ADAPTABILITY OF NERICA-10 RICE IN AUS SEASON UNDER ORGANIC-INORGANIC FERTILIZER MANAGEMENT

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CERTIFICATE

This is to certify that the thesis entitled **'Adaptability of Nerica-10 Rice in Aus Season Under Organic-Inorganic Fertilizer Management'** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **Master of Science** in **Soil Science**, embodies the result of a piece of bonafide research work carried out by **Pijush Roy**, Registration number: **06-02105** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:

Dhaka, Bangladesh

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DEDICATED

TO

MY BELOVED PARENTS

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ABSTRACT

The experiment was conducted in the research Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from April to July 2013 to study the adaptability of NERICA-10 rice in Aus season under organic-inorganic fertilizer management. NERICA-10 was used as the test crop in this experiment. The experiment consisted of 10 treatments. The treatments were as follows: T_1: $N_{120}P_{25}K_{80}$, T_2: $N_{100}P_{20}K_{60}$, T_3: $N_{80}P_{16}K_{50}$, T_4: $N_{60}P_{14}K_{40}$, T_5: $N_{40}P_{12}K_{32}$, T_6: $N_{100}P_{20}K_{60}$ + 20 kg N supplement by cowdung, T_7: $N_{80}P_{16}K_{50}$ + 40 kg N supplement by cowdung, T_8: $N_{60}P_{14}K_{40}$ + 60 kg N supplement by cowdung and T_9: $N_{40}P_{12}K_{32}$ + 80 kg N supplement by cowdung. The experiment was laid out in a randomized complete block design (RCBD) with three replications. At the different days after transplanting (DAS) and at harvest the tallest plant (24.40, 48.94, 79.74, 83.62 and 98.11 cm) was recorded from T_7 while, at the same DAS the shortest plant (15.77, 35.34, 56.96, 66.56 and 77.21 cm) was observed from T_1. The maximum number of effective tillers hill^{-1} (13.73) was found from T_7 and the minimum number of effective tillers hill^{-1} (8.60) was obtained from T_0. The longest panicle (22.74 cm) was recorded from T_7, whereas the shortest panicle (15.33 cm) was observed from T_0. The maximum number of filled grains plant^{-1} (90.22) was observed from T_7 and the minimum number of filled grains plant^{-1} (69.87) was recorded from T_0. The highest grains yield (2.71 t ha^{-1}) was observed from T_7 and the lowest grain yield (1.28 t ha^{-1}) from T_0. The highest N, P, K, S and Zn concentration in grain (0.768%, 0.323%, 0.398%, 0.127% and 0.0166%) was observed from T_7, whereas the lowest N, P, K, S and Zn concentration in grain (0.385%, 0.176%, 0.219%, 0.069% and 0.0080%) was found from T_0. The highest N, P, K, S and Zn concentration in straw (0.518%, 0.088%, 1.208%, 0.094% and 0.0050%) was recorded from T_7, while the lowest N, P, K, S and Zn concentration in straw (0.267%, 0.033%, 0.566%, 0.046% and 0.0026%) was observed from T_0. The highest N, P, K, S and Zn uptake by grain (22.50 kg ha^{-1}, 9.46 kg ha^{-1}, 11.66 kg ha^{-1}, 3.72 kg ha^{-1} and 0.49 kg ha^{-1}) was observed from T_7, whereas the lowest N, P, K, S and Zn uptake by grain (4.93 kg ha^{-1}, 2.25 kg ha^{-1}, 2.80 kg ha^{-1}, 0.88 kg ha^{-1} and 0.10 kg ha^{-1}) was recorded from T_0. The highest N, P, K, S and Zn uptake by straw (18.34 kg ha^{-1}, 3.12 kg ha^{-1}, 42.76 kg ha^{-1}, 3.33 kg ha^{-1} and 0.18 kg ha^{-1}) was found from T_7, while the lowest N, P, K, S and Zn uptake by straw (85.79 kg ha^{-1}, 0.72 kg ha^{-1}, 12.28 kg ha^{-1}, 1.00 kg ha^{-1} and 0.06 kg ha^{-1}) was observed from T_0. The highest pH (7.22) was obtained from T_8 and the lowest pH (6.04) was found from T_0. The highest organic matter (1.55%) was recorded from T_8, whereas the lowest organic matter (1.21%) was observed from T_0. Applications of 60 kg cowdung, 60 kg N, 14 kg P_2O_5 and 40 kg K_2O ha^{-1}) was the superior among the other treatments in consideration of yield contributing characters and yield of NERICA 10 rice under the climatic condition of Bangladesh.

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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, 2009). The population of Bangladesh is increasing at an alarming rate and the cultivable land is reducing due to urbanization and industrialization resulting in more shortage of food. As it is not possible to have horizontal expansion of rice area, rice yield $unit^{-1}$ area should be increased to meet this ever-increasing demand of food in the country.

Rice has been grown in Ganges delta of Bangladesh for thousands of years and the country was once home to 4,000 varieties of the grain, but it is unable to produce enough for its own needs, even without one of its frequent natural disasters. In Bangladesh Aus is the fallow season and farmers cultivate vegetable crops. 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. If theses varieties are cultivated in Aus season, farmers will not cultivate Aman rice. So, rice cultivation in Aus season is low in Bangladesh and land remain fallow or under other crops. NERICA is a drought tolerant short duration crop. So it can be cultivated in rain fed Aus season and can save irrigation cost as well as time which is a good sign for ensuring food security of the nation. Bangladeshi officials say NERICA, the New Rice of 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.

NERICA, originally intended to raise rice output in African countries, can be harvested in 90 to 100 days, requires limited water, it was designed for Africa's dry lands. In Bangladesh ten millions of farmers require a large amount of water, particularly those in the drought-hit north, to invest in irrigation systems and leading to sharp falls in groundwater levels. Moreover, the high-yielding rice varieties currently used in Bangladesh take between 140 and 160 days to harvest. NERICA's shorter harvest period was what first prompted BADC to turn to the rice strain in hopes that it could solve a key dilemma in Bangladesh. During dry season especially in the high to medium high land of northern region of Bangladesh, irrigation water scarcity is becoming severe due to lowering of water table resulting from extensive water lifting through deep and shallow tubewells for Boro rice cultivation. Cultivation of dry HYV Aus rice under such a harsh environment may pave the new way of increasing rice production in Bangladesh. Drought resistant rice cv. NERICA 10 may be the answer to this problem if grown under proper management practices.

As NERICA 10 is a new crop, development of proper fertilizer management strategy is one of the most important practices for its successful adoption in Bangladesh. Among the production factors affecting crop yield, nutrient is the single most important factor that plays a dominant role in yield increase if other production factors are not limiting. It is reported that chemical fertilizers today hold the key to success of production systems of Bangladesh agriculture being responsible for about 50% of the total crop production (BARC, 1997). Nutrient imbalance can be minimized by judicious application of different fertilizers. There is need to develop appropriate management technique to evaluate the performance and to assess the nutrient requirement for rice cultivation in the country. Depleted soil fertility is a major constrain to higher crop production in Bangladesh. The increasing land use intensity has resulted in a great exhaustion of nutrient in soils. The farmers of this country use on an average 102 kg nutrients ha^{-1} annually (70 kg N + 24 kg P + 6 kg K + 2 kg S and Zn) while the crop removal is about 200 kg ha^{-1} (Islam *et al*., 1994).

A suitable combination of organic and inorganic sources of nutrients is necessary for sustainable agriculture that can ensure quality food production. Nambiar (1991) views that integrated use of organic manure and chemical fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining better soil fertility. The long-term research of BRRI revealed that the application of cowdung @ 5 t ha^{-1} $year^{-1}$ improved rice productivity as well as prevented the soil resources from degradation (Bhuiyan, 1994). Thus, it is necessary to use fertilizer and manure in an integrated way in order to obtain sustainable crop yield without affecting soil fertility. Mineralization and immobilization are biochemical in nature and are mediated through the activities of microorganisms. The rate and extent of mineralization determines crop availability of nutrients. The transformation of N, P and S in soil depends on the quality and quantity of organic matter as well as soil fertility. Organic fertilizer enhances soil porosity by increasing regular and irregular pores and causes a priming effect of native soil organic matter. Application of both chemical and organic fertilizers needs to be applied for the improvement of soil physical properties and supply of essential plant nutrients for higher yield.

Development of proper fertilizer management strategy is one of the most important management practices for NERICA 10 is a new crop for its successful adoption in Bangladesh. Under this circumstance the present research work has been taken with the following objectives:

- To observe the performance of NERICA-10 rice in Aus season of Bangladesh following organic and inorganic fertilizer management;
- To find the nutrient concentration and uptake by grain and straw of NERICA-10 rice due to application of organic and inorganic fertilizer; and
- To measure the nutrient status of post harvest soil due to application of organic and inorganic fertilizer in NERICA-10 rice.

CHAPTER II

REVIEW OF LITERATURE

Integrated use of organic manure and nitrogen fertilizer is the essential factor for sustainable soil fertility and crop productivity. Sole and combined use of cowdung and inorganic fertilizer increase plant growth, yield contributing characters and yield because is the store house of plant nutrients. Experimental evidences that the use of cowdung and nitrogen, phosphorus & potassium sulphur have an intimate effect on the yield and yield attributes of rice. NERICA is a drought tolerant short duration crop. In context of Bangladesh in Aus season this crop may be a potential variety of rice for increasing yield of rice. But, development of proper fertilizer management strategy is important agronomic practices for NERICA 10 is a new crop for its successful adoption in Bangladesh although there were no information in Bangladesh context. The available relevant reviews that are related to the effect of level of various organic manure and nitrogen fertilizer on the yield and yield attributes of other rice variety or genotypes are reviewed below-

2.1 Effect of cowdung

Rajput and Warsi (1991) conducted a field experiment and reported that rice yield was increased to 34.44 kg ha^{-1} with the application at FYM of 10 t ha^{-1}. Indulker and Malewar (1991) stated that application of 10 t ha^{-1} FYM alone produced grain yield of 2.19 t ha^{-1} and the untreated control gave 2.06 t ha^{-1}. Sharma and Mitra (1991) reported a significant increase in N, P and K uptake and also the nutritional status of soil with 5 t ha^{-1} of FYM of rice based cropping system.

Gurung and Sherchan (1993) reported that the application of cowdung with chemical fertilizers produced significantly higher grain yield than that of chemical fertilizers alone.

Kant and Kumar (1994) reported that the increasing rates of amendments with FYM increased the number of effective tillers $hill^{-1}$ significantly, number of grain $panicle^{-1}$, weight of 1000 grains also increased over the control. At the maximum level of FYM (30 t ha^{-1}) the increase of 48% tillers $hill^{-1}$, 14% number of grain per panicle and 4.5% weight of 1000 grains over the control were recorded. They also reported that higher rate of FYM (30 t ha^{-1}) resulted 22.00% increase in grain yield over the untreated plots.

Thakur and Patel (1998) conducted field experiments during *kharif* season to study the effect of split application of 60 or 80 kg N ha^{-1} on growth, yield and nitrogen uptake by rice with and without 5 t FYM ha^{-1} and proposed that both N rates increased yields attributes, yield, plant N content and N uptakes of rice compared with N or application of FYM alone. N rates and use of split doses had no effect. The highest grain yield (3.84 t ha^{-1}) was recorded with the application of 80 kg N ha^{-1} in three split doses with 5 t ha^{-1} FYM during both the years, 60 kg N in three split doses with 5 t ha^{-1} FYM gave seed grain 3.85 t ha^{-1}.

A field experiment was conducted by Gupta *et al.* (1999) on clay loam soil in 1993 in Jummu and Kasmir using rice cv. PC-19 as test crop with 0-100 kg P_2O_5 ha^{-1} and 0 or 10 t FYM. The crop also received a basal dressing of N, K and Zn. Grain yield was highest with 100 kg P_2O_5 + FYM (5.20 t ha^{-1}).

Mannan *et al.* (2000) reported that manuring with cowdung up to 10 t/ha in addition to recommended inorganic fertilizers with late N application improved grain and straw yields and quality of transplant aman rice over inorganic fertilizer alone.

Saitoh *et al.* (2001) conducted an experiment to evaluate the effect of organic fertilizers (cowdung and poultry 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 decreased in the number of panicle. Yearly application of manure increased the total carbon and nitrogen content in soil.

2.2 Effect of nitrogen fertilizer

Of the 16 essential nutrient elements nitrogen is the major and primary elements for the growth and development and better yield of crops. Plants response best to nitrogen compared to other nutrient elements. Urea has been found to be very effective nitrogenous fertilizers. Nitrogen is play pivotal role at yield and yield attributes of rice.

BRRI (1992) reported that both grain and straw yields of rice were increased significantly up to 80 kg N ha^{-1}. Application of nitrogen from 120 to 160 kg nitrogen ha^{-1} significantly reduced the yield which was assumed to be due to excessive vegetative growth follower by lodging after flowering.

Awasthi and Bhan (1993) reported that increasing levels of nitrogen up to 60 kg ha^{-1} influenced LAI and dry matter production of rice. Patel and Upadhaya (1993) found that plant height of rice increased significantly with increasing rate of N up to 150 kg ha^{-1}.

Kumar *et al.* (1995) observed a field experiment with four levels of nitrogen (0, 60, 120 and 180 kg N ha^{-1}) and reported that productive tillers increased significantly with the increase of N doses from 0-120 kg N ha^{-1}, but differences in productive tillers between 120 and 180 kg N ha^{-1} were not significant.

Effective tillers m^{-2} responded significantly to the application of N fertilizer (Behera, 1995). Effective tillers increased significantly with increase the level of N fertilizer up to 80 kg N ha^{-1}. Patel and Upadhyay (1993) conducted an experiment with 3 levels of N (90, 120 and 150 kg ha^{-1}) and reported that total and effective tillers m^{-2} increased significantly with increasing rates of N up to 120 kg ha^{-1}.

Palm *et al.* (1996) conducted a field trial at Waraseoni in rainy season and observed that yield of rice cv. R. 269 was the highest (4.47 t ha^{-1}) when 100 kg N ha^{-1} was applied 30% basally, 40% at tillering and 30% at panicle initiation stage.

Khanda and Dixit (1996) reported that the increased levels of applied nitrogen significantly influenced the grain yields. They found that maximum grain and straw yields of 4.58 and 6.21 t ha^{-1} were obtained from 90 kg N ha^{-1}, respectively. Adhikary and Rhaman (1996) reported that rice grain yield ha^{-1} in various treatments of N showed significant effect. The highest yield was obtained from 100 kg N ha^{-1} (4.52 t ha^{-1}) followed by 120 kg N ha^{-1} (4.46 t ha^{-1}) and 80 kg N ha^{-1} (4.40 t ha^{-1}).

Verma and Achraya (1996) observed that LAI increased significantly at maximum tillering and flowering stages with increasing levels of nitrogen. BINA (1996) stated that the effect of different levels of nitrogen was significant only for number of tillers $hill^{-1}$, effective tillers $hill^{-1}$, straw yield and crop duration. The highest number of total and productive tillers $hill^{-1}$ was obtained from the highest level (120 kg ha^{-1}) of N application.

Dwibvedi (1997) noticed that application of nitrogen significantly increased in growth, yield and yield components, grain yield, straw yield as well as harvest index with 60 kg N ha^{-1}. BRRI (1997) reported during *boro* and transplant *aman* to determined rice seed yield. The experiment was laid out with four nitrogen levels 0, 50, 100 and 150 kg ha^{-1} and noted that seed yield increased gradually with the gradual increase of nitrogen.

Islam and Bhuiya (1997) studied the effect of nitrogen and phosphorus on the growth, yield and nutrient uptake of deep-water rice. They observed that nitrogen and phosphorus fertilization significantly increased the number of fertile tiller m^{-2} and also that of grains $panicle^{-1}$, which in turn resulted in significant increase in grain yield. The application of 60 kg N ha^{-1} alone gave 22% yield benefit over control.

Singh *et al.* (1998) studied the performance of three hybrids KHR 1, Pro Agro 103 and MGR 1 using Jaya and Rasi as standard checks at four levels of N (0, 60, 120, and 180 kg ha^{-1}). They observed that the varieties responded linearly to the applied N level up to 120 kg ha^{-1}.

Kumar and Sharma (1999) conducted a field experiment with 4 levels of nitrogen (0, 40, 80 and 120 kg N ha^{-1}) and observed that dry matter accumulation in rice increased from 0-40 kg N ha^{-1} at 40 DAS, 0-120 kg N ha^{-1} at 60 DAS, 0-80 kg ha^{-1} at 80 DAS. Nitrogen application also hastened the growth and resulted in higher percentage of total dry matter accumulation in early stage of crop growth.

Bellido *et al*. (2000) evaluate a field experiment with 4 levels of nitrogen (0, 50, 100 and 150 kg N ha^{-1}) and reported that the amount of total dry matter was significantly greater at the N fertilizer rates of 100 and 150 kg nitrogen ha^{-1}.

BRRI (2000) reported that the grain yield was linearly increased with increasing nitrogen rates. Chopra and Chopra (2000) cited that seed yield increased linearly up to 80 kg N ha^{-1}. Castro and Sarker (2000) conducted field experiment to see the effects of N applications as basal (80, 60, and 45kg N ha^{-1}) and top dressing (10, 30 and 45 kg ha^{-1}) on the yield and yield components of Japonica rice and obtained high effective tiller, percentage of ripened grains and high grain yields from 45 kg N ha^{-1} (basal) and 45 kg N ha^{-1} (top dressing). Singh *et al.* (2000) stated that each increment dose of N significantly increased grain and straw yields of rice over its preceding dose. Consequently the crop fertilized with 100 kg N ha^{-1} gave maximum grain yield (2647 kg ha^{-1}).

Pully *et al*. (2000) observed that increased yield associated with application of nitrogen stage, although booting stage nitrogen application had no effect or shoot growth or nitrogen uptake. These preliminary results suggested a single application of nitrogen is sufficient to maintain healthy rice growth, alleviating the need for additional N application after flooding. Rice may be responded to N applied as late as booting, but only when the rice is N limited and not severely N stressed.

Munnujan *et al*. (2001) treated 4 levels of nitrogen fertilizer (0, 40, 80, and 160 kg ha^{-1}) application at three levels each planting density (20, 40 and 80 hill m^{-1}) and conducted that the highest grain yield (3.8 t ha^{-1}) was obtained with 180 kg N ha^{-1}, which was similar to the yield obtained at 80 kg N ha^{-1} (3.81 t ha^{-1}).

Sarker *et al.* (2001) obtained the nitrogen responses of a Japonica (Yumelvitachi) and an Indica (Takanari) rice variety with different nitrogen levels viz. 0, 40, 80, and 120 kg N ha^{-1}. They observed that application of nitrogen increased grain and straw yields significantly but harvest index was not increased significant.

Angayarkanni and Ravichandran (2001) conducted a field experiment in Tamil Nadu, India from July to October 1997 to determine the best split application of 150 kg N ha^{-1} for rice cv. IR20. They found that applying 16.66% of the recommended N as basal, followed by 33.33% N at 10 DAT, 25% N at 20 DAT and 25% N at 40 DAT recorded the highest grain (6189.4 kg ha^{-1}) and straw (8649.6 kg ha^{-1}) yields, response ratio (23.40) and agronomic efficiency (41.26).

Bayan and Kandasamy (2002) noticed that the application of recommended doses of nitrogen in four splits at 10 days after sowing active tillering, panicle initiation and at heading stages recorded significantly lower dry weight of weeds and increased crop growth viz. effective tillers m^{-2}.

Duhan and Singh (2002) reported that the rice yield and uptake of nutrients increased significantly with increasing N levels. Moreover, the application along with various green manures (GM) showed additive effect on the yield and uptake of micronutrients. Under all GM treatments, the yield and uptake were always higher with 120 kg ha^{-1} than with lower level of nitrogen.

Mondal and Swamy (2003) found that application of N (120 kg ha^{-1}) as urea in equal splits during transplanting, tillering, panicle initiation and flowering resulted in the highest number of panicle, number of grains $panicle^{-1}$, 1000-grain weight, straw yield and harvest index.

2.3 Effect of phosphorus

Nair and Rajasree (2004) 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.

Moula (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.

Das and Sinha (2006) conducted a field experiment on sandy loam soil during the kharif season 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}.

Li *et al.* (2007) conducted an experiment to evaluate the contributions of rice root morphology and phosphorus uptake kinetics to P uptake by rice from iron phosphates. The Fe-P treatment significantly decreased plant dry weight, P uptake per plant, and P concentration in plant dry matter of all cultivars in comparison with the control plants. The P uptake per plant from Fe-P by rice was significantly correlated with root surface area and root volume as well as with the number of lateral roots suggesting that the ability of rice to absorb P from Fe-P was closely related to root morphology.

Dunn and Stevens (2008) conducted a field experiment to evaluate the effect of polymer coating of phosphate fertilizer on rice yield. Three rates of phosphate fertilizer, including polymer coated and non coated, were compared to an untreated check. Net return was calculated based on crop price and input costs. At the rate of 25 lb/acre P_2O_5 rate the polymer coated treatments produced greater yields than equivalent non coated treatments.

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 dhan 36, BRRI dhan 45, EH_1 and EH_2) and T. Aman (BRRI dhan 30, BRRI dhan 49, 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}.

Tang *et al*. (2011) conducted a field experiment on winter wheat (*Triticum aestivum* L.) and 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.

2.4 Effect of potassium

Singh *et al.* (2000) 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.

Sarkar 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.

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.

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.

Natarajan *et al*. (2005) conducted an experiment during 2002-2003 with two rice hybrids, KRH2 and DRRHI in main plots and three levels of potassium (0, 40, and 80 kg ha^{-1}) in subplots to study the performance of rice hybrids with different K levels. The results clearly indicated that hybrid KRH2 performed superior with different levels of K.

Krishnappa *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 $panicle^{-1}$.

Muangsri *et al*. (2008) reported that the effect of rice straw and rice hull in combination with nitrogen, phosphorus and potassium fertilizer on yield of rice grown on Phimai soil series. The treatments consisted of the control (without fertilizer) NPK fertilizer, rice straw at the rate of 0.75, 1.5 and 3.0 g kg^{-1} soil in combination with NPK fertilizer, and rice hull at the rate of 0.75, 1.5, 3.0 and 4.5 g kg^{-1} soil in combination with NPK fertilizer. The results showed that the growth, yield and nutrient uptake of rice plant grown on Phimai soil series without fertilizer were the lowest. Yield of rice plant grown on the soil amended with rice straw in combination with NPK fertilizer tended to be higher than that of rice plant grown on the soil amended with only NPK fertilizer.

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.

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).

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.

2.5 Combined effect of organic and inorganic fertilizer on the yield of rice

The concept of integrated nutrient management is the continuous improvement of soil productivity through appropriate use of fertilizers and organic manure including green manure. Considerable work has been done in India, China, Thailand, Philippines and other countries of the world with respect to the use of green manure (GM), poultry manure (PM) and farmyard manure (FYM) as alternative or supplementary sources of nutrients. In Bangladesh, only limited attempts have been made in this perspective.

Maskina *et al*. (1986) studied the effect of N application on wetland rice in a loamy sand soil amended with cattle manure (60 kg N ha^{-1}) or PM (80 kg N ha^{-1}). The absence of urea N: PM increases the rice grain yield by 98%, which was 2.6 times higher than cattle manure (37%). Rice yield increased linearly with N rates whether or not the soil was amended with organic manure. Urea N equivalent to cattle and PM varied from 21 to 53 kg ha^{-1} and 50 to 123 kg ha^{-1} respectively. Apparent recovery of N from poultry manure ranged from 38 to 82% compared with 51 to 69% from urea and 20 to 25% from cattle manure and pig manure.

Miyazaki *et al*. (1986) found a field experiment with 0-30 t compost ha^{-1} + 0 or 80 kg N ha^{-1} for rice growing on a wet Andosol. Application of 10 and 30 t compost ha^{-1} increased soil ammonium N in the plough layer by 1 and 3 mg per 100 g dry soil, respectively. Compost application increased soil N content, 60% of compost N remained in the soil and 50% of the N released by decomposition was taken up by the rice plants. Increased N uptake increased total DM yield and spikelet number. In cooler year, however, the percentage of ripened grains was lower with heavy application of compost than in warm years. Compost @ 20 t ha^{-1} gave a relatively stable high rice yield.

Besides chemical fertilizers, organic manure like poultry manure is another good source of nutrient of soil. Experiments on the use and agronomic efficiency of poultry manure showed that 4 t ha^{-1} poultry manure along with 60 kg N ha^{-1} as urea produced grain yield of rice similar to that with 120 kg N ha^{-1} as urea alone (Meelu and Singh, 1991).

Ali (1994) carried out several experiments on integrated nutrient management at different places of Bangladesh. They reported that when Boro rice received total chemical fertilizers followed by Aman rice receiving the same, the combined yield increase over the control was 96 and 86% for grain and straw, respectively. But these figures were 125 and 102% when Boro rice crop was fertilized with 100% chemical fertilizers + 5 t FYM ha^{-1} followed by Aman rice with only 100% chemical fertilizer.

Miah (1994) stated that only the first crop following the application recovered one-fifth to one-half of the nutrient supplied by animal manure, reminder was held as humus to very slow decomposition, 2.4% element being released per annum. Islam (1995) found a significant yield increase with fertilizers with cowdung compared to fertilizer-N alone in T. Aman rice. In the following rice, the yields with fertilizer-N + residual of cowdung were higher than fertilizer-N alone. Flynn *et al*. (1995) studied the residual effect of broiler litter as a supplemental of mineral N and concluded that broiler litter applied in autumn at the rate of 9 t ha^{-1} reduced the mineral N from 44 kg to 22 kg ha^{-1}.

Gupta (1995) conducted field trial on different organic manure in India and reported that the application of field manure (10 t ha^{-1}) produced the highest grain yield (4.5 t ha^{-1}) followed by PM and FYM which produced yields of 4.1 and 3.9 t ha^{-1} of rice grain respectively. The increase in rice yield with organic manure was 34 to 55% higher over control and 5 to 22% higher over NPK fertilizers. Gupta *et al.* (1996) concluded that the rate of application of poultry manure could be reduced by 80 kg/ha of soil with the application of 1% poultry manure (PM). Organic C and available P contents of soil after harvest were increased with PM applications.

Zhang *et al*. (1996) measured various crop response to a mixed municipal solid waste (refuse) bio-solids co-compost (named Nutrin plus) and examined the fate of certain metals associated with Nutri plus compost. There were six treatments cheek, 50, 100 and 200 t compost ha^{-1}, NPKS (75 kg N ha^{-1}, 20 kg P ha^{-1}, 45 kg K ha^{-1}, and 18 kg S ha^{-1}), PK (2 kg P, 45 kg K ha^{-1}), and three crops: rape, wheat and bearly. The research results showed that the compost slightly increased heavy metal concentrations in the soil but did not cause any phytotoxicity to crops. Yield from 100 and 200 t ha^{-1} application was higher with compost than with NPKS treatment. However, the yield of 50 t ha^{-1} compost application was similar to that of NPKS treatment. The compost apparently was more beneficial in the year of application. The results suggest that Nutri plus compost application generated positive yield response in all three crops. Crop yield increased as the application rate increased.

Singh *et al*. (1996) carried out a field experiment in India where irrigated rice was given 60, 80 or 120 kg N ha^{-1} per year as poultry manure, urea, poultry manure + urea respectively. In the first year, PM did not perform better than urea but in the fourth year, 120 g and 150 kg N as PM produced significantly higher grain yield than the same rate as urea. The PM help to sustain the grain yield of rice during the 3 years while the yield decreased with urea application.

Hossain *et al.* (1997) conducted a field experiment to evaluate the effect of integrated nutrient management on rice cropping in Old Brahmaputra Floodplain soil and found that the grain yield of BR 11 rice increased significantly due to the application of fertilizer alone or in combination with manures over control.

Devi *et al.* (1997) conducted a field trail (1987-93) to develop a system for integrated nutrient supply for a rice-rice cropping sequence. Application of 45:45:45 kg NPK ha^{-1} as mineral fertilizers and 45 kg N ha^{-1} as FYM in the kharif seasons followed by 90:45:45 kg mineral NPK ha^{-1} in the rabi seasons gave the highest yields in all years expect 1993 and application of half of the N in the *kharif* season or crop residues or green manure gave the highest yield.

Goshal *et al*. (1998) in an experiment with rice found increased grain and dry matter yield when inorganic N fertilizer (50 kg N ha^{-1}) was applied alone or when a combination of organic (10 t FYM ha^{-1}) and inorganic N fertilizer (25 kg N ha^{-1}) were applied as compared with organic sources (20 t FYM ha^{-1}) alone.

Mondal and Chettri (1998) conducted field experiment during 1991-93 in West Bangal, India to study integrated nutrient management for high productivity and fertility building under a rice based cropping system with application of S as ammonium sulfate along with green manure in suit and farmyard manure to rice only. The result showed maximum grain yields of rice (4.96 and 5.77 t ha^{-1}) in the wet and dry seasons, respectively.

Yadav (1998) conducted long-term fertilizer experiments on a rice-wheat cropping system at four locations in India. Long-term rice-wheat cropping system resulted in depletion of soil organic carbon and available N and P at two locations but increased in organic carbon, available N and K at the third location. The available P and K content of the soil also increased at the fourth location.

Singh *et al.* (1999) conducted field experiment during the rainy and winter seasons of 1990-91 to 1992-93 at Bari Bhag, Uttar Pradesh, India using recommended rates of N, P, K and Zn (120, 60, 40, 20 kg ha^{-1}) respectively, or 10 t/ha of FYM or rice straw 25 or 50% recommended rates (R.R) : N+RRP, K and Zn. Rice yield was the highest with FYM + S50 RRN, followed by the RRN, P, K and Zn.

Liang-Yunjiang *et al.* (1999) observed that a mathematical model which analyzed the effect of application of organic and inorganic fertilizer on yields of rice growing on paddy soils was established. The model was used to study the effect of various factors on yields and to produce a strategy for optimization of management for high rice yields.

Abedin Miah and Mosleahuddain (1999) conducted a long term fertility trail in Sonatala silt-loam soil at Bangladesh Agricultural University farm, Mymensingh to evaluate the effects of continued fertilization and manureing on soil properties and yield of crops. Grain yield of rice increased due to N, P, K and S application but the rate of increase varied in different seasons. Residual S showed remarkable decrease in the yield in Aman season. The yield of Aman showed a decreasing trend over the years but the yield of Aus remained almost static. The NPKSZn treatment maintained its superiority both in T-Aman and Aus rice although the performance of NFYM was very close to NPKSZn treatment. In general, the response of T-Aman to S containing treatments showed a decreasing trend over the years. The availability of P, S and Zn increased in soil due to long continued application. P fertilization also improved the micronutrient status of soil. No considerable changes in K status were noted due to K application. Nutrient balance study showed a severe loss of most of the nutrients through soil degradation.

Singh and Singh (2000) reported that the effect of sewage sludge-based compost in the growth attributes and yield of rice during 1997, in Allhabad, Uttar Pradesh, India. The treatment were control, Jamuna compost at 2520 g ha^{-1} + urea at 986.60 g ha^{-1}, Jamuna compost at 5040 g ha^{-1} + urea at 657.33 g ha^{-1}, Jamuna compost at 7560 g ha^{-1} + urea at 328.60 g ha^{-1}, Jamuna compost at10083 g ha^{-1} + urea at 1315 g ha^{-1}. All the treatment equally received P and 2268.75 g ha^{-1} and potash at 403.33 g ha^{-1}. The plant height was highest at 100% urea application compared to 76.7 cm in Jamuna compost at 105 days after sowing. Similar effect was observed in the number of tillers m^{-2} row length. The fresh and dry weight at rice samples from 100% urea application was 102.8 g and 22.1 g, respectively, in sludge-based Jamuna compost at 75 DAS. The highest grain yield of 44.58 q ha^{-1} was observed in 100% urea application, and it was the least in Jamuna compost (13.74 q ha^{-1}). However, application of Jamuna compost, alone with urea at 25 and 50%, showed and increase in growth and yield parameters of rice, which was on par with 100% urea application.

Yamagata (2000) a field experiment to determined the growth response of upland rice (*Oryza sativa* L.) and maize (*Zea mays*) to organic nitrogen by amending the soil with an inorganic N source (ammonium sulfate) and with an organic N source. N uptake was highest under the RBS treatment, but the inorganic N concentration in soil was lower when organic and inorganic N was applied together as compared to inorganic N alone. Upland rice also took up more N than maize in a pot experiment with RBS without differences in root spread.

Rahman (2001) reported that in rice-rice cropping pattern, the highest grain yield of Boro rice was recorded in the soil test basis (STB) N P K S Zn fertilizers treatment while in T. Aman rice the 75% or 100% of N P K S Zn (STB) fertilizers plus GM with or without cow dung gave the highest or a comparable yield. The mean yearly N, P, K, S and Zn uptake by rice (Boro + T. Aman) increased with increasing supply of nutrients. Application of cow dung along with N P K S Zn (STB) resulted in markedly higher uptake of nutrients in Boro rice. In T. Aman rice, application of NPKS (STB) with GM and/or CD showed higher N, P, K, S, Zn uptake than that of NPKS (FRG) and NPK (FP) treatments. The total N content and the available N, P, K, S, and Zn status in soils increased slightly due to manuring. The whole results suggested that the integrated use of fertilizers with manure (viz. *Sesbania*, cow dung) could be an efficient practice for ensuring higher crop yields without degradation of soil fertility.

Rajni Rani *et al.* (2001) conducted a pot experiment in a glass house of Varanasi, Utter Pradesh, India during *kharif* season to assess the response of rice to different combinations of vermicompost (VC), poultry manure (PM) and nitrogen fertilizers. Results showed that at integrated treatments significant increase in plant height, number of effective panicle over the treatment having full nitrogen dose through urea.

Keeling *et al*. (2003) determined the green waste compost and provided with additional fertilizers and showed consistently that the response of rice rape to compost and fertilizer applied together than the response to the individual additives, but only very stable compost was used (>10 months processing).

Experiments with 15 N-labeled fertilizer showed that rice was able to utilize the applied N-more efficiently when cultivated with the stable compost.

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

Davarynejad *et al.* (2004) conducted an experiment to investigate the effect of manure and municipal compost and their enrichment with chemical fertilizers on growth and yield of rice. Results showed that compost alone did not increase grain yield. However, when enriched with different levels of chemical fertilizer the highest amount of grain yield was produced. The yield was comparable to the yield obtained from 40 t ha^{-1} of compost. This indicated that compost might be an appropriate substitute for manure and half of chemical fertilizer needed for soil.

Vijay and Singh (2006) was conducted a field experiment during kharif season of 2003 and 2004 at J.V. college, Baraut, Uttar Pradesh, India, to study the effect of organic manures and fertilizer treatments on growth, yield and yield attributes of rice (*Oryza sativa* cv. Pusa Bashmati). The manure treatment comprises compost. Fertilizer treatments included N at 0, 40, 80 and 120 kg ha^{-1}. Application of compost significantly improved the growth, yield and yield attributes of rice during the years of experimentation. However, the organic manure compost did not show marked variation among the other treatments.

2.6 Soil fertility and properties for integrated use of fertilizers and manure

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

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

Prasad and Kerketta (1991) conducted an experiment to assess the soil fertility, crop production and nutrient removal for cropping sequences in the presence of recommended doses of fertilizers and cultural practices along with 5 t ha^{-1} compost applied to the crops. There was an overall increase in organic C, increase in total N (83.9%), available N (69.9%), available P (117.3%) and CEC (37.7%).

Bhandari *et al*. (1992) reported that an application of fertilizers or their combined use with organic manure increased the organic C status of soil. The NPK fertilizers at 100% level and their combined use with organic N also increased the available N and P by 5.22 kg and 0.8-3.8 kg ha^{-1} from their initial values.

Meelu *et al.* (1992) reported that organic C and total N increased significantly when *Sesbania* and *Crotolaria* were applied in the preceded rice crop for two wet seasons. Medhi *et al*. (1996) reported that incorporation of organic and inorganic sources of N increased soil solution NH_4-N to a peak and then declined to very low levels.

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

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

Nimbiar (1997) views that integrated use of organic manure and chemical fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining healthy soil fertility status. Intensive crop production systems have witnessed serious problems associated with loss of soil fertility as a result of excessive soil mining of plant nutrients and consequently reduction in productivity. Application of external source of plant nutrients is a key element in optimal management of soil organic matter, crop residues and manure for ensuring the bio-availability, the cycling and the balance of nutrients in the soil - plant systems.

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

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

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

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

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted in the research Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from April to July 2013 to study the adaptability of NERICA-10 rice in Aus season under organic-inorganic fertilizer management. This chapter includes materials and methods that were used in conducting the experiment. It includes a short description of the location of experimental site, climate and soil condition of the experimental plot, materials used for the experiment, design of the experiment, data collection procedure and procedure of data analysis. The details are presented below under the following headings -

3.1 Experimental site and soil

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

3.2 Climate

The climate of the experimental area is characterized by high temperature, high humidity and medium rainfall with occasional gusty winds during the *kharif* season (March-September) and a scanty rainfall associated with moderately low temperature in the *rabi* season (October-February). The weather information regarding temperature, rainfall, relative humidity and sunshine hours prevailed at the experimental site during the cropping season April to July 2013 have been presented in Appendix I.

3.3 Planting material

NERICA-10 was used as the test crop in this experiment. This variety the New Rice for Africa, developed around a decade ago by an institute in Ivory Coast and it can be harvested in 90 to 100 days, requires limited water, it was designed for Africa’s dry lands and is very high-yielding.

Table 1. Morphological characteristics of the experimental field

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

(FAO and UNDP, 1988)

Table 2. Initial physical and chemical characteristics of the soil (0-15 cm depth)

Characteristics	Value
Mechanical fractions:	
% Sand (2.0-0.02 mm)	18.60
% Silt (0.02-0.002 mm)	45.40
% Clay (<0.002 mm)	36.00
Textural class	Silty Loam
Consistency	Granular and friable when dry
pH (1: 2.5 soil- water)	5.5
CEC (cmol/kg)	17.9
Organic C (%)	0.686
Organic Matter (%)	1.187
Total N (%)	0.06
Exchangeable K (mol kg^{-1})	0.12
Available P (mg kg^{-1})	19.85
Available S (mg kg^{-1})	14.40

3.4 Land preparation

The land was first opened on 05 April, 2013 by a tractor and prepared thoroughly by ploughing and cross ploughing with a power tiller followed by country plough for obtaining good tilth. Laddering helped breaking the clods and leveling the land followed every ploughing. Before seed sowing each unit of plot was cleaned by removing the weeds, stubbles and crop residues.

3.5 Experimental design and layout

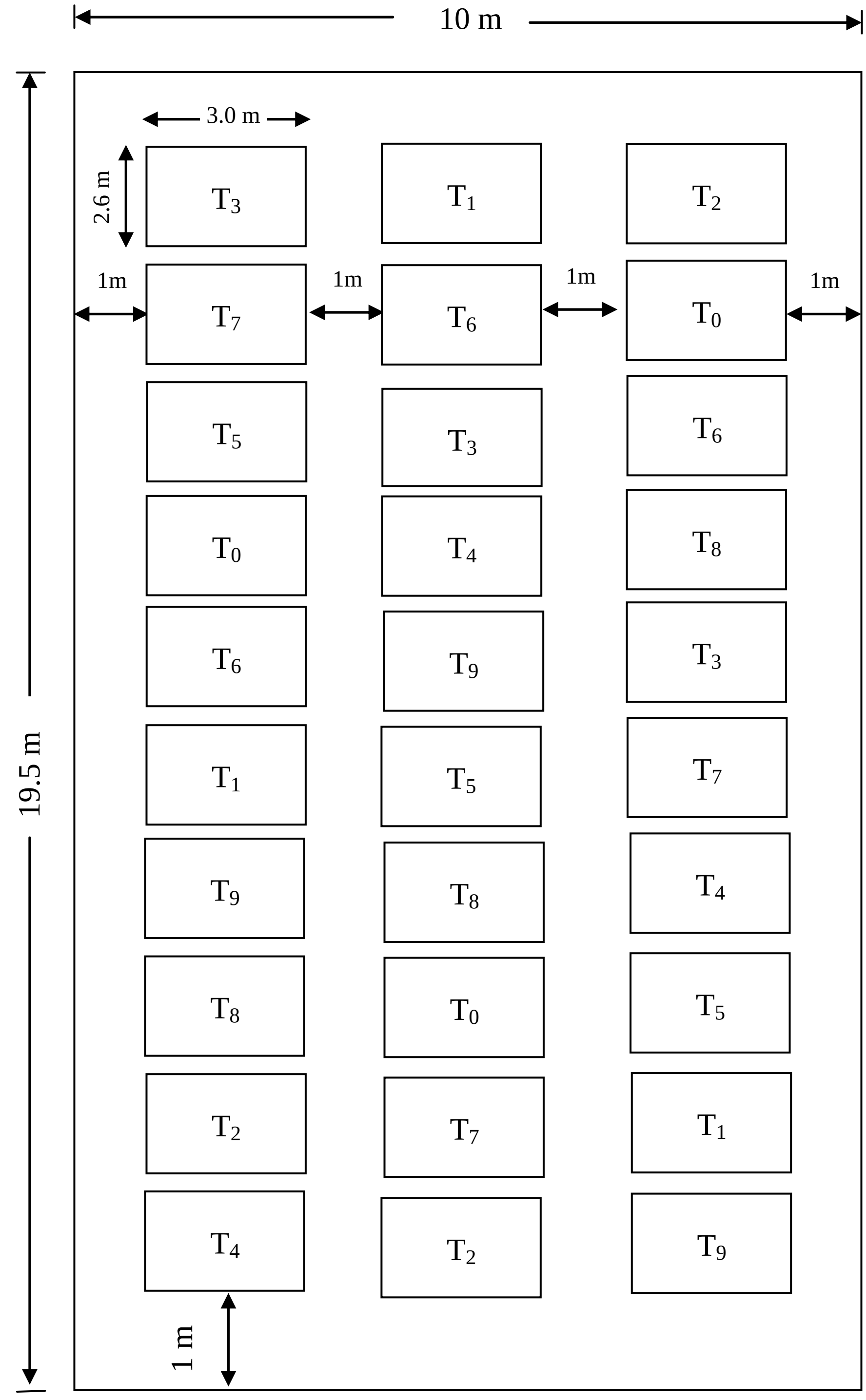
The experiment was laid out in a randomized complete block design (RCBD), where the experimental area was divided into three blocks representing the replications to reduce soil heterogenetic effects. Each block was divided into ten unit plots as treatments with raised bunds around. Thus the total numbers of plots were 30. The unit plot size was 3.0 m × 2.6 m and was separated from each other by 0.5 m ails. The distance maintained between two blocks were 1.0 m. The layout of the experiment is shown in Figure 1.

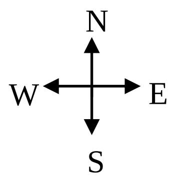
3.6 Initial soil sampling

Before land preparation, initial soil samples at 0-15 cm depth were collected from different spots of the experimental field. The composite soil sample were air-dried, crushed and passed through a 2 mm (10 meshes) sieve. After sieving, the soil samples were kept in a plastic container for physical and chemical analysis of the experimental soil.

3.7 Organic and inorganic fertilizer application

The amounts of S and Zn fertilizers were applied @ 70 kg and 2 kg ha^{-1} and cowdung, urea, TSP, MoP were applied in the plot as per the treatments. Full amounts of TSP, MoP, gypsum, zinc and cowdung were applied as basal dose before sowing of rice seeds. Urea were applied in 3 equal splits: one third was applied at basal before seed sowing, one third at active tillering stage (30 DAS) and the remaining one third was applied at 5 days before panicle initiation stage (55 DAS).





Plot size: 3.0 m × 2.6 m

Plot spacing: 50 cm

Between replication: 1.0 m

Treatments

T_0: Control condition (No organi inorganic fertilizer)

T_1: $N_{120}P_{25}K_{80}$

T_2: $N_{100}P_{20}K_{60}$

T_3: $N_{80}P_{16}K_{50}$

T_4: $N_{60}P_{14}K_{40}$

T_5: $N_{40}P_{12}K_{32}$

T_6: $N_{100}P_{20}K_{60}$ + 20 kg N supplemented by cowdung

T_7: $N_{80}P_{16}K_{50}$ + 40 kg N supplemented by cowdung

T_8: $N_{60}P_{14}K_{40}$ + 60 kg N supplemented by cowdung

T_9: $N_{40}P_{12}K_{32}$ + 80 kg N supplemented by cowdung

Figure 1. Field layout of the experimental plot

3.8 Treatments

The experiment consisted of 10 treatments. The treatments were as follows:

T_0: Control condition (No organic and inorganic fertilizer)

T_1: $N_{120}P_{25}K_{80}$

T_2: $N_{100}P_{20}K_{60}$

T_3: $N_{80}P_{16}K_{50}$

T_4: $N_{60}P_{14}K_{40}$

T_5: $N_{40}P_{12}K_{32}$

T_6: $N_{100}P_{20}K_{60}$ + 20 kg N supplemented by cowdung

T_7: $N_{80}P_{16}K_{50}$ + 40 kg N supplemented by cowdung

T_8: $N_{60}P_{14}K_{40}$ + 60 kg N supplemented by cowdung

T_9: $N_{40}P_{12}K_{32}$ + 80 kg N supplemented by cowdung

3.9 Seed sowing

Seeds of NERICA-10 were sowing on 18 April, 2013 in well prepared plot. 3-4 seeds $hill^{-1}$ was used following a spacing of 25 cm × 20 cm.

3.10 Intercultural operations

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

3.10.1 Irrigation

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

3.10.2 Weeding

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

3.10.3 Insect and pest control

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

3.11 Crop harvest

The crop was harvested at full maturity when 80-90% of the grains were turned into straw colored on 05 August, 2013. The crop was cut at the ground level and plot wise crop was bundled separately and brought to the threshing floor.

3.12 Collected data on yield components

3.12.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 30, 40, 50, 60 days after sowing (DAS) and at harvesting stage. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the panicle.

3.12.2 Effective tiller $hill^{-1}$

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

3.12.3 In-effective tiller $hill^{-1}$

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

3.12.4 Total tiller $hill^{-1}$

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

3.12.5 Length of panicle

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

3.12.6 Filled grain panicle^{-1}

The total numbers of filled grain was collected randomly from selected 10 plants of a plot on the basis of grain in the spikelet and then average numbers of filled grain panicle^{-1} was recorded.

3.12.7 Unfilled grain panicle^{-1}

The total numbers of unfilled grain was collected randomly from selected 10 plants of a plot on the basis of not grain in the spikelet and then average numbers of unfilled grain panicle^{-1} was recorded.

3.12.8 Total grain panicle^{-1}

The total numbers of grain was collected randomly from selected 10 plants of a plot by adding filled and unfilled grain and then average numbers of grain panicle^{-1} was recorded.

3.12.9 Weight of 1000 seeds

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

3.12.10 Grain yield

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

3.12.11 Straw yield

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

3.12.12 Biological yield

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

Biological yield = Grain yield + Straw yield.

3.12.13 Harvest index

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

$$HI = \frac{\text{Economic yield (grain weight)}}{\text{Biological yield (Total dry weight)}} \times 100$$

3.13 Chemical analysis of grain and straw samples

3.13.1 Collection of samples

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

3.13.2 Preparation of samples

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

3.13.3 Digestion of samples with sulphuric acid for N

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

3.13.4 Digestion of samples with nitric-perchloric acid for P, K, S and Zn

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

3.13.5 Determination of P, K, S and Zn from samples

3.13.5.1 Phosphorus

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

3.13.5.2 Potassium

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

3.13.5.3 Sulphur

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

3.13.5.4 Zinc

Zinc content was determined from the digest of the grain and straw samples (with $BaCl_2$ solution as described by Page *et al*., 1982. The digested Zn was determined by developing turbidity by adding $BaCl_2$ seed solution. The intensity of turbidity was measured by spectrophotometer at 420 nm wavelengths (Hunter, 1984).

3.14 Nutrient uptake

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

Nutrient uptake = Nutrient content (%) × Oven dried yield (kg ha^{-1})/100

3.15 Post harvest soil sampling

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

3.16 Soil analysis

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

3.16.1 Soil pH

Soil pH was measured with the help of a glass electrode pH meter, the soil water ratio being maintained at 1: 2.5 as described by Page *et al.*, 1982.

3.16.2 Organic matter

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

3.16.3 Total nitrogen

Total N content of soil were determined followed by the Micro Kjeldahl method. One gram of oven dry ground soil sample was taken into micro kjeldahl flask to which 1.1 gm catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se in the ratio of 100:10:1), and 6 ml H_2SO_4 were added. The flasks were swirled and heated 200^0C and added 3 ml H_2O_2 and then heating at 360^0C was continued until the digest was clear and colorless. After cooling, the content was taken into 100 ml volumetric flask and the volume was made up to the mark with distilled water. A reagent blank was prepared in a similar manner. These digests were used for nitrogen determination (Page *et al*., 1982).

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

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

Where,

T = Sample titration (ml) value of standard H_2SO_4

B = Blank titration (ml) value of standard H_2SO_4

N = Strength of H_2SO_4

S = Sample weight in gram

3.16.4 Available phosphorus

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

3.16.5 Exchangeable potassium

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

3.17 Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference of different treatments on yield contributing characters, yield and soil properties of NERICA 10. The mean values of all the characters were calculated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to adaptability of NERICA-10 rice in Aus season under organic-inorganic fertilizer management. Data on different growth parameter, yield contributing characters, yield, nutrient content in grain & straw, nutrient uptake by grain & straw and characteristics of post harvest soil was recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix II-IX. The results have been presented and possible interpretations given under the following headings:

4.1 Yield contributing characters and yield of NERICA rice

4.1.1 Plant height

Plant height of NERICA-10 rice showed statistically significant variation due to different organic-inorganic fertilizer management at 30, 40, 50, 60 DAS and at harvest under the present trial (Appendix II). At the different days after transplanting (DAS) and at harvest the longest plant (24.40, 48.94, 79.74, 83.62 and 98.11 cm) was recorded from T_7 ($N_{80}P_{16}K_{50}$ + 40 kg N supplement by cowdung) while, at the same period of observation the shortest plant (15.77, 35.34, 56.96, 66.56 and 77.21 cm) was observed from T_1 as control condition (Figure 2). Data revealed that plant height of NERICA-10 rice was significantly influenced by organic-inorganic fertilizer management. All the treatments produced significantly tallest plants compared to the control treatment. Nambiar (1991) views that integrated use of organic manure and chemical fertilizers would be quite promising not only in providing greater stability in production by ensuring optimum vegetative growth. Plant height of rice was significantly influenced by the organic-inorganic fertilizer management that is earlier reported by Babu *et al.* (2001) earlier from an experiment. Similar results also reported by Rajani Rani *et al*. (2001), Singh *et al.* (1999), Hossain *et al.* (1997) and Sharma and Mitra (1991).

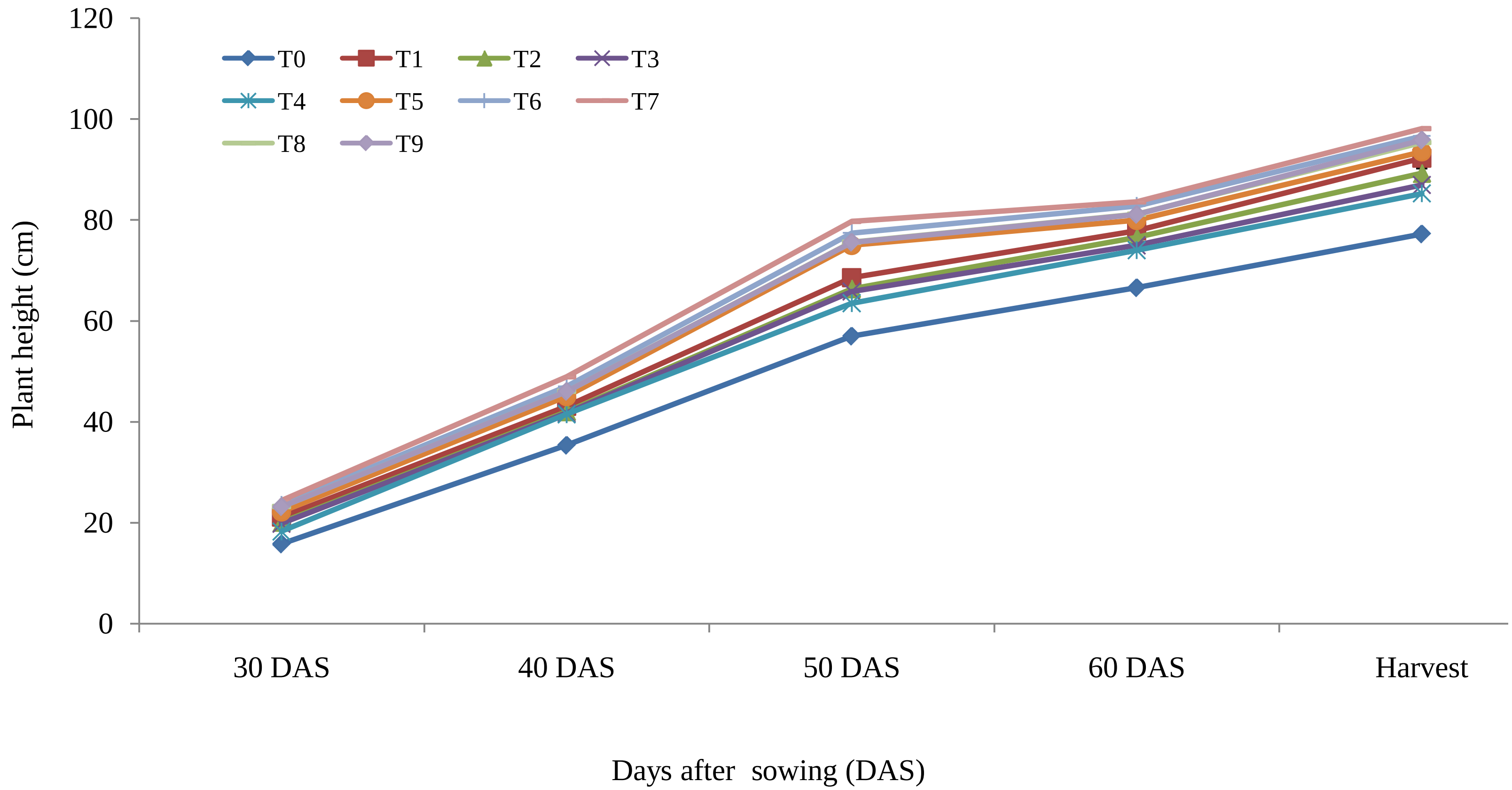


Figure 2. Effect of different organic-inorganic fertilizer management on plant height of NERICA 10 rice.

4.1.2 Number of effective tillers hill^{-1}

Statistically significant variation due to different organic-inorganic fertilizer management in terms of number of effective tillers hill^{-1} of NERICA-10 rice showed (Appendix III). Data revealed that the maximum number of effective tillers hill^{-1} (13.73) was found from T_7 ($N_{80}P_{16}K_{50}$ + 40 kg N supplement by cowdung) which was statistically similar (13.00, 12.87,1 12.81, 12.33, 11.73, 11.53 and 11.27, respectively) with T_6 ($N_{100}P_{20}K_{60}$ + 20 kg N supplement by cowdung), T_8 ($N_{60}P_{14}K_{40}$ + 60 kg N supplement by cowdung), T_9 ($N_{40}P_{12}K_{32}$ + 80 kg N supplement by cowdung), T_5 ($N_{40}P_{12}K_{32}$), T_1 ($N_{120}P_{25}K_{80}$), T_2 ($N_{100}P_{20}K_{60}$) and T_3 ($N_{80}P_{16}K_{50}$), respectively. On the other hand, the minimum number of effective tillers hill^{-1} (8.60) was obtained from T_0 as control condition which was statisticallly similar (10.53) with T_5 ($N_{40}P_{12}K_{32}$) treatment (Table 3). Chander and Pandey (1996) reported a significant increase in effective tillers hill^{-1} due to application of higher doses of organic and inorganic fertilizer.

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

Different organic-inorganic fertilizer management showed statistically significant variation in terms of number of non-effective tillers hill^{-1} of NERICA-10 rice (Appendix III). The maximum number of non-effective tillers hill^{-1} (3.20) was observed from T_7 which was statistically similar (3.13, 3.07, 3.05, 2.93 and 2.73, respectively) with T_6, T_8, $T_{9,}$ T_5, T_1 and T_4, respectively, whereas the minimum number of non-effective tillers hill^{-1} (2.07) from T_0 as control condition which was statistically similar (2.47 and 2.53) with T_2 and T_3 treatment (Table 3).

4.1.4 Total tillers hill^{-1}

Number of total tillers hill^{-1} of NERICA-10 rice varied significantly due to different organic-inorganic fertilizer management (Appendix III). The maximum number of total tillers hill^{-1} (16.93) was found from T_7 which was statistically similar (16.13, 15.93, 15.86, 15.27, 14.47, 14.00 and 13.80, respectively) with T_6, T_8, T_9, T_5, T_1, T_2 and T_3, respectively. On the other hand, the minimum number of total tillers hill^{-1} (10.67) was obtained from T_0 as control condition which was statistically similar (13.27) with T_4 treatment (Figure 3).

Table 3. Effect of organic-inorganic fertilizer management on effective, non-effective and total tillers, length of panicle, filled, unfilled and total grains of NERICA-10 rice in Aus season

Treatment	Number of effective tillers hill^{-1}	Number of non-effective tillers hill^{-1}	Number of filled grains plant^{-1}	Number of unfilled grains plant^{-1}	Number of total grains plant^{-1}
T_0	8.60 c	2.07 d	69.87 d	5.79 d	75.65 d
T_1	11.73 ab	2.73 a-c	82.73 a-c	7.07 a-c	89.81 a-c
T_2	11.53 ab	2.47 cd	80.20 bc	6.82 bc	87.02 bc
T_3	11.27 a-c	2.53 b-d	79.40 bc	6.74 bc	86.14 bc
T_4	12.33 ab	2.93 a-c	86.00 ab	6.46 cd	83.06 cd
T_5	10.53 bc	2.73 a-c	76.60 cd	7.40 ab	93.40 ab
T_6	13.00 ab	3.13 ab	89.27 a	7.73 a	96.99 a
T_7	13.73 a	3.20 a	90.22 a	7.82 a	98.04 a
T_8	12.87 ab	3.07 a-c	88.27 ab	7.63 ab	95.89 ab
T_9	12.81 ab	3.05 a-c	88.23 ab	7.61 ab	95.85 ab
$LSD_{(0.05)}$	2.554	0.539	8.172	0.817	8.989
Level of significance	0.05	0.01	0.01	0.01	0.01
CV(%)	12.58	11.27	5.72	6.70	5.80

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

T_0: Control condition (No organic and inorganic fertilizer)

T_1: $N_{120}P_{25}K_{80}$

T_2: $N_{100}P_{20}K_{60}$

T_3: $N_{80}P_{16}K_{50}$

T_4: $N_{60}P_{14}K_{40}$

T_5: $N_{40}P_{12}K_{32}$

T_6: $N_{100}P_{20}K_{60}$ + 20 kg N supplemented by cowdung

T_7: $N_{80}P_{16}K_{50}$ + 40 kg N supplemented by cowdung

T_8: $N_{60}P_{14}K_{40}$ + 60 kg N supplemented by cowdung

T_9: $N_{40}P_{12}K_{32}$ + 80 kg N supplemented by cowdung

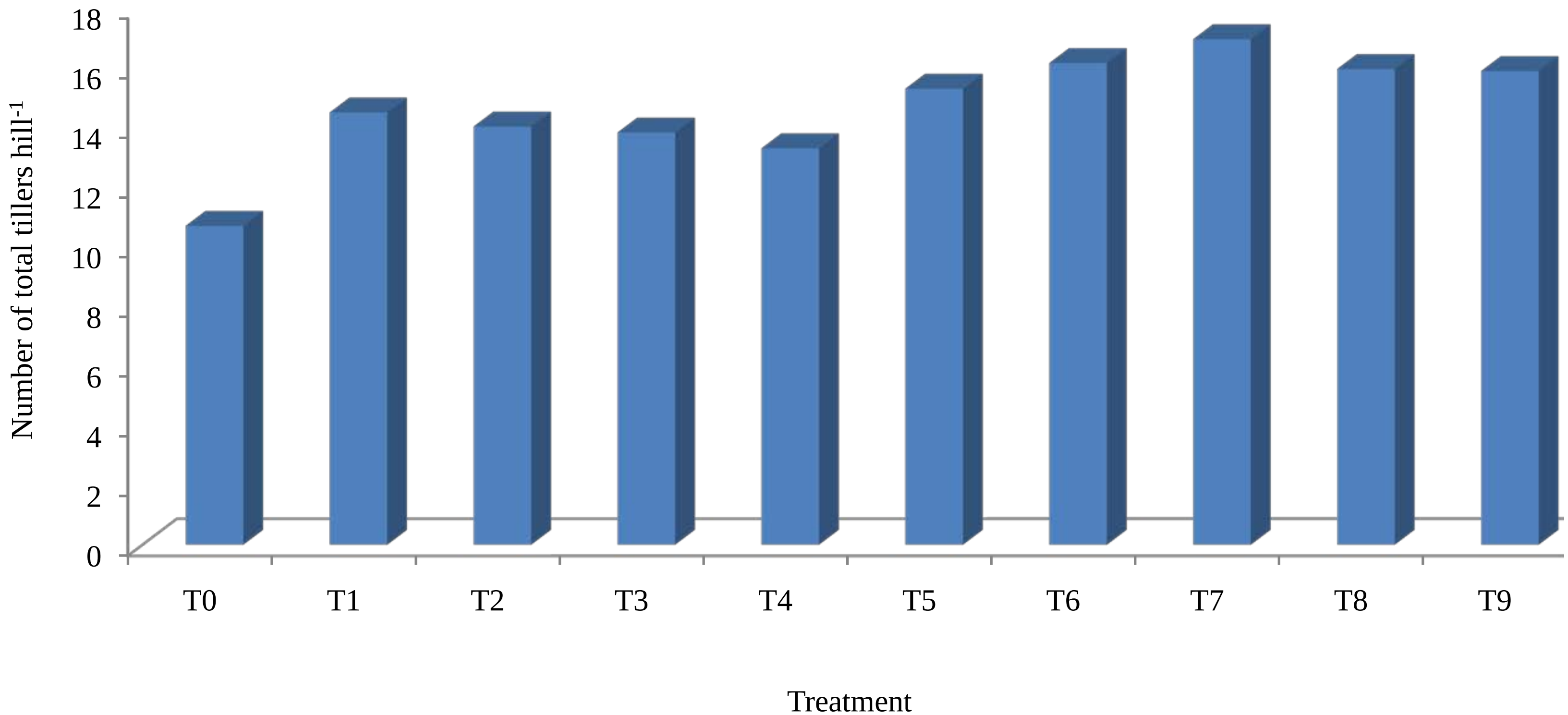


Figure 3. Effect of different organic-inorganic fertilizer management on number of total tillers hill^{-1} of NERICA 10 rice

4.1.5 Length of panicle

Statistically significant variation was recorded due to different organic-inorganic fertilizer management in terms of length of panicle of NERICA-10 rice (Appendix III). The longest panicle (22.74 cm) was recorded from T_7 which was statistically similar (22.43 cm, 21.93 cm, 21.91 cm, 21.25 cm, 20.83 cm and 19.49 cm, respectively) with T_6, T_8, T_9, T_5, T_1 and T_2, respectively, whereas the shortest panicle (15.33 cm) was observed from T_0 as control condition which was statistically similar (18.37 cm and 18.04 cm) with T_3 and T_4 treatment (Figure 4). Haque (1999) and Azim (1996) noted a significant increase in panicle length due to the application of organic manure and chemical fertilizers. Babu *et al*. (2001); Ahmed and Rahman (1991) and Apostol (1989) also reported similar results.

4.1.6 Number of filled grain plant^{-1}

Number of filled grains plant^{-1} of NERICA-10 rice showed statistically significant variation due to different organic-inorganic fertilizer management (Appendix III). The maximum number of filled grains plant^{-1} (90.22) was observed from T_7 which was statistically similar (89.27, 88.27, 88.23, 86.00 and 82.73, respectively) with T_6, T_8, T_9, T_5 and T_1, respectively and closely followed (80.20 and 79.40, respectively) by T_2 and T_3. On the other hand, the minimum number of filled grains plant^{-1} (69.87) was recorded from T_0 as control condition which was statistically similar (76.60) with T_4 treatment (Table 3).

4.1.7 Number of unfilled grain plant^{-1}

Different organic-inorganic fertilizer management showed statistically significant variation in terms of number of unfilled grains plant^{-1} of NERICA-10 rice (Appendix III). The maximum number of unfilled grains plant^{-1} (7.82) was found from T_7 which was statistically similar (7.73, 7.63, 7.40 and 7.07, respectively) with T_6, T_8, T_5 and T_1, respectively and closely followed (6.82 and 6.74, respectively) by T_2 and T_3, whereas the minimum number of unfilled grains plant^{-1} (5.79) was recorded from T_0 as control condition which was statistically similar (6.46) with T_4 treatment (Table 3).

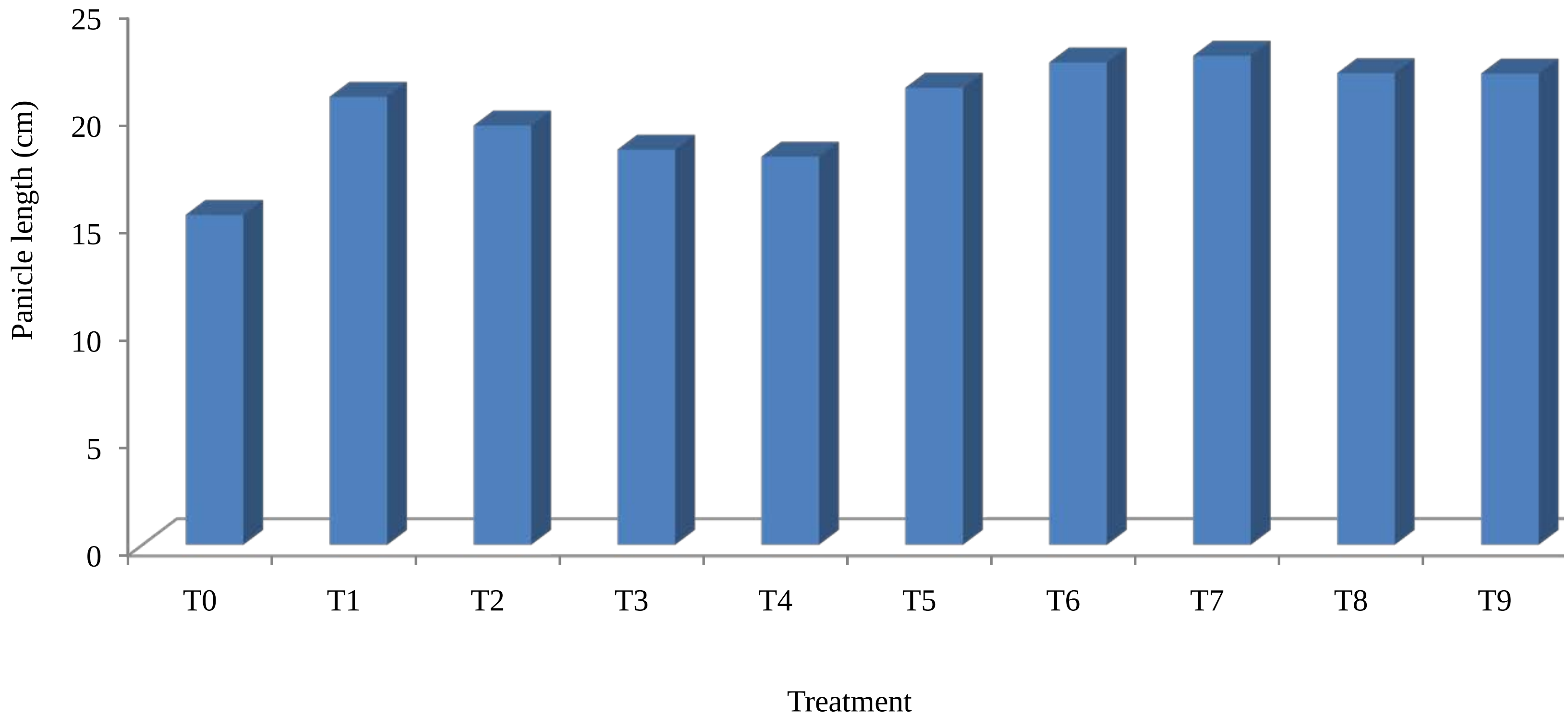


Figure 4. Effect of different organic-inorganic fertilizer management on panicle length of NERICA 10 rice

4.1.8 Number of total grain plant^{-1}

Number of total grains plant^{-1} of NERICA-10 rice showed statistically significant variation due to different organic-inorganic fertilizer management (Appendix III). The maximum number of total grains plant^{-1} (98.04) was obtained from T_7 which was statistically similar (96.99, 95.89, 95.85, 96.99, 93.40 and 89.81, respectively) with T_6, T_8, T_9, T_5 and T_1, respectively and closely followed (87.02 and 86.14, respectively) by T_2 and T_3, again the minimum number of total grains plant^{-1} (75.65) was found from T_0 as control condition which was statistically similar (83.06) with T_4 treatment (Table 3). Grains panicle^{-1} significantly increased due to the application of organic manures and chemical fertilizers (Razzaque, 1996). These results are also in agreement with Hoque (1999) and Azim (1996).

4.1.9 Weight of 1000 grains

Statistically significant variation due to different organic-inorganic fertilizer management in terms of weight of 1000 grains of NERICA-10 rice (Appendix IV). The highest weight of 1000 grains (31.01 g) was found from T_7 which was statistically similar (30.46 g, 30.42 g, 30.40, 30.21 g, 29.16 g, 28.68 g, 28.38 g and 27.67 g, respectively) with T_6, T_8, T_9, T_5, T_1, T_2, T_3 and T_4, respectively, whereas the minimum weight of 1000 grains (24.96 g) from T_0 as control condition (Table 4). Abedin *et al.* (1999) reported that the combined application of organic manure and nitrogen increased the 1000-grain weight of rice.

4.1.10 Grain yield

Different organic-inorganic fertilizer management varied significantly in terms of grain yield of NERICA-10 rice (Appendix IV). The highest grains yield (2.93 t ha^{-1}) was observed from T_7 which was statistically similar (2.81 t ha^{-1}, 2.71 t ha^{-1}, 2.70 t ha^{-1}, 2.60 t ha^{-1}, 2.54 t ha^{-1} and 2.40 t ha^{-1}, respectively) with T_6, T_8, T_9, T_5, T_1 and T_2 followed (2.31 t ha^{-1}) by T_3, and the lowest grain yield (1.28 t ha^{-1}) was found from T_0 as control condition (Table 4). Devivedi and Thakur (2000) reported the grain yield was significantly increased due to application of organic manure and chemical fertilizers.

Table 4. Effect of organic-inorganic fertilizer management on weight of 1000 seeds, grain, straw and biological yield and harvest index of NERICA-10 rice in Aus season

Treatment	Weight of 1000 seeds (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
T_0	24.96 b	1.28 d	2.17 d	3.45 e	37.10 b
T_1	29.16 a	2.54 a-c	3.15 a-c	5.69 a-d	44.69 a
T_2	28.68 a	2.40 a-c	2.96 bc	5.36 b-d	44.78 a
T_3	28.38 a	2.31 bc	2.91 bc	5.23 cd	44.28 a
T_4	27.67 ab	2.18 c	2.74 c	4.91 d	44.31 a
T_5	30.21 a	2.60 a-c	3.30 ab	5.90 a-c	44.05 a
T_6	30.46 a	2.81 ab	3.46 a	6.28 ab	44.82 a
T_7	31.01 a	2.93 a	3.54 a	6.46 a	45.27 a
T_8	30.42 a	2.71 a-c	3.45 a	6.16 a-c	44.03 a
T_9	30.37 a	2.70 a-c	3.43 a	6.13 a-c	44.01 a
$LSD_{(0.05)}$	3.061	0.518	0.410	0.868	4.013
Level of significance	0.05	0.01	0.01	0.01	0.05
CV(%)	6.10	12.38	7.72	9.13	5.41

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

T_0: Control condition (No organic and inorganic fertilizer)

T_1: $N_{120}P_{25}K_{80}$

T_2: $N_{100}P_{20}K_{60}$

T_3: $N_{80}P_{16}K_{50}$

T_4: $N_{60}P_{14}K_{40}$

T_5: $N_{40}P_{12}K_{32}$

T_6: $N_{100}P_{20}K_{60}$ + 20 kg N supplemented by cowdung

T_7: $N_{80}P_{16}K_{50}$ + 40 kg N supplemented by cowdung

T_8: $N_{60}P_{14}K_{40}$ + 60 kg N supplemented by cowdung

T_9: $N_{40}P_{12}K_{32}$ + 80 kg N supplemented by cowdung

4.1.11 Straw yield

Straw yield of NERICA-10 rice showed statistically significant variation due to different organic-inorganic fertilizer management (Appendix IV). The highest straw yield (3.54 t ha^{-1}) was obtained from T_7 which was statistically similar (3.46 t ha^{-1}, 3.45 t ha^{-1}, 3.43 t ha^{-1}, 3.30 and 3.15 t ha^{-1} and 4.84 t ha^{-1}, respectively) with T_6, T_8, T_9, T_5 and T_1 followed (2.96 t ha^{-1} and 2.91 t ha^{-1}) by T_2 and T_3, while the lowest straw yield (2.17 t ha^{-1}) was found from T_0 as control condition (Table 4). Ahmed and Rahman (1991) reported that the application of organic manure and chemical fertilizers increased the straw yields of rice. These findings are well corroborated with the work of Islam (1997) and Khan (1998). It is clear that organic manure in combination with inorganic fertilizer encouraged vegetative growth of plants and thereby increasing straw yield.

4.1.12 Biological yield

Statistically significant variation was observed due to different organic-inorganic fertilizer management in terms of biological yield of NERICA-10 rice (Appendix IV). The highest biological yield (6.46 t ha^{-1}) was recorded from T_7 which was statistically similar (6.28 t ha^{-1}, 6.16 t ha^{-1}, 6.13 t ha^{-1} 5.90 t ha^{-1} and 5.69 t ha^{-1}, respectively) with T_6, T_8, T_9, T_5 and T_1 followed (5.36 t ha^{-1}) by T_2, whereas the lowest biological yield (3.45 t ha^{-1}) was observed from T_0 as control condition (Table 4).

4.1.13 Harvest index

Harvest index of NERICA-10 rice showed statistically significant variation due to different organic-inorganic fertilizer management (Appendix IV). The highest harvest index (45.27%) was obtained from T_7 which was statistically similar (44.82%, 44.78%, 44.31%, 44.28%, 44.05%, 44.03%, 44.01% and 43.96%, respectively) with T_6, T_2, T_1, T_5, T_3, T_5, T_8 and T_9, respectively, while the lowest harvest index (37.10%) was found from T_0 as control condition (Table 4).

4.2 N, P, K, S and Zn concentration in grain and straw

4.2.1 N, P, K, S and Zn concentration in grain

N, P, K, S and Zn concentration in grain of NERICA-10 rice showed statistically significant variation due to different organic-inorganic fertilizer management (Appendix V). The highest N, P, K, S and Zn concentration in grain (0.768%, 0.323%, 0.398%, 0.127% and 0.0166%) was observed from T_7, whereas the lowest N, P, K, S and Zn concentration in grain (0.385%, 0.176%, 0.219%, 0.069% and 0.0080%) was found from T_0 as control condition (Table 5). An increase in nutrient contents both in rice grain and straw due to the application of organic and inorganic fertilizers was reported by many investigators (Razzaque, 1996; Azim, 1999 and Hoque, 1999).

4.2.2 N, P, K, S and Zn concentration in straw

Different organic-inorganic fertilizer management showed statistically significant variation in terms of N, P, K, S and Zn concentration in straw of NERICA-10 rice (Appendix VI). The highest N, P, K, S and Zn concentration in straw (0.518%, 0.088%, 1.208%, 0.094% and 0.0050%) was recorded from T_7, while the lowest N, P, K, S and Zn concentration in straw (0.267%, 0.033%, 0.566%, 0.046% and 0.0026%) was observed from T_0 as control condition (Table 6).

4.3 N, P, K, S and Zn uptake by grain and straw

4.3.1 N, P, K, S and Zn uptake by grain

Statistically significant variation was recorded in terms of N, P, K, S and Zn uptake by grain of NERICA-10 rice due to different organic-inorganic fertilizer management (Appendix VII). The highest N, P, K, S and Zn uptake by grain (22.50 kg ha^{-1}, 9.46 kg ha^{-1}, 11.66 kg ha^{-1}, 3.72 kg ha^{-1} and 0.49 kg ha^{-1}) was observed from T_7, whereas the lowest N, P, K, S and Zn uptake by grain (4.93 kg ha^{-1}, 2.25 kg ha^{-1}, 2.80 kg ha^{-1}, 0.88 kg ha^{-1} and 0.10 kg ha^{-1}) was recorded from T_0 as control condition (Table 7). Sengar *et al.* (2000) reported that the nutrient uptake by rice grain increased significantly with the combined application of organic manure and chemical fertilizers. Rahman (2001); Duhan *et al*. (2002); Azim (1999) and Hoque (1999) also reported similar results.

Table 5. Effect of organic-inorganic fertilizer management on N, P, K, S and Zn concentrations in grain of NERICA-10 rice in Aus season

Treatment	Concentration (%) in grain				
	N	P	K	S	Zn
T_0	0.385 e	0.176 d	0.219 d	0.069 b	0.0080 b
T_1	0.621 b-d	0.275 a-c	0.342 a-c	0.113 a	0.0134 ab
T_2	0.604 b-d	0.262 a-c	0.336 bc	0.112 a	0.0120 ab
T_3	0.560 cd	0.259 bc	0.328 bc	0.112 a	0.0121 ab
T_4	0.510 de	0.239 c	0.317 c	0.109 a	0.0111 ab
T_5	0.661 a-c	0.289 a-c	0.374 a-c	0.122 a	0.0143 a
T_6	0.713 ab	0.307 ab	0.386 ab	0.126 a	0.0151 a
T_7	0.768 a	0.323 a	0.398 a	0.127 a	0.0166 a
T_8	0.703 a-c	0.301 ab	0.377 a-c	0.125 a	0.0149 a
T_9	0.689 a-c	0.297 ab	0.374 a-c	0.123 a	0.0147 a
$LSD_{(0.05)}$	0.134	0.055	0.055	0.017	0.006
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	12.90	11.76	9.89	6.36	14.33

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

T_0: Control condition (No organic and inorganic fertilizer)

T_1: $N_{120}P_{25}K_{80}$

T_2: $N_{100}P_{20}K_{60}$

T_3: $N_{80}P_{16}K_{50}$

T_4: $N_{60}P_{14}K_{40}$

T_5: $N_{40}P_{12}K_{32}$

T_6: $N_{100}P_{20}K_{60}$ + 20 kg N supplemented by cowdung

T_7: $N_{80}P_{16}K_{50}$ + 40 kg N supplemented by cowdung

T_8: $N_{60}P_{14}K_{40}$ + 60 kg N supplemented by cowdung

T_9: $N_{40}P_{12}K_{32}$ + 80 kg N supplemented by cowdung

Table 6. Effect of organic-inorganic fertilizer management on N, P, K, S and Zn concentrations in straw of NERICA-10 rice in Aus season

Treatment	Concentration (%) in straw				
	N	P	K	S	Zn
T_0	0.267 c	0.033 e	0.566 d	0.046 c	0.0026 b
T_1	0.443 ab	0.068 b-d	1.084 bc	0.077 ab	0.0042 ab
T_2	0.424 ab	0.065 cd	1.072 c	0.074 b	0.0036 ab
T_3	0.408 ab	0.061 d	1.059 c	0.072 b	0.0038 ab
T_4	0.377 bc	0.059 d	1.044 c	0.070 b	0.0033 ab
T_5	0.464 ab	0.074 a-d	1.153 ab	0.090 ab	0.0048 a
T_6	0.508 a	0.085 ab	1.187 a	0.090 ab	0.0045 a
T_7	0.518 a	0.088 a	1.208 a	0.094 a	0.0050 a
T_8	0.492 ab	0.081 a-c	1.166 a	0.089 ab	0.0047 a
T_9	0.488 ab	0.080 a-c	1.164 a	0.088 ab	0.0046 a
$LSD_{(0.05)}$	0.110	0.017	0.077	0.017	0.002
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	14.45	15.89	4.28	9.30	15.81

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

T_0: Control condition (No organic and inorganic fertilizer)

T_1: $N_{120}P_{25}K_{80}$

T_2: $N_{100}P_{20}K_{60}$

T_3: $N_{80}P_{16}K_{50}$

T_4: $N_{60}P_{14}K_{40}$

T_5: $N_{40}P_{12}K_{32}$

T_6: $N_{100}P_{20}K_{60}$ + 20 kg N supplemented by cowdung

T_7: $N_{80}P_{16}K_{50}$ + 40 kg N supplemented by cowdung

T_8: $N_{60}P_{14}K_{40}$ + 60 kg N supplemented by cowdung

T_9: $N_{40}P_{12}K_{32}$ + 80 kg N supplemented by cowdung

Table 7. Effect of organic-inorganic fertilizer management on N, P, K, S and Zn uptake by grain of NERICA-10 rice in Aus season

Treatment	Uptake by grain (kg ha^{-1})				
	N	P	K	S	Zn
T_0	4.93 e	2.25 d	2.80 d	0.88 e	0.10 d
T_1	15.77 b-d	6.99 a-c	8.69 a-c	2.87 a-d	0.34 a-c
T_2	14.50 b-d	6.29 bc	8.06 bc	2.69 b-d	0.29 bc
T_3	12.94 cd	5.98 bc	7.58 bc	2.59 cd	0.28 bc
T_4	11.12 d	5.21 c	6.91 c	2.38 d	0.24 c
T_5	17.19 a-d	7.51 a-c	9.72 a-c	3.17 a-d	0.37 a-c
T_6	20.04 ab	8.63 ab	10.85 ab	3.54 ab	0.42 ab
T_7	22.50 a	9.46 a	11.66 a	3.72 a	0.49 a
T_8	19.05 a-c	8.16 a-c	10.22 a-c	3.39 a-c	0.40 ab
T_9	18.60 a-c	8.02 a-c	10.10 a-c	3.32 a-c	0.40 ab
$LSD_{(0.05)}$	9.23	3.971	4.635	1.253	0.205
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	12.41	12.00	10.33	16.73	13.69

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

T_0: Control condition (No organic and inorganic fertilizer)

T_1: $N_{120}P_{25}K_{80}$

T_2: $N_{100}P_{20}K_{60}$

T_3: $N_{80}P_{16}K_{50}$

T_4: $N_{60}P_{14}K_{40}$

T_5: $N_{40}P_{12}K_{32}$

T_6: $N_{100}P_{20}K_{60}$ + 20 kg N supplemented by cowdung

T_7: $N_{80}P_{16}K_{50}$ + 40 kg N supplemented by cowdung

T_8: $N_{60}P_{14}K_{40}$ + 60 kg N supplemented by cowdung

T_9: $N_{40}P_{12}K_{32}$ + 80 kg N supplemented by cowdung

4.3.2 N, P, K, S and Zn uptake by straw

N, P, K, S and Zn uptake by straw of NERICA-10 rice showed statistically significant variation due to different organic-inorganic fertilizer management (Appendix VIII). The highest N, P, K, S and Zn uptake by straw (18.34 kg ha^{-1}, 3.12 kg ha^{-1}, 42.76 kg ha^{-1}, 3.33 kg ha^{-1} and 0.18 kg ha^{-1}) was found from T_7, while the lowest N, P, K, S and Zn uptake by straw (5.79 kg ha^{-1}, 0.72 kg ha^{-1}, 12.28 kg ha^{-1}, 1.00 kg ha^{-1} and 0.06 kg ha^{-1}) was observed from T_0 as control condition (Table 8).

4.4 pH, organic matter and N, P and K in post harvest soil

4.4.1 pH

Different organic-inorganic fertilizer management showed statistically significant variation in terms of pH in post harvest soil of NERICA-10 rice (Appendix IX). The highest pH (7.22) was obtained from T_8 which was statistically similar (7.12, 6.91 and 6.78, respectively) with T_7, T_6 and T_5, respectively. On the other hand, the lowest pH (6.04) was found from T_0 as control condition which was statistically similar (6.15, 6.22, 6.44 and 6.55, respctively) with T_4, T_3, T_2 and T_1, respectively (Table 9). Bharadwaj and Tyagi (1994) reported that the soil pH reduce due to the application of FYM plus pressmud. Similar results were also observed by Islam (1997), Khan (1998) and Swarup and Singh (1994).

4.4.2 Organic matter

Organic matter in post harvest soil of NERICA-10 rice showed statistically significant variation due to different organic-inorganic fertilizer management (Appendix IX). The highest organic matter (1.55%) was recorded from T_8 which was statistically similar (1.52%, 1.49% and 1.46%, respectively) with T_7, T_6 and T_5, respectively, whereas the lowest organic matter (1.21%) was observed from T_0 as control condition which was statistically similar (1.31% and 1.35%, respctively) with T_4 and T_3, respectively (Table 9). Organic carbon also increased due to application of organic and inorganic fertilizer as reported by Haque *et al*. (2001); Mathew and Nair (1997); Azim (1999) and Hoque (1999).

Table 8. Effect of organic-inorganic fertilizer management on N, P, K, S and Zn uptake by straw of NERICA-10 rice in Aus season

Treatment	Uptake by straw (kg ha^{-1})				
	N	P	K	S	Zn
T_0	5.79 e	0.72 e	12.28 d	1.00 d	0.06 e
T_1	13.95 a-d	2.14 b-d	34.15 bc	2.43 bc	0.13 a-d
T_2	12.55 b-d	1.92 cd	31.73 c	2.19 c	0.11 c-e
T_3	11.87 cd	1.78 cd	30.82 c	2.10 c	0.11 b-d
T_4	10.33 d	1.62 d	28.61 c	1.92 c	0.09 de
T_5	15.31 a-c	2.44 a-c	38.05 ab	2.97 ab	0.16 a-c
T_6	17.58 a	2.94 ab	41.07 a	3.11 a	0.16 a-c
T_7	18.34 a	3.12 a	42.76 a	3.33 a	0.18 a
T_8	16.97 ab	2.79 ab	40.23 ab	3.07 ab	0.16 ab
T_8	16.74 ab	2.74 ab	39.93 ab	3.02 ab	0.16 ab
$LSD_{(0.05)}$	6.903	1.165	9.523	0.959	0.077
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	8.94	12.16	10.73	14.63	10.04

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

T_0: Control condition (No organic and inorganic fertilizer)

T_1: $N_{120}P_{25}K_{80}$

T_2: $N_{100}P_{20}K_{60}$

T_3: $N_{80}P_{16}K_{50}$

T_4: $N_{60}P_{14}K_{40}$

T_5: $N_{40}P_{12}K_{32}$

T_6: $N_{100}P_{20}K_{60}$ + 20 kg N supplemented by cowdung

T_7: $N_{80}P_{16}K_{50}$ + 40 kg N supplemented by cowdung

T_8: $N_{60}P_{14}K_{40}$ + 60 kg N supplemented by cowdung

T_9: $N_{40}P_{12}K_{32}$ + 80 kg N supplemented by cowdung

Table 9. Effect of organic-inorganic fertilizer management on pH, organic matter, total N, available P and exchangeable K of post harvest soil of NERICA-10 rice in Aus season

Treatment	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me %)
T_0	6.04 e	1.21 e	0.021 d	3.98 e	0.105 e
T_1	6.55 bcde	1.39 bcd	0.069 a	9.58 ab	0.171 a
T_2	6.44 cde	1.38 bcd	0.042 bc	6.76 d	0.134 cd
T_3	6.22 de	1.35 cde	0.034 cd	6.69 d	0.129 d
T_4	6.15 e	1.31 de	0.032 cd	6.20 d	0.119 de
T_5	6.78 abcd	1.46 abcd	0.070 a	9.83 a	0.173 a
T_6	6.91 abc	1.49 abc	0.050 bc	8.03 c	0.151 bc
T_7	7.12 ab	1.52 ab	0.056 ab	8.51 bc	0.162 ab
T_8	7.22 a	1.55 a	0.050 bc	8.03 c	0.153 b
T_8	7.21 a	1.52 a	0.048 bc	8.01 c	0.151 b
$LSD_{(0.05)}$	0.558	0.145	0.017	1.136	0.017
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	4.88	6.03	14.55	8.74	8.49

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

T_0: Control condition (No organic and inorganic fertilizer)

T_1: $N_{120}P_{25}K_{80}$

T_2: $N_{100}P_{20}K_{60}$

T_3: $N_{80}P_{16}K_{50}$

T_4: $N_{60}P_{14}K_{40}$

T_5: $N_{40}P_{12}K_{32}$

T_6: $N_{100}P_{20}K_{60}$ + 20 kg N supplemented by cowdung

T_7: $N_{80}P_{16}K_{50}$ + 40 kg N supplemented by cowdung

T_8: $N_{60}P_{14}K_{40}$ + 60 kg N supplemented by cowdung

T_9: $N_{40}P_{12}K_{32}$ + 80 kg N supplemented by cowdung

4.4.3 Total Nitrogen

Different organic-inorganic fertilizer management varied significantly in terms of total nitrogen in post harvest soil of NERICA-10 rice (Appendix IX). The highest total nitrogen (0.070%) was observed from T_5 which was statistically similar (0.069% and 0.056%, respectively) with T_1 and T_7, respectively and closely followed (0.050% and 0.042%) by T_6, T_8 and T_2. On the other hand, the lowest total nitrogen (0.021%) was found from T_0 as control condition which was statistically similar (0.032% and 0.034%, respctively) with T_4 and T_3, respectively (Table 9). Several workers reported that organic manure had a positive influenced on total and available N content of soil. Similar were also observed by Razzaque (1996) and Azim (1999).

4.4.4 Available phosphorus

Available phosphorous in post harvest soil of NERICA-10 rice showed statistically significant variation due to different organic-inorganic fertilizer management (Appendix IX). The highest available phosphorous (9.83 ppm) was recorded from T_5 which was statistically similar (9.58 ppm) with T_1 and closely followed (8.51 ppm) by T_7, whereas the lowest available phosphorous (3.98 ppm) was observed from T_0 as control condition which was closely followed (6.76 ppm, 6.69 ppm and 6.20 ppm, respctively) with T_2, T_3 and T_4, respectively (Table 9). Similar results were also found by Zhang *et al.* (1996); Mathew and Nair (1997); Hoque (1999) and Azim (1999).

4.4.5 Exchangeable potassium

Statistically significant variation was recorded in terms of exchangeable potassium in post harvest soil of NERICA-10 rice due to different organic-inorganic fertilizer management (Appendix IX). The highest exchangeable potassium (0.173 me%) was found from T_5 which was statistically similar (0.171 me% and 0.162 me%, respectively) with T_1 and T_7, respectively and closely followed (0.153 me% and 0.151 me%) by T_8 and T_7, while the lowest exchangeable potassium (0.105 me%) was recorded from T_0 as control condition which was statistically similar (0.119 me%) with T_4 (Table 9).

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from April to July 2013 to study the adaptability of NERICA-10 rice in Aus season under organic-inorganic fertilizer management. NERICA-10 was used as the test crop in this experiment. The experiment consisted of 10 treatments. The treatments were as follows: T_0: Control condition (No organic and inorganic fertilizer)- T_1: $N_{120}P_{25}K_{80}$, T_2: $N_{100}P_{20}K_{60}$, T_3: $N_{80}P_{16}K_{50}$, T_4: $N_{60}P_{14}K_{40}$, T_5: $N_{40}P_{12}K_{32}$, T_6: $N_{100}P_{20}K_{60}$ + 20 kg N supplement by cowdung, T_7: $N_{80}P_{16}K_{50}$ + 40 kg N supplement by cowdung, T_8: $N_{60}P_{14}K_{40}$ + 60 kg N supplement by cowdung and T_9: $N_{40}P_{12}K_{32}$ + 80 kg N supplement by cowdung. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Data on different growth parameter, yield contributing characters, yield, nutrient content in grain and straw, nutrient uptake by grain &and straw and characteristics of post harvest soil was recorded and statistically significant variation was observed for different treatments.

At the different days after transplanting (DAS) and at harvest the longest plant (24.40, 48.94, 79.74, 83.62 and 98.11 cm) was recorded from T_7 while, at the same DAS the shortest plant (15.77, 35.34, 56.96, 66.56 and 77.21 cm) was observed from T_1. The maximum number of effective tillers hill^{-1} (13.73) was found from T_7 and the minimum number of effective tillers hill^{-1} (8.60) was obtained from T_0. The maximum number of in-effective tillers hill^{-1} (3.20) was observed from T_7, whereas the minimum number of in-effective tillers hill^{-1} (2.07) was recorded from T_0 as control condition. The maximum number of total tillers hill^{-1} (16.93) was found from T_7 and, the minimum number of total tillers hill^{-1} (10.67) was obtained from T_0. The longest panicle (22.74 cm) was recorded from T_7, whereas the shortest panicle (15.33 cm) was observed from T_0. The maximum number of filled grains plant^{-1} (90.22) was observed from T_7 and the minimum number of filled grains plant^{-1} (69.87) was recorded from T_0. The maximum number of unfilled grains plant^{-1} (7.82) was found from T_7, whereas the minimum number of unfilled grains plant^{-1} (5.79) was recorded from T_0. The maximum number of total grains plant^{-1} (98.04) was obtained from T_7, again the minimum number of total grains plant^{-1} (75.65) was found from T_0. The highest weight of 1000 grains (31.01 g) was found from T_7, whereas the minimum weight of 1000 grains (24.96 g) was recorded from T_0. The highest grains yield (2.93 t ha^{-1}) was observed from T_7 and the lowest grain yield (1.28 t ha^{-1}) was found from T_0. The highest straw yield (3.54 t ha^{-1}) was obtained from T_7, while the lowest straw yield (2.17 t ha^{-1}) was found from T_0. The highest biological yield (6.46 t ha^{-1}) was recorded from T_7, whereas the lowest biological yield (3.45 t ha^{-1}) was observed from T_0. The highest harvest index (45.27%) was obtained from T_7, while the lowest harvest index (37.10%) was found from T_0.

The highest N, P, K, S and Zn concentration in grain (0.768%, 0.323%, 0.398%, 0.127% and 0.0166%) was observed from T_7, whereas the lowest N, P, K, S and Zn concentration in grain (0.385%, 0.176%, 0.219%, 0.069% and 0.0080%) was found from T_0. The highest N, P, K, S and Zn concentration in straw (0.518%, 0.088%, 1.208%, 0.094% and 0.0050%) was recorded from T_7, while the lowest N, P, K, S and Zn concentration in straw (0.267%, 0.033%, 0.566%, 0.046% and 0.0026%) was observed from T_0. The highest N, P, K, S and Zn uptake by grain (22.50 kg ha^{-1}, 9.46 kg ha^{-1}, 11.66 kg ha^{-1}, 3.72 kg ha^{-1} and 0.49 kg ha^{-1}) was observed from T_7, whereas the lowest N, P, K, S and Zn uptake by grain (4.93 kg ha^{-1}, 2.25 kg ha^{-1}, 2.80 kg ha^{-1}, 0.88 kg ha^{-1} and 0.10 kg ha^{-1}) was recorded from T_0. The highest N, P, K, S and Zn uptake by straw (18.34 kg ha^{-1}, 3.12 kg ha^{-1}, 42.76 kg ha^{-1}, 3.33 kg ha^{-1} and 0.18 kg ha^{-1}) was found from T_7, while the lowest N, P, K, S and Zn uptake by straw (5.79 kg ha^{-1}, 0.72 kg ha^{-1}, 12.28 kg ha^{-1}, 1.00 kg ha^{-1} and 0.06 kg ha^{-1}) was observed from T_0. The highest pH (7.22) was obtained from T_8 and the lowest pH (6.04) was found from T_0. The highest organic matter (1.55%) was recorded from T_8, whereas the lowest organic matter (1.21%) was observed from T_0. The highest total nitrogen (0.070%) was observed from T_5 and the lowest total nitrogen (0.021%) was found from T_0. The highest available phosphorous (9.83 ppm) was recorded from T_5, whereas the lowest available phosphorous (3.98 ppm) was observed from T_0. The highest exchangeable potassium (0.173 me%) was found from T_5, while the lowest exchangeable potassium (0.105 me%) was recorded from T_0.

Applications of 60 kg cowdung, 60 kg N, 14 kg P_2O_5 and 40 kg K_2O ha^{-1}) was the superior among the other treatments in consideration of yield contributing characters and yield of NERICA 10 rice under the climatic condition of Bangladesh.

Considering the results of the present experiment, further studies in the following areas may be suggested:

1. Such study is needed to be repeated in different agro-ecological zones (AEZ) of Bangladesh for the evaluation of regional adaptability,
2. Other organic manure and doses of chemical fertilizer may be used for further study, and
3. Other combination of organic manures and chemicals fertilizer may be used for further study to specify the specific combination.

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APPENDIXCES

Appendix I. Monthly record of air temperature, rainfall, relative humidity, soil temperature and Sunshine of the experimental site during the period from April to August 2013

Month (2013)	*Air temperature (ºc)		*Relative humidity (%)	*Rain fall (mm) (total)	*Sunshine (hr)
	Maximum	Minimum			
April	24.5	12.4	68	00	5.7
May	27.1	16.7	67	30	6.7
June	31.4	19.6	54	11	8.2
July	33.6	23.6	69	163	6.4
August	33.2	25.4	72	195	6.3

* Monthly average,
Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka - 1212

Appendix II. Analysis of variance of the data on plant height of NERICA 10 rice as influenced by organic-inorganic fertilizer management

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at				
		30 DAT	40 DAT	50 DAT	60 DAT	at harvest
Replication	2	0.410	0.060	0.101	2.758	0.118
Treatment	9	13.386**	22.585**	43.478**	85.550**	155.036**
Error	18	71.203	4.079	1.526	4.733	3.890

**: Significant at 0.01 level of probability

Appendix III. Analysis of variance of the data on yield contributing characters of NERICA 10 rice as influenced by organic-inorganic fertilizer management

Source of variation	Degrees of freedom	Mean square						
		Number of effective tillers $hill^{-1}$	Number of in-effective tillers $hill^{-1}$	Number total tillers $hill^{-1}$	Length of panicle (cm)	Number of filled grains $plant^{-1}$	Number of unfilled grains $plant^{-1}$	Number of total grains $plant^{-1}$
Replication	2	0.087	0.002	0.067	0.157	5.406	0.183	3.659
Treatment	9	12.928**	1.031**	14.08**	16.445**	335.453**	11.395**	228.08**
Error	18	0.789	0.246	1.490	1.138	9.605	0.707	7.293

**: Significant at 0.01 level of probability

Appendix IV. Analysis of variance of the data on yield contributing characters and yield of NERICA 10 rice as influenced by organic-inorganic fertilizer management

Source of variation	Degrees of freedom	Mean square				
		Weight of 1000 seeds (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	0.119	0.020	0.080	0.181	0.240
Treatment	9	8.303**	4.917**	2.341**	13.858**	48.823**
Error	18	0.363	0.304	0.271	1.025	2.487

**: Significant at 0.01 level of probability

Appendix V. Analysis of variance of the data on N, P, K, S and Zn concentrations in grain of NERICA 10 rice as influenced by organic-inorganic fertilizer management

Source of variation	Degrees of freedom	Mean square				
		Concentration (%) in grain				
		N	P	K	S	Zn
Replication	2	0.001	0.0001	0.0001	0.0001	0.0001
Treatment	9	0.007**	0.003**	0.002**	0.001**	0.001**
Error	18	0.001	0.0001	0.0001	0.0001	0.0001

**: Significant at 0.01 level of probability

Appendix VI. Analysis of variance of the data on N, P, K, S and Zn concentrations in straw of NERICA 10 rice as influenced by organic-inorganic fertilizer management

Source of variation	Degrees of freedom					
		Concentration (%) in straw				
		N	P	K	S	Zn
Replication	2	0.0001	0.0001	0.001	0.0001	0.0001
Treatment	9	0.007**	0.0001**	0.037**	0.0001**	0.0001**
Error	18	0.0001	0.0001	0.005	0.0001	0.0001

**: Significant at 0.01 level of probability

Appendix VII. Analysis of variance of the data N, P, K, S and Zn uptake by grain of NERICA 10 rice as influenced by organic-inorganic fertilizer management

Source of variation	Degrees of freedom	Mean square				
		Uptake by grain (kg ha^{-1})				
		N	P	K	S	Zn
Replication	2	1.367	0.450	0.376	0.162	0.121
Treatment	9	152.54**	15.047**	31.116**	3.536**	1.167**
Error	18	12.136	1.684	1.801	0.333	0.034

**: Significant at 0.01 level of probability

Appendix VIII. Analysis of variance of the data N, P, K, S and Zn uptake by straw of NERICA 10 rice as influenced by organic-inorganic fertilizer management

Source of variation	Degrees of freedom	Mean square				
		Uptake by straw (kg ha^{-1})				
		N	P	K	S	Zn
Replication	2	2.317	0.127	5.352	0.078	0.032
Treatment	9	16.146**	0.328*	149.435**	0.556**	0.413**
Error	18	4.372	0.168	34.135	0.168	0.034

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix IX. Analysis of variance of the data on the post harvest soil of NERICA 10 rice as influenced by organic-inorganic fertilizer management

Source of variation	Degrees of freedom	Mean square				
		pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me %)
Replication	2	0.015	0.010	0.0001	0.196	0.0001
Treatment	9	0.123**	0.034**	0.0001**	9.904**	0.001**
Error	18	0.030	0.011	0.0001	2.493	0.0001

**: Significant at 0.01 level of probability