value = 1.712 and CV=8.84 for effective tiller hill^{-1} andLSD value = 0.5307 and CV=10.89 for non-effective tiller hill^{-1})

T_0: No chemical fertilizer, no organic manure (Control); **T_1:** 100% recommended N (100 kg Nha^{-1}) + recommended PKSZn**T_2:** 75 kg N from urea + 25kg N supplemented by sludge + recommended PKSZn**T_3:** 50 kg N from urea + 50 kg N supplemented by sludge + recommended PKSZn**T_4:** 25 kg N from urea + 75kg N supplemented by sludge + recommended PKSZn**T_5:** Whole N supplemented by sludge **T_6:** Foliar spray of chitosan + recommended NPKSZn**T_7:** : Foliar spray of double chitosan + recommended NPKSZn**T_8**: Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn

4.1.6 Total number of tiller

Total number tiller was significantly influenced among the treatments shown in (Table 5). The highest number of total tiller (17.85) was found in T_8 treatment receiving Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZnwhich was statistically identical with T_7 (17.62) receiving Foliar spray of double chitosan + recommended NPKSZn and T_6 (16.47) receiving . The lowest number of total tiller was recorded in control, T_0(10.38) which was statistically similar with T_3 (12.65) receiving 50 kg N from urea + 50 kg N supplemented by sludge + recommended PKSZn. The treatments may be ranked in the order of T_8> T_7> T_6> T_1>T5>T_2> T_4>T_3>T_0 in terms of total number of tiller.Bhuvaneswari*et al.*(2008)showed varying chitosan application methods did not affect tiller numbers per plant. The maximum tiller numbers obtained from treatment of seed soaking in chitosan solution before planting and soil application, however did not significantly differ from the control. Their treatment combination were Tr1- no chitosan application (control) , Tr2- seed soaking with chitosan solution Tr3 - seed soaking and soil application with chitosan solution and Tr4 - seed soaking and foliar spraying with chitosan solution.

Table 5. Effect of treated sludge & chitosan on total number of tiller over control of NERICA 10

Treatment	Total Tiller
T_0	10.38d
T_1	14.53bc
T_2	14.00bc
T_3	12.6cd
T_4	14.07bc
T_5	14.18bc
T_6	16.47ab
T_7	17.62a
T_8	17.85a
C.V (%)	**11.42%**
LSD Value	**2.893**

(In a column figures having similar letter do not differ significantly whereas figures with dissimilar letter differ significantly as per LSD)

T_0: No chemical fertilizer, no organic manure (Control); **T_1:** 100% recommended N (supplemented by sludge + recommended PKSZn**T_3:** 50 kg N from urea + 50 kg N supplemented by sludge 100 kg Nha^{-1}) + recommended PKSZn**T_2:** 75 kg N from urea + 25kg N + recommended PKSZn**T_4:** 25 kg N from urea + 75kg N supplemented by sludge + recommended PKSZn**T_5:** Whole N supplemented by sludge **T_6:** Foliar spray of chitosan + recommended NPKSZn**T_7:** : Foliar spray of double chitosan + recommended NPKSZn**T_8:** Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn.

4.1.7 Filled grains panicle^{-1}

There was a significant effect of the treatments on number of filled grains per panicle (Figure 6). The number of filled grain panicle^{-1} ranged from 68.50 to 87.99. The maximum number of filled grains per panicle (87.99) was noted when Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) +

recommended PKSZn(T_8) was applied which were statistically identical almost all other treatments except T_0, T_1, T_3, T_4. The minimum number of filled grains per panicle (68.50) was recorded in control T_0 treatment receiving no chemical fertilizer and no organic manure. The treatments may be ranked in the order of T_8>T_6> T_7> T_2>T5>T_1> T_3>T_4>$T_0$with the respect of the number of filled grain panicle^{-1}. Wang *et al*. (2011)showed that the application of N, P and K fertilizer significantly increased the number of filled grain panicle^{-1}and the highest the number of filled grain panicle^{-1}

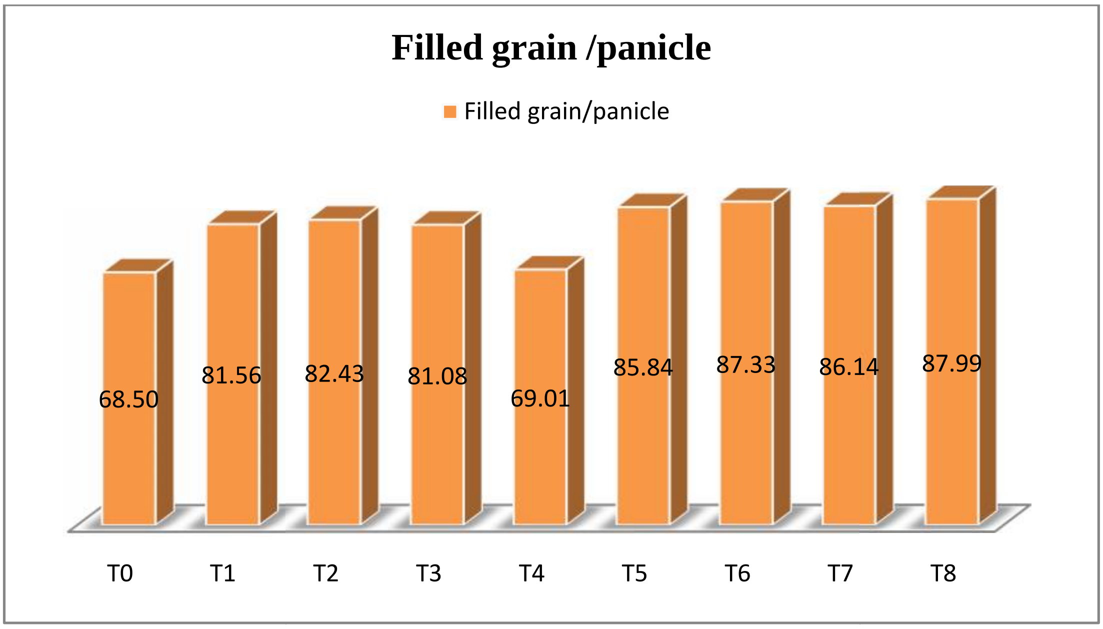


Fig 6 . Effect of treated sludge & chitosan on filled grain panicle^{-1}control of NERICA 10 **(**LSD value = 5.78 and CV=4.11)

T_0: No chemical fertilizer, no organic manure (Control); **T_1:** 100% recommended N (100 kg Nha^{-1}) + recommended PKSZn**T_2:** 75 kg N from urea + 25kg N supplemented by sludge + recommended PKSZn**T_3:** 50 kg N from urea + 50 kg N supplemented by sludge + recommended PKSZn**T_4:** 25 kg N from urea + 75kg N supplemented by sludge + recommended PKSZn**T_5:** Whole N supplemented by sludge **T_6:** Foliar spray of chitosan + recommended NPKSZn**T_7:** : Foliar spray of double chitosan + recommended NPKSZn**T_8**: Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn

4.1.8 Unfilled grains panicle^{-1}

The effects of different treatments on number of unfilled grains per panicle are shown in (Figure 7). The number of unfilled grain per panicleranged from 6.17 to 7.70. The highest number of unfilled grains per panicle (7.70) was noted in treatment T_0. The lowest number of unfilled grains per panicle (6.17) was recorded in control T_8 treatment. The treatments may be ranked in the order of $T_8>T_5>T_6>T_1> T_4> T_7> T_3>T_2>T_0$with respect of the number of unfilled grains per panicle.

These results were corroborated with the findings of Sarkar and Singh et *al.* (2002) who found increased the number of filled grains per panicleand decreased the number of unfilled grains per paniclesignificant increased with the application of N, P, K and S.

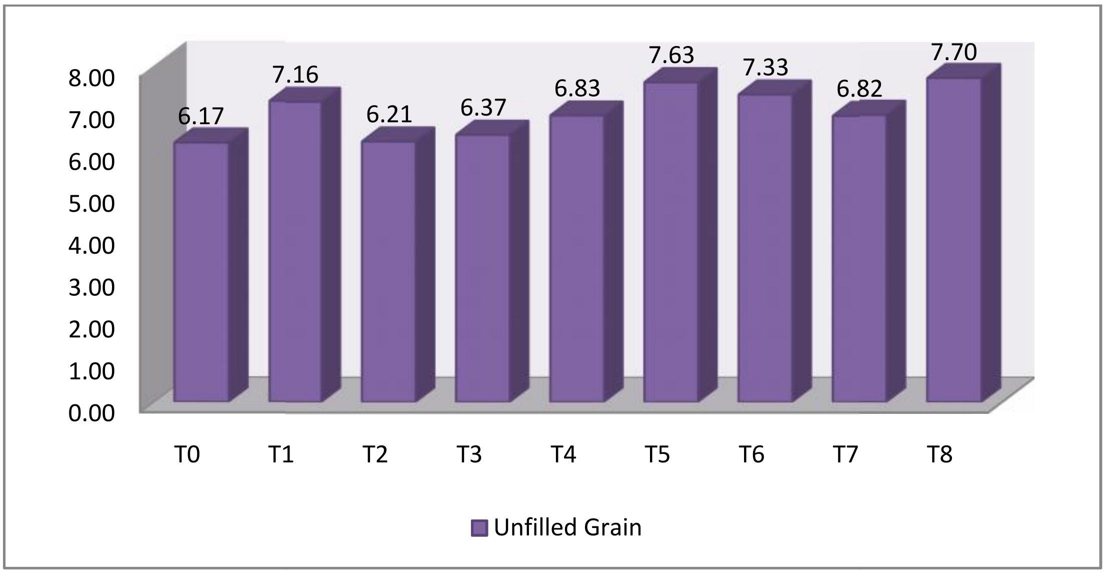


Fig 7 . Effect of treated sludge & chitosan on unfilled grains panicle^{-1} over control of NERICA 10 (LSD value = 0.85 and CV=7.11)

T_0: No chemical fertilizer, no organic manure (Control); **T_1:** 100% recommended N (100 kg Nha^{-1}) + recommended PKSZn**T_2:** 75 kg N from urea + 25kg N supplemented by sludge + recommended PKSZn**T_3:** 50 kg N from urea + 50 kg N supplemented by sludge + recommended PKSZn**T_4:** 25 kg N from urea + 75kg N supplemented by sludge + recommended PKSZn**T_5:** Whole N supplemented by sludge **T_6:** Foliar spray of chitosan + recommended NPKSZn**T_7:** : Foliar spray of double chitosan + recommended NPKSZn**T_8**: Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn

4.1.9Total number of grains panicle^{-1}

There was significant effect of the treatments on number of filled grains per panicle (Figure 8). The number of total grain panicle^{-1} ranged from to 97.90 to 74.37. The highest number of total grains per panicle (97.90) was noted when Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn (T_8) was applied which were statistically with T_7 (97.58) having Foliar spray of double chitosan + recommended NPKSZn, T_6 (92.60) having Foliar spray of chitosan + recommended NPKSZn and T_5 (93.42) receiving Whole N supplemented by sludge. The minimum number of total grains per panicle (74.37) was recorded in control T_0 treatment receiving no chemical fertilizer and no organic manure. The treatments may be ranked in the order of T_8> T_7> T_6> T_5> T3> T_1> T_2>T_4>T_0 with the respect of the number of total grain panicle^{-1}.

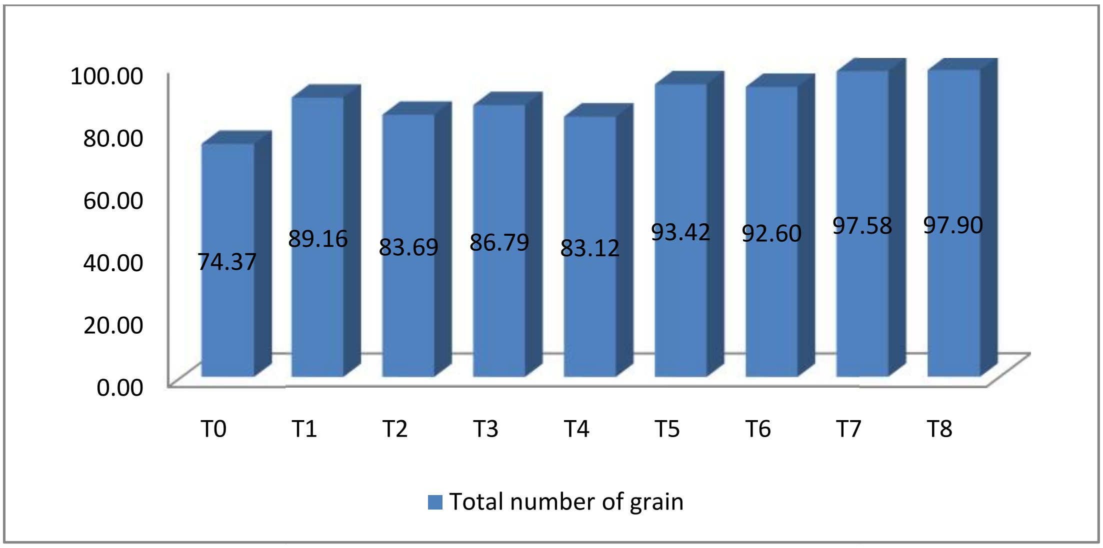


Fig 8 . Effect of treated sludge & chitosan on total grain panicle^{-1}over control of NERICA 10 (LSD value = 7.89 and CV=5.13)

T_0: No chemical fertilizer, no organic manure (Control); **T_1:** 100% recommended N (100 kg Nha^{-1}) + recommended PKSZn**T_2:** 75 kg N from urea + 25kg N supplemented by sludge + recommended PKSZn**T_3:** 50 kg N from urea + 50 kg N supplemented by sludge + recommended PKSZn**T_4:** 25 kg N from urea + 75kg N supplemented by sludge + recommended PKSZn**T_5:** Whole N supplemented by sludge**T_6:** Foliar spray of chitosan + recommended NPKSZn**T_7:** : Foliar spray of double chitosan + recommended NPKSZn**T_8**: Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn.

4.2.0 1000-grain weight

1000 seed weight significantly varied among the treatment (Figure 9). The maximum weight of 1000 seed weight was found in T_8 (31.71 g) which were statistically similar with all other treatments except T_0 (23.76 g) T_1 (27.16g), T_2 (27.86 g) and T_4 (26.22 g). T_7 (31.74 g) was the second highest treatment in terma of 1000 seed weight. The minimum weight of 1000 seed was observed in control T_0 (23.76 g).Boonlertnirun*et al.* (2008)concluded application of chitosan by varying application methods did not affect 1,000- grain weight. The maximum seed weight was gained from seed soaking in chitosan solution before

planting and then applying in soil whereas chitosan application by seed soaking in chitosan solution before planting and then foliar spraying showed the minimum seed weight. Nevertheless, no significant difference was found among treatments.

This was contrary to the observations ofKrivtsov*et al.* (1996) found that thousand grain weight of wheat plants was increased with application of polymeric chitosan at low concentration.

Debiprasad *et al*. (2010) found that application of 120 kg N ha^{-1} through chemical fertilizer with the combination of press mud and cowdung increased 1000-grain weight.

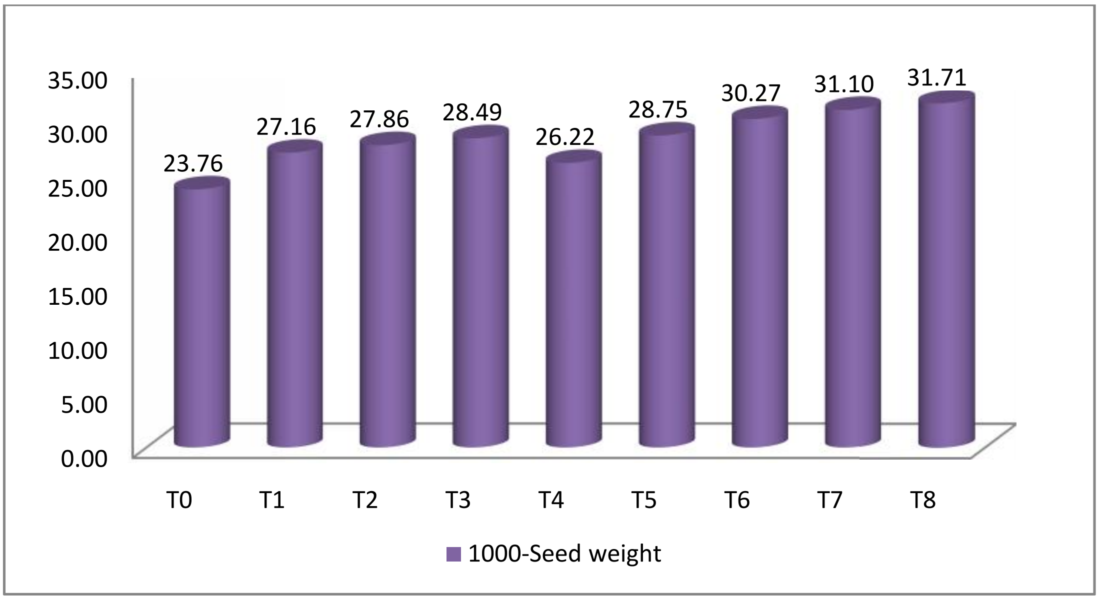


Fig 9 . Effect of treated sludge & chitosan on 1000 grain weight over control of NERICA 10 (LSD value = 3.47 and CV=7.06)

T_0: No chemical fertilizer, no organic manure (Control); **T_1:** 100% recommended N (100 kg Nha^{-1}) + recommended PKSZn**T_2:** 75 kg N from urea + 25kg N supplemented by sludge + recommended PKSZn**T_3:** 50 kg N from urea + 50 kg N supplemented by sludge + recommended PKSZn**T_4:** 25 kg N from urea + 75kg N supplemented by sludge + recommended PKSZn**T_5:** Whole N supplemented by sludge**T_6:** Foliar spray of chitosan + recommended NPKSZn**T_7:** : Foliar spray of double chitosan + recommended NPKSZn**T_8**: Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn

4.2 Yield components

4.2.1 Grain yield (t/ha)

Grain yield showed significant variation among the varieties (Figure 10). The treatment T_8 (2.20 t/ha)was founded to lowest treatments in terms of grain yield receiving foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn. T_8 were statistically identical with all other treatments except T_6 (1.02 t/ha) and control,T_0 (0.90 t/ha). Control T_0 was the lowest grain yield producing treatment.The treatments may be ranked in the order of T_8>T_6>T_7>T_1>T_2> T_4> T_3> T_5>$T_0$with respect of the grain yield.

Abedin*et al.* (1999) reported that application of chitosan at 2 mg L' improved yield components (number and weight) of rice plants. Chitosan application had a tendency to increase grain yield of rice plants over than untreated seed.

Lower grain yield was obtained from no application of mixed chemical fertilizer and chitosan and chitosan application alone was not significantly different from them Boonlertnirun *et al.*(2010).Yadav*et al.* (1998) reported that grain yield was significantly increased due to application of chemical fertilizers and residual effects of organic manures.

4.2.2 Straw yield (t/ha)

Effect of treated sludge & chitosan on straw yield of Nerica Rice 10 was significant among the different treatments (Figure 10). The maximum straw yield was found in T_8 (5.56 t/ha) which were statistically similar with T_7 (5.43 t/ha) and T_6 (5.34 t/ha). The minimum straw yield was recorded in control, T_0 (3.34 t/ha). The treatments may be ranked in the order of T_8>T_7>T_6>T_1>T_2> T_3> T_5> T_4>$T_0$with respect of the straw yield.

Saha*et al.* (2007) reported that the straw yield was significantly increased due to application of chemical fertilizers and residual effects of organic manures.

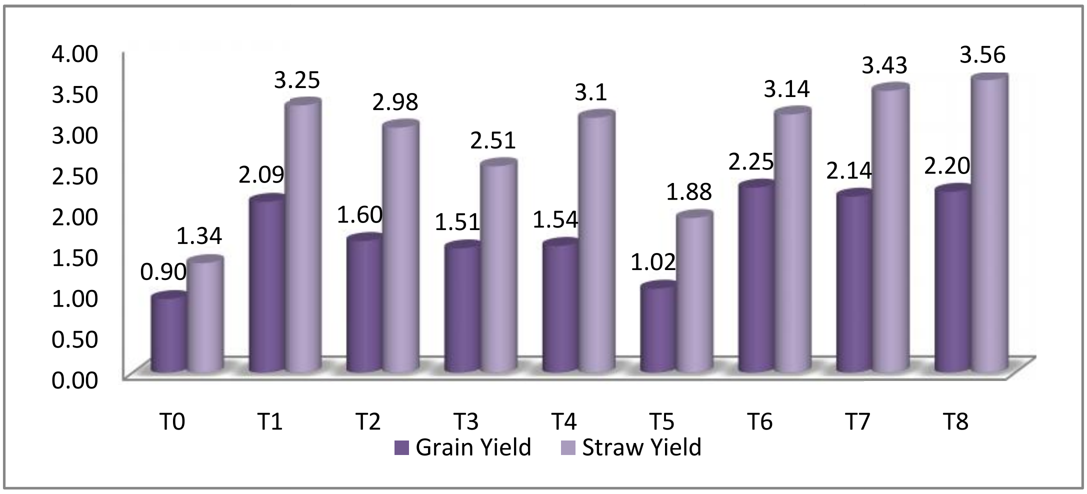


Fig 10. Effect of treated sludge & chitosan on grain yield and straw yield over control of NERICA 10 (LSD value = 0.94 and CV=6.86 for grain yield LSD=0.58 and CV=7.13 for straw yield)

T_0: No chemical fertilizer, no organic manure (Control); **T_1:** 100% recommended N (100 kg Nha^{-1}) + recommended PKSZn**T_2:** 75 kg N from urea + 25kg N supplemented by sludge + recommended PKSZn**T_3:** 50 kg N from urea + 50 kg N supplemented by sludge + recommended PKSZn**T_4:** 25 kg N from urea + 75kg N supplemented by sludge + recommended PKSZn**T_5:** Whole N supplemented by sludge **T_6:** Foliar spray of chitosan + recommended NPKSZn**T_7:** : Foliar spray of double chitosan + recommended NPKSZn**T_8**: Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn.

4.2.3 Biological yield (t/ha)

Biological yieldwas significantly influenced by different combination of treatment (Figure 11). The highest biological was found from T_7 (9.95 t/ha) which were statistically similar with T_5(9.78 t/ha), T_6(9.66 t/ha) and T_8 (9.37 t/ha). On the other handthe lowest biological yieldwas recorded from control T_0 (5.29 t/ha). Biological yieldmay be ranked among the treatments in the order of $T_7 > T_5 > T_6 > T_8 > T_1 > T_2 > T_3 > T_4 > T_0$ treatments where T_2 (8.25 t/ha), T_3 (8.05 t/ha)and T_4 (7.58 t/ha) werestatistically similar.

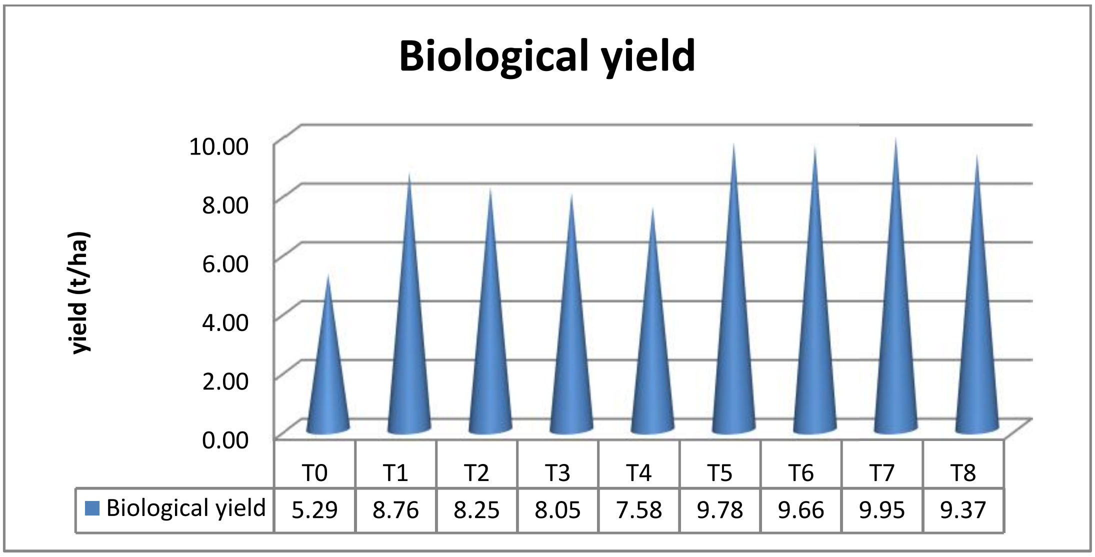


Fig 11 . Effect of treated sludge & chitosan on biological yield over control of NERICA 10 (LSD value = 1.05 and CV=7.18)

T_0: No chemical fertilizer, no organic manure (Control); **T_1:** 100% recommended N (100 kg Nha^{-1}) + recommended PKSZn**T_2:** 75 kg N from urea + 25kg N supplemented by sludge + recommended PKSZn**T_3:** 50 kg N from urea + 50 kg N supplemented by sludge + recommended PKSZn**T_4:** 25 kg N from urea + 75kg N supplemented by sludge + recommended PKSZn**T_5:** Whole N supplemented by sludge**T_6:** Foliar spray of chitosan + recommended NPKSZn**T_7:** : Foliar spray of double chitosan + recommended NPKSZn**T_8**: Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn

4.2.4 Harvest index

Harvest index were statistically identical among the treatments (Table 6). The highest harvest index was observed in T_8 (47.07) which were statistically similar with all other treatments except control T_0 (36.89).

Table 6. Effect of treated sludge & chitosan on harvest index over control of NERICA 10

Treatment	Harvest Index
T_0	36.89 b
T_1	44.72 a
T_2	44.64 a
T_3	44.92 a
T_4	43.73 a
T_5	43.99 a
T_6	44.88 a
T_7	45.29 a
T_8	47.07 a
C.V (%)	**5.52%**
LSD Value	**4.20**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability.

T_0: No chemical fertilizer, no organic manure (Control); **T_1:** 100% recommended N (100 kg Nha^{-1}) + recommended PKSZn**T_2:** 75 kg N from urea + 25kg N supplemented by sludge + recommended PKSZn**T_3:** 50 kg N from urea + 50 kg N supplemented by sludge + recommended PKSZn**T_4:** 25 kg N from urea + 75kg N supplemented by sludge + recommended PKSZn**T_5:** Whole N supplemented by sludge**T_6:** Foliar spray of chitosan + recommended NPKSZn**T_7:** : Foliar spray of double chitosan + recommended NPKSZn**T_8**: Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn

4.3 Nutrient content in post harvest soil

4.3.1 pH, organic matter and NPKS status of post harvest soil

The result of nutrient content of soil is listed below. This result can be conducted by different test of post harvest soil in Bangladesh Sugarcane Research institute (BSRI) lab**.**

Table 7 :pH, organic matter and NPKS status of post harvest soil

Treatments	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (meq/100g soil)
T0	5.9f	1.08 e	0.062e	14.09e	0.08def
T1	6.0cde	1.14bcd	0.061e	14.18de	0.14b
T2	6.2ab	1.17bcd	0.066d	14.37cd	0.10de
T3	6.28ab	1.19cde	0.064d	14.22d	0.11d
T4	6.32abc	1.24de	0.069c	14.55c	0.13b
T5	6.36cde	1.27abcd	0.063e	14.68c	0.17abc
T6	6.41def	1.31abc	0.072b	15.33b	0.13b
T7	6.44abc	1.38ab	0.071b	15.17bc	0.16a
T8	6.52a	1.42a	0.075a	15.53a	0.18a
LSD.05	0.1087	0.156	0.16	1.112	0.16
CV (%)	3.03	6.03	14.25	3.76	5.75

4.3.2 Effect of different levels of sludge & chitosan on pH of post harvest soil

pH of post harvest soil showed significant variation due to the application of different levels of treated sludge & chitosan(Figure 12 and table 7). The highest pH of post harvest soil was recorded from T_8(6.52)treatment because of sludge effect which were statistically similar to all other treatments except T_0(5.9), T_1(6.02), T_5(6.36) and T_6(6.41). On the other hand, the lowest pH of post harvest soilwas recorded from control T_0 (5.9) treatment.

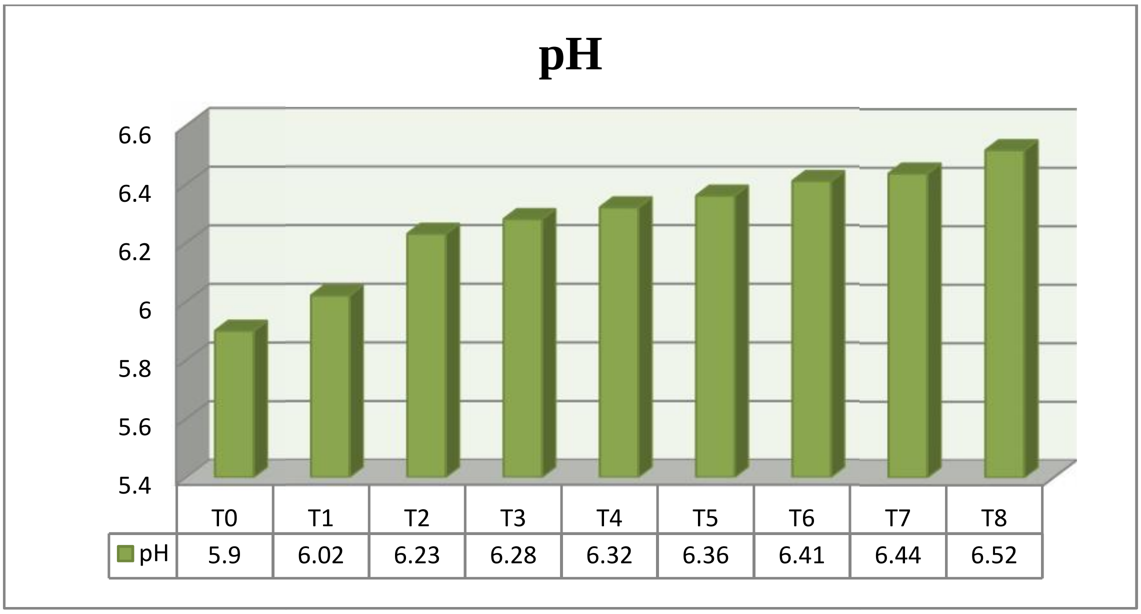


Fig 12. Effect of different levels of Sludge & Chitosan on pH concentration percentage of post harvest soil(LSD value = 0.1087and CV= 3.03)

T_0: No chemical fertilizer, no organic manure (Control); **T_1:** 100% recommended N (100 kg Nha^{-1}) + recommended PKSZn**T_2:** 75 kg N from urea + 25kg N supplemented by sludge + recommended PKSZn**T_3:** 50 kg N from urea + 50 kg N supplemented by sludge + recommended PKSZn**T_4:** 25 kg N from urea + 75kg N supplemented by sludge + recommended PKSZn**T_5:** Whole N supplemented by sludge **T_6:** Foliar spray of chitosan + recommended NPKSZn**T_7:** : Foliar spray of double chitosan + recommended NPKSZn**T_8:** Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn

4.3.3 Effect of different levels of sludge & chitosan on organic matter percentage in post harvest soil

Organic matterof post harvest soil showed significant variation among the treatments (Figure 13 and table 7). The highest organic matter of post harvest soil was recorded from T_8 (1.28%) treatment. On the other hand, the lowest organic matter of post harvest soil was recorded from T_1(1.03%) treatment .

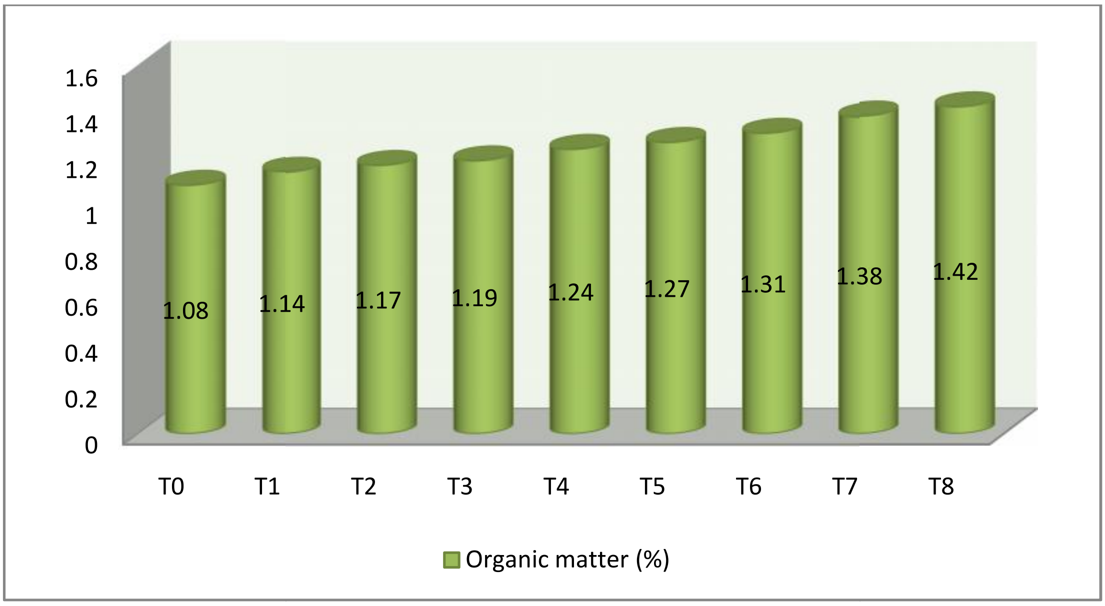


Fig 13. Effect of different levels of sludge & chitosan on Organic matter (%) concentration percentage of post harvest soil(LSD value = 0.1087and CV= 3.03)

T_0: No chemical fertilizer, no organic manure (Control); **T_1:** 100% recommended N (100 kg Nha^{-1}) + recommended PKSZn**T_2:** 75 kg N from urea + 25kg N supplemented by sludge + recommended PKSZn**T_3:** 50 kg N from urea + 50 kg N supplemented by sludge + recommended PKSZn**T_4:** 25 kg N from urea + 75kg N supplemented by sludge + recommended PKSZn**T_5:** Whole N supplemented by sludge **T_6:** Foliar spray of chitosan + recommended NPKSZn**T_7:** : Foliar spray of double chitosan + recommended NPKSZn**T_8**: Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn

4.3.4 Effect of different levels of sludge & chitosan on the N content in post harvest soil

Nitrogen content of post harvest soil showed significant variation due todifferent level of treated Sludge & Chitosan in post harvest soil (Figure 14 and table 7). The maximum nitrogen content of post harvest soil was found in T_8 (0.075%). On the other hand, the lowest organic matter of post harvest soil was observed in T_1treatment (0.061%) which were statistically identical to control T_0(0.062%) and T_5(0.063%).

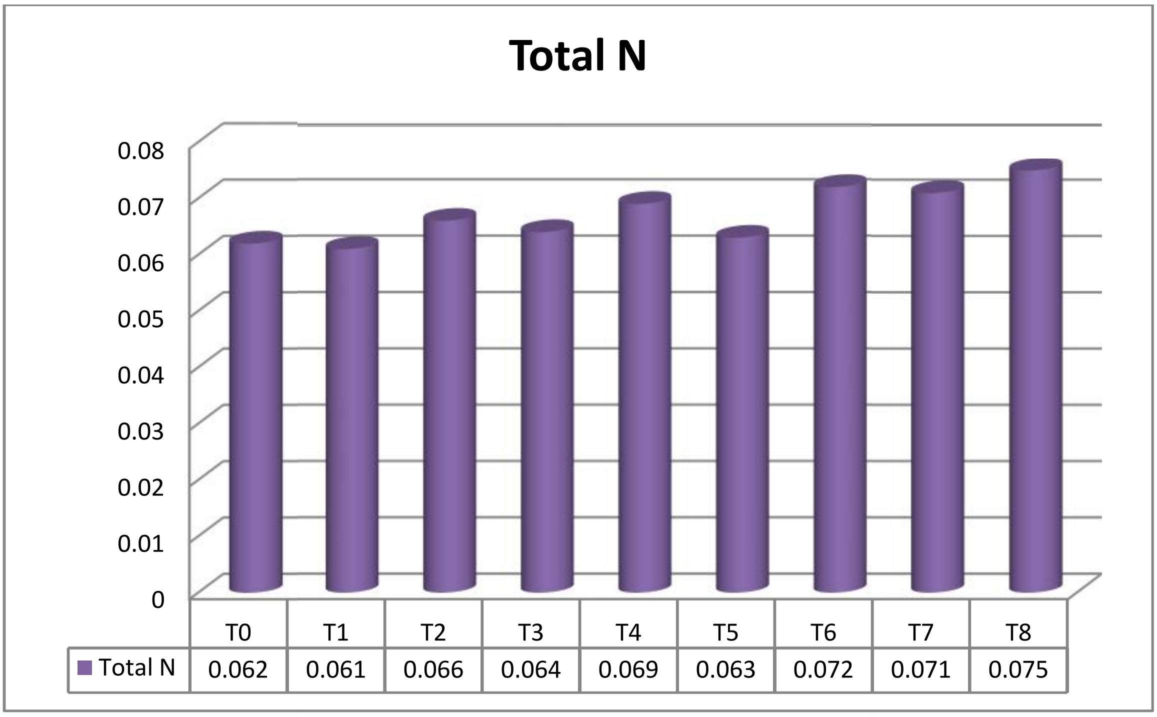


Fig 14. Effect of different levels of sludge & chitosan on N concentration percentage of post harvest soil(LSD value = 0.0127and CV= 1.92 for organic matter concentration; LSD value = 0.0013 and CV= 9.25 for N concentration)

T_0: No chemical fertilizer, no organic manure (Control); **T_1:** 100% recommended N (100 kg Nha^{-1}) + recommended PKSZn**T_2:** 75 kg N from urea + 25kg N supplemented by sludge + recommended PKSZn**T_3:** 50 kg N from urea + 50 kg N supplemented by sludge + recommended PKSZn**T_4:** 25 kg N from urea + 75kg N supplemented by sludge + recommended PKSZn**T_5:** Whole N supplemented by sludge **T_6:** Foliar spray of chitosan + recommended NPKSZn**T_7:** : Foliar spray of double chitosan + recommended NPKSZn**T_8**: Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn

4.3.5Effect of different levels of sludge & chitosan on the P content in post harvest soil

Phosphorus content of post harvest soil does not differ significantly among the treatments (Figure 15 and table 7). The highest phosphorus content of post harvest soil was recorded from T_6 (15.33 ppm).On the other hand, the lowest phosphorus content of post harvest soil was observed in T_0(14.09 ppm) treatment.

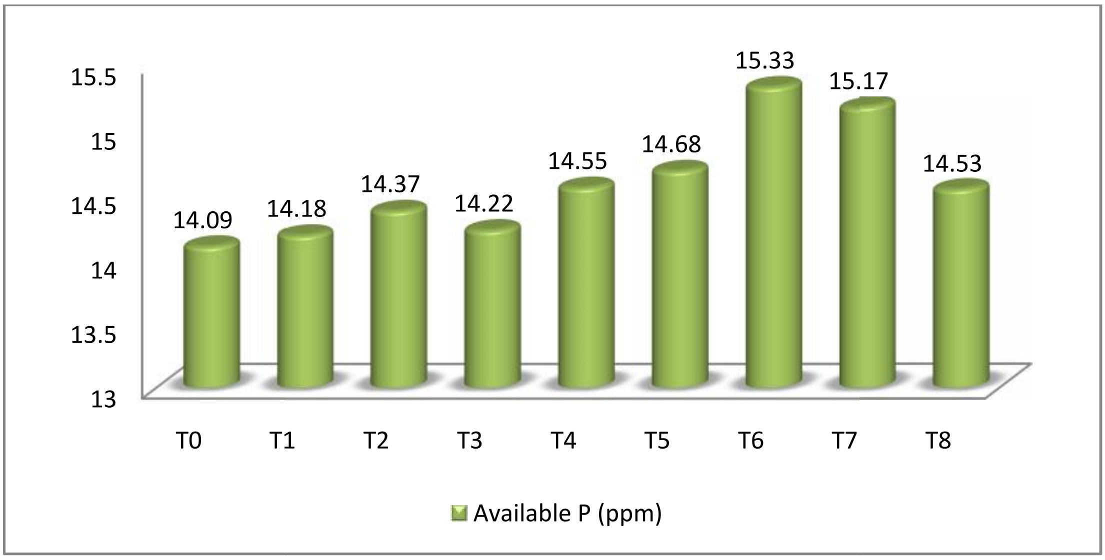


Fig 15. Effect of different levels of sludge & chitosan on P concentration percentage of post harvest soil (LSD value = NS and CV= 11.16)

T_0: No chemical fertilizer, no organic manure (Control); **T_1:** 100% recommended N (100 kg Nha^{-1}) + recommended PKSZn**T_2:** 75 kg N from urea + 25kg N supplemented by sludge + recommended PKSZn**T_3:** 50 kg N from urea + 50 kg N supplemented by sludge + recommended PKSZn**T_4:** 25 kg N from urea + 75kg N supplemented by sludge + recommended PKSZn**T_5:** Whole N supplemented by sludge **T_6:** Foliar spray of chitosan + recommended NPKSZn**T_7:** : Foliar spray of double chitosan + recommended NPKSZn**T_8**: Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn

4.3.6 Effect of different levels of sludge & chitosan on the K content in post harvest soil

Potassium content of post harvest soil showed insignificant variation among the treatments (Figure 16 and table 7). The highest potassium content of post harvest soil was observed in T_8(0.18meq/100 g soil).On the other hand, the lowest potassium content of post harvest soil was found in T_0(0.08meq/100 g soil) treatment.

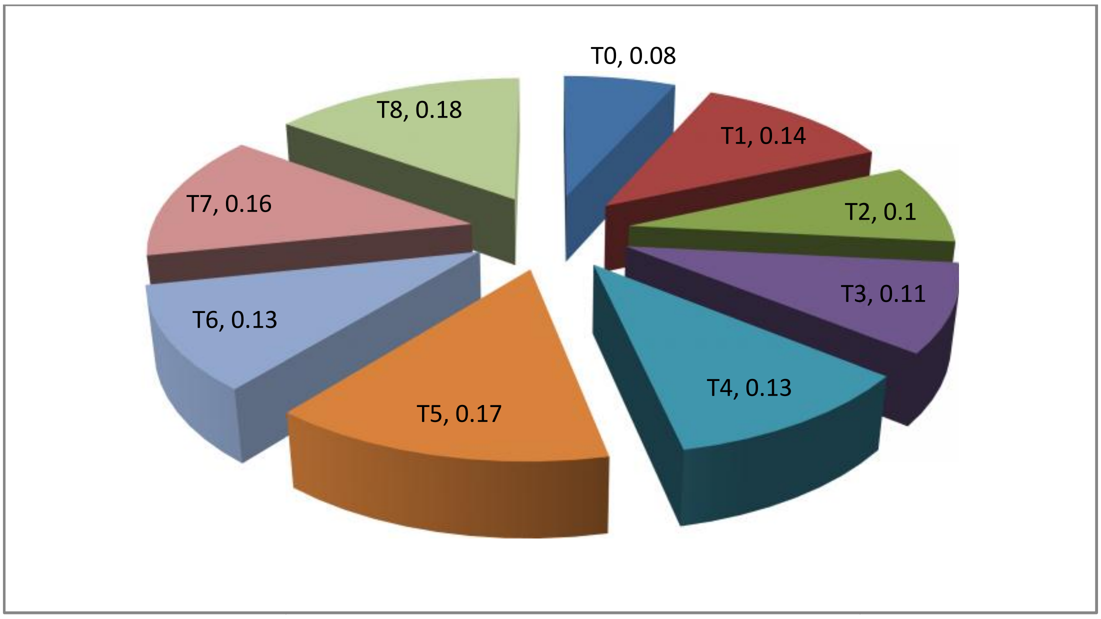


Fig 16. Effect of different levels of sludge & chitosan on K concentration percentage of post harvest soil(LSD value = NS and CV= 13.75)

T_0: No chemical fertilizer, no organic manure (Control); **T_1:** 100% recommended N (100 kg Nha^{-1}) + recommended PKSZn**T_2:** 75 kg N from urea + 25kg N supplemented by sludge + recommended PKSZn**T_3:** 50 kg N from urea + 50 kg N supplemented by sludge + recommended PKSZn**T_4:** 25 kg N from urea + 75kg N supplemented by sludge + recommended PKSZn**T_5:** Whole N supplemented by sludge **T_6:** Foliar spray of chitosan + recommended NPKSZn**T_7:** : Foliar spray of double chitosan + recommended NPKSZn**T_8:** Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn

4.3.7 Effect of different levels of sludge & chitosan on the S content in post harvest soil

Sulphur content of post harvest soil showed significant variation among the treatments (Table 8). The highest sulphur content of post harvest soil was recorded from T_8 (13.05 ppm). On the other hand, the lowest sulphur content of post harvest soil was recorded from control T_0 (10.58 ppm). The statistically similar S concentration are found in T3 (12.04 ppm), T4 (12.17ppm), T5 (12.49ppm) and T6 (12.23ppm)treatments.

Table 8. Effect of different levels of sludge & chitosan on S concentration percentage of post harvest soil

Treatments	Available S (ppm)
T_0	10.58e
T_1	11.18de
T_2	11.64bcd
T_3	12.04abcd
T_4	12.17abc
T_5	12.49abc
T_6	12.23abcd
T_7	11.44cde
T_8	13.05a
$LSD_{.05}$	**0.2922**
CV (%)	**12.63**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability.

T_0: No chemical fertilizer, no organic manure (Control); **T_1:** 100% recommended N (100 kg Nha^{-1}) + recommended PKSZn**T_2:** 75 kg N from urea + 25kg N supplemented by sludge + recommended PKSZn**T_3:** 50 kg N from urea + 50 kg N supplemented by sludge + recommended PKSZn**T_4:** 25 kg N from urea + 75kg N supplemented by sludge + recommended PKSZn**T_5:** Whole N supplemented by sludge **T_6:** Foliar spray of chitosan + recommended NPKSZn**T_7:** : Foliar spray of double chitosan + recommended NPKSZn**T_8**: Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn

CHAPTER V

SUMMARY AND CONCLUSION

The field experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka, during the period from March 15, 2014 to June 30, 2014 to study on the effect of treated sludge & chitosan on growth and yield of Nerica Rice 10 in Aus season under the Modhupur Tract (AEZ-28).

The experiment was comprised of nine sets of treatments T_0: No chemical fertilizer, no organic manure (Control); T_1: 100% recommended N (100 kg Nha^{-1}) + recommended PKSZn T_2: 75 kg N from urea + 25kg N supplemented by sludge + recommended PKSZn T_3: 50 kg N from urea + 50 kg N supplemented by sludge + recommended PKSZn T_4: 25 kg N from urea + 75kg N supplemented by sludge + recommended PKSZn T_5: Whole N supplemented by sludge T_6: Foliar spray of chitosan (twice in a week upto flowering) + recommended NPKSZn T_7: : Foliar spray of double chitosan + recommended NPKSZn T_8: Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn**,** viz. The experiment was laid out in RCBD design with three replications.

The data on crop growth and yield characters (plant height, length of flag leaf, number of effective tiller $hill^{-1}$, number of ineffective tiller $hill^{-1}$, total number of tiller, panicle length, number of filled and unfilled grains $panicle^{-1}$, number of total grain $panicle^{-1}$, 1000 grains weight, grain and straw yield, biological yield and harvest index) were recorded in the field and analyzed using the MSTAT-C. The mean differences among the treatments were compared by least significant difference test at 5% level of significance.

It revealed that T_8 (Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn) showed taller plant height at 30, 60 DAT and at harvest. At 80 DAT T_7 (Foliar spray of double chitosan + recommended NPKSZn) showed highest plant height. Control T_0 showed the lowest plant height throughout the growing period at 30, 60, 80 DAT and at harvest. T_8

(Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn) revealed the longest flag leaf (48.03 cm) whereas T_2 (75 kg N from urea + 25kg N supplemented by sludge + recommended PKSZn) showed the smallest flag leaf (41.10 cm).

The maximum number of effective tiller $panicle^{-1}$ (12.87), total number of tiller $panicle^{-1}$ (7.85), filled grain $panicle^{-1}$ (87.99), unfilled grain $panicle^{-1}$ (7.70), total grain $panicle^{-1}$ (97.90), 1000 grain weight (31.71 g), straw yield (5.56 t/ha) and harvest index (47.07) were showed by T_8 (Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn). On the other hand the lowest number of effective tiller $panicle^{-1}$ (7.85), ineffective tiller $panicle^{-1}$ (2.05), total number of tiller $panicle^{-1}$ (10.38), filled grain $panicle^{-1}$ (68.50), unfilled grain $panicle^{-1}$ (6.17), total grain $panicle^{-1}$ (74.37), 1000 seed weight (23.76 g), grain yield (0.90 t/ha), straw yield (3.34 t/ha), biological yield (5.29 t/ha and harvest index (36.89) were showed by control T_0 (No chemical fertilizer, no organic manure). Treatment T_7 (Foliar spray of double chitosan + recommended NPKSZn) was revealed the highest ineffective tiller $panicle^{-1}$ (3.28), biological yield (9.95 t/ha).

Treatment T_8 (Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn) was showed the highest concentration of pH (6.52), organic matter (1.42%), total N (0.075%) and available S (13.05 ppm), available P (14.53 ppm) and exchangeable K (0.18 meq/100g soil) in post harvest soil. The lowest concentration of pH (5.9), organic matters (1.08%), available P (14.09 ppm), available K (0.08 meq/100 soil) available S (10.58 ppm) in post harvest soil were showed by control T_0 (No chemical fertilizer, no organic manure). The minimum concentration of total N (0.061%) recorded from T_1 (100% recommended N (100 kg Nha^{-1}) + recommended PKSZn).

From the results of the study, it may be concluded that the performance of NERICA-10 was better in respect of growth, yield and yield contributing characters when supplied Treatment T_8 (Foliar spray of chitosan + ½ recommended N (50 kg Nha^{-1}) + recommended PKSZn)

CHAPTER VI

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APPENDICES

Appendix I. Analysis of variance of the data on yield contributing characters of NERICA 10

Sources of variation	df	Plant height (cm)	Panicle length (cm)	Effective tillers hill^{-1} (no.)	Filled Grain/ Panicle (no.)	Un-filled Grain/ Panicle (no.)	1000-seed weight (g)	Grain weight (t/ha)	Straw Weight (t/ha)
Replication	2	0.34	1.626	0.0124	15.364	0.0506	0.666	0.1663	0.5157
Factor A	8	9.798 **	9.0308 *	10.0824 *	48.764 **	4.21 *	8.4282 *	2.7002 *	12.6654 *
Error	16	15.264	2.664	0.978	6.564	0.241	0.0043	0.020	0.114

Appendix II. Analysis of variance of the data on N,P,K and S content(%) of NERICA 10

Sources of variation	df	Grain				Straw			
		N	P	K	S	N	P	K	S
Replication	2	0.002	0.003	0.001	0.019	0.002	0.002	0.001	0.001
Factor A	8	0.005 *	0.003 *	0.003 **	0.0015 *	0.008 *	0.001 NS	0.011 *	0.001 NS
Error	16	0.001	0.001	0.001	0.024	0.005	0.002	0.004	0.001

** = Significant at 1% level of probability, * = Significant at 5% level of probability, **NS** = Non Significant.

Appendix III. Analysis of variance of the data on N,P,K and S content of NERICA 10 in soil.

Sources of variation	df	Grain			
		N (%)	P (ppm)	K (meq./100g soil)	S (ppm)
Replication	2	0.001	1.230	0.001	0.002
Factor A	8	0.002 NS	6.181 **	0.001 **	54.055 **
Error	16	0.001	0.414	0.001	0.060

** = Significant at 1% level of probability, * = Significant at 5% level of probability, **NS** = Non Significant.