PERFORMANCE OF NERICA RICE IN AUS SEASON UNDER INTEGRATED NUTRIENT MANAGEMENT SYSTEM

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A Thesis

Submitted to the Department of Soil Science
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE (M.S.)
IN
SOIL SCIENCE

SEMESTER: JANUARY-JUNE, 2013

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CERTIFICATE

This is to certify that the thesis entitled **"PERFORMANCE OF NERICA RICE IN AUS SEASON UNDER INTEGRATED NUTRIENT MANAGEMENT SYSTEM"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) IN SOIL SCIENCE**, embodies the results of a piece of *bona fide* research work carried out by **MD. KASHEDUL,** Registration No. 11-04705, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.

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

Dated:

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DEDICATED

TO

MY BELOVED PARENTS AND

RESPECTED TEACHERS

ACKNOWLEDGEMENT

All praises to the Almighty Allah who enable me to complete a piece of research work and prepare this thesis for the degree of Master of Science (M.S.) in Soil Science.

I feel much pleasure to express my gratitude, sincere appreciation and heartfelt indebtedness to my reverend research supervisor Professor Dr. Alok Kumar Paul, Department of Soil Science, Sher-e-Bangla Agricultural University (SAU), Dhaka-1207, Bangladesh for his scholastic guidance, support, encouragement, valuable suggestions and constructive criticism throughout the study period.

I also express my gratefulness to respected co-supervisor, Most. Afrose Jahan, Professor and honorable Chairman, Department of Soil Science, Sher-e-Bangla Agricultural University (SAU), Dhaka-1207 for her constant inspiration, valuable suggestions, cordial help, heartiest co-operation, providing all facilities and supports which were needed to completing the study.

I would like to express my sincere gratitude to my respectable teacher Jharna Rani Sarkar, Assistant Professor, Department of Soil Science, Sher-e-Bangla Agricultural University (SAU), Dhaka-1207 for her valuable advise and providing necessary facilities to conduct the research work.

I would like to express my deepest respect and thanks to all my honorable teachers of the Department of Soil Science, Sher-e-Bangla Agricultural University (SAU) for their valuable suggestions, instructions, cordial help and encouragement.

I am extremely thankful to all MS student of July-Dec./2011 and Jan.-June/2012 semester, all officers and staffs of the Department of Soil Science, Sher-e-Bangla Agricultural University (SAU), Dhaka-1207 for their kind support and sincere co-operation during my study.

Finally, I express my deepest sense of gratitude to my beloved parents, brothers, sisters, other family members, relatives, well wishers and friends for their inspiration, help and encouragement throughout the study.

Dhaka, Bangladesh ***The Author***

June, 2013

ABSTRACT

A field experiment was conducted to assess the effect of integrated nutrient management on the growth and yield of NERICA 10 at the research farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during Aus season (Mid March-July), 2012. 100 kg N form urea and 20 kg N substituted by vermicompost (T_3 Treatment) produced the maximum yield and yield attributing characters of NERICA 10. But the effect of vermicompost along with nitrogenous fertilizer was the most pronounced than that of cowdung or nitrogenous fertilizer alone. Similar effects were also observed on N, P, K, S content and their uptake by NERICA 10. The effect of 100 kg N from urea along with 20 kg N from vermicompost (T_3 Treatment) was statistically identical to 100 kg N from urea with 20 kg N substituted by cowdung (T_4 Treatment), 80 kg N from urea with 40 kg N substituted by vermicompost (T_5 Treatment), 80 kg N from urea with 40 kg N substituted by cowdung (T_6 Treatment), 60 kg N from urea with 60 kg N substituted by vermicompost (T_7 Treatment), 40 kg N from urea with 80 kg N substituted by vermicompost (T_9 Treatment) and 100% N substituted by equal portion of vermicompost and cowdung (T_{11} Treatment). The effect of 100 kg N from urea along with 20 kg N from vermicompost (T_3 Treatment) was dissimilar with Control (T_1 Treatment), 100% recommended N i.e.120 kg nitrogen / ha (T_2 Treatment), 60 kg N from urea with 60 kg N substituted by cowdung (T_8 Treatment) and 40 kg N from urea with 80 kg N substituted by cowdung (T_{10} Treatment). In post harvest soils, the contents of total nitrogen, available phosphorus, exchangeable potassium and available sulphur increased due to application of cowdung and vermicompost compared to initial soil. In the contrary, soil pH value decreased slightly as compared to that of initial soil. The overall results indicate that 100 kg N from urea along with 20 kg N from vermicompost was the best treatment in producing higher rice yield with sustenance of soil fertility.

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CHAPTER I

INTRODUCTION

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. Bangladeshi officials say NERICA, the New Rice for Africa, developed around a decade ago by an institute in Ivory Coast, could boost the food security in Bangladesh as global weather patterns make that task more challenging. The country initially trialed NERICA, which is drought-resistant and fast-growing, in 2009 and after better-than-expected field results last year a nationwide trial has been rolled out involving 1,500 farmers.

In 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 farmers cultivate vegetable crops.

NERICA is a drought tolerant short duration crop usually requires 90-100 days. 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.

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 and is very high-yielding. In contrast, many rice strains now popular with Bangladesh's ten millions of farmers require a large amount of water, forcing farmers, 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, according to the BADC, which provides some 70 percent of the rice and cereal seeds used by local farmers. 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 tube wells 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 in Bangladesh, development of proper fertilizer management strategy is one of the most important agronomic practices for its successful adoption in Bangladesh.

Integrated Nutrient Management (INM) maintains soils as storehouses of plant nutrients that are essential for vegetative growth. INM's goal is to integrate the use of all natural and man-made sources of plant nutrients, so that crop productivity increases in an efficient and environmentally benign manner, without sacrificing soil productivity of future generations. INM relies on a number of factors, including appropriate nutrient application and conservation and the transfer of knowledge about INM practices to farmers and researchers.

Integrated nutrient management (INM) implies the maintenance or adjustment of soil fertility and of plant nutrient supply to an optimum level for sustaining the desired crop productivity on one hand and to minimize nutrient losses to the environment on the other. It is achieved through efficient management of all nutrient sources. Nutrient sources to a plant growing on a soil include soil minerals and decomposing soil organic matter, mineral and synthetic fertilizers, animal manures and composts, by-products and wastes, plant residue, and biological nitrogen fixation (BNF). Irrigation water and aerial deposition generally are minor nutrient sources. The INM is, however, not a matter of conserving soil nutrient alone, but rather it combines organic and mineral methods of soil fertility management with physical and biological measures of soil and water conservation. It integrates technologies that are site-specific to agronomic and socio-economic conditions to redress nutrient imbalances and organic matter deterioration.

The INM must essentially look into three main challenges: (i) judicious use of mineral fertilizers; (ii) maximize use of organic materials; and (iii) minimize negative environmental impacts. The overall strategy of INM, for determining the yield-based nutrient requirements, involves several steps, for example (i) availability of on-farm and off-farm resources; (ii) yield target based on resource availability; (iii) nutrient requirement to achieve desired yield; (iv) integration of mineral and organic fertilizers; (v) time and method of fertilizer application; (vi) efficient soil and water conservation measures; and (vii) sustaining physical, chemical, and biological fertility of soils. From an experiment it was found that the hybrid rice Chinese cultivar-Sonarbangla-1 produced a 20% higher rice yield (7.55 t ha^{-1}) than the check variety, BRRI Dhan-29, (6.26 t ha^{-1}) in Bangladesh (Parvez *et al.*, 2003).

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

Combined application of cowdung and vermicompost along with chemical nitrogen fertilizer improves soil health and soil productivity but only use of nitrogenous fertilizer for a long period causes deterioration of physical condition and organic matter status and reduces crop yield. When cowdung and vermicompost are applied along with chemical fertilizers for efficient growth of crop, decline in organic carbon is arrested and the gap between potential yield and actual yield is bridged to large extent (Rabindra *et al.*, 2005). Now a days, it is the demand of time to develop an integrated nutrient management programm for higher crop yield and improve soil health ultimately increase the crop sustainability. Keeping these facts in mind the following objectives are undertaken:

1. To observe the performance of NERICA 10 rice variety in Aus season of Bangladesh.
2. To increase the Aus rice cultivation with proper short duration variety viz. NERICA before transplanted Aman cultivation.
3. To maintain the soil health by adopting Integrated Nutrient Management system in rice cultivation.

Chapter II
Review of Literature

CHAPTER II

REVIEW OF LITERATURE

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

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

2.1.1 Nitrogenous fertilizers

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

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

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

Salahuddin *et al.* (2009) conducted an experiment to study the effect of nitrogen levels and plant spacing on the yield and yield contributing characters of T. aman rice (var. BRRI dhan31) and found that panicle length increased with the increase of nitrogen rate up to 150 kg N ha^{-1} and thereafter declined. The longest panicle (24.50

cm) was observed when 150 kg N ha^{-1} was applied and the shortest (18.15 cm) from control. Nitrogen nutrient takes part in panicle formation as well as panicle elongation and for this reason, panicle length increased with the increase of N-fertilization up to 150 kg N ha^{-1}.

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

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

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

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

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

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

Chu Van Hach and Nguyen Thi Hong Nam (2006) conducted a field experiment in Vietnam during the rainy and summer seasons of 2004 to study the effects of N fertilizer on the growth, yield components and economic efficiency of rice cultivars. During the rainy season, the main plots consisted of 5 rates of N fertilizer (urea) i.e. 0

(control), 30, 60, 90 and 120 kg ha^{-1}. In the summer season, the 5 rates of N fertilizer were control were 0, 40, 80, 120 and 160 kg N ha^{-1}. The results showed that the application of N fertilizer at 60 kg ha^{-1} resulted in the greatest economic efficiency during the rainy season for all cultivars; further increase in the rate of N fertilizer beyond 90 kg N ha^{-1} gave a negative economic efficiency value. During the dry season following the application of 80 kg N ha^{-1} the economic efficiency value was highest for all cultivars. At higher nitrogen rates (120-160 kg N ha^{-1}), economic efficiency values were lowest.

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

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

Singh *et al.* (2000) stated that each incremental dose of N gave significantly higher grain and straw yields of over pre-seeding dose, consequently the crop fertilized with 100 kg N ha^{-1} gave maximum grain yield.

2.1.2 Phosphatic fertilizers

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

Islam *et al.* (2010) conducted a field experiment with five phosphorus rates (0, 5, 10, 20 and 30 kg P ha^{-1}) with four rice genotypes in Boro (BRRI 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}.

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. At higher P_2O_5 rates both polymers coated and non coated treatments produced equivalent yields. The 25 lb P_2O_5 coated TSP treatment produced the greatest returns to producers.

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 ($P<0.05$) decreased plant dry weight, P uptake per plant, and P concentration in plant dry matter of all cultivars in comparison with the control plants. In Fe-P treated plants, significant ($P<0.05$) genotype variation was shown in root morphology including root length, surface area, volume and number of lateral roots. The P uptake per plant from Fe-P by rice was significantly ($P<0.05$) 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.

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

Moula (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.

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.

2.1.3 Potassic fertilizers

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

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

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

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 investigation carried out in pots. A completely randomized design with 3 replications was used. 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. Application of rice hull in combination with NPK fertilizer increased nutrient absorption and rice yield better than with NPK alone, especially at the rate of 1.5 g kg^{-1} soil. 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.

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 $panicle^{-1}$.

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.

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

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

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

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.

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

Singh *et al.* (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.

2.1.4 Sulphur fertilizers

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

Patel *et al.* (2010) conducted a field experiment to study the performance of rice and a subsequent wheat crop along with changes in properties of a sodic soil treated with gypsum, press mud and pyrite under draining and nondraining conditions in a greenhouse experiment. The highest rice yield was obtained with press mud applied at a rate of 50 and 75% gypsum requirement.

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

Bhuvaneswari *et al.* (2007) conducted a field experiment in Tamil Nadu, India during the 2001 kharif season to study the effect of sulphur at varying rates i.e. 0, 20, 40 and 60 kg ha^{-1} with different organic fertilizers i.e. green manure, farmyard manure, sulfitation press mud and lignite fly ash each applied at 12.5 t ha^{-1} on yield, S use efficiency and S optimization of rice cv. ADT 43. The results revealed that rice responded significantly to the application of S and organic compared to the control. The highest grain (5,065 kg ha^{-1}) and straw yield (7,525 kg ha^{-1}) was obtained with 40 kg S ha^{-1} application. Green manure addition caused 8.9% increase in grain yield and 10.6% increase in straw yield, closely followed by sulfitation press mud. Sulphur use efficiency was highest at 20 kg ha^{-1} and higher in the presence of organic fertilizers.

Bhuvaneswari and Chandrasekharan (2006) conducted a field experiment in Annamalainagar, Tamil Nadu, India during the kharif season of 2001 to study the effects of organic manures and sulphur on yield and nutrient uptake by rice (cv. ADT-43). The treatments consisted of 4 levels of S (0, 20, 40 and 60 kg ha^{-1}) applied through gypsum and various organic fertilizers (green manure, farmyard manure, sulfitation press mud and lignite flyash) applied at 12.5 t ha^{-1} each. The sulphur and organic fertilizers significantly enhanced yield and nutrient uptake. The highest grain (5,065 kg ha^{-1}) and straw (7,524 kg ha^{-1}) yields, and uptake of N, P, K and S were obtained with the application of 40 kg S ha^{-1}. Sulphur use efficiency was greatest at 20 kg S ha^{-1}. Among the organic fertilizers green manure, closely followed by sulfitation press mud, registered the highest rice yield, sulphur use efficiency, and uptake of N, P, K and S.

Singh *et al.* (2005) conducted a field experiment during the kharif season on an Inceptisol in Varanasi, Uttar Pradesh, India to study the effect of S and Mn fertilizer application on the content and quality of bran oil of different rice cultivars viz. Pant-12 (short duration), Swarna (long duration) and Malviya-36 (medium duration). The treatments comprised S and Mn applied at 0, 25, 50 and 0, 10, 20 kg ha^{-1} through gypsum and $MnCl_2$, respectively and their combinations. A uniform application of recommended doses of N, P and K was given in all the experimental plots. Application of both S and Mn significantly enhanced the bran content and yield of rice over the control. The highest dose of Mn and S on an average caused an increase of 15.2 and 45.0% in bran oil yield over the control, respectively. Increasing levels of S brought about noticeable increment in the percentage of unsaturated fatty acids, including PUFA indicating improvement in the quality of bran oil.

Azmi *et al.* (2004) studies on long-term influence of four fertility levels and management practices under rice-wheat-sorghum and rice-mustard-mungbean rotations on soil fertility build-up and the yield of crops are being carried out in a Calciorthent of Pusa, Bihar, India. Increasing fertility levels significantly increased the crop yield and S uptake under both rotations. Depth-wise distribution of available S was also studied from the same experiment and the results revealed that high fertility level increased the available S at all the soil depths investigated. However, at medium and high fertility, available S was almost equal beyond 30-45 cm depth under rice-wheat-sorghum rotation. Higher fertility reduced leaching losses to some extent. Accumulation of available S under rice-wheat-sorghum rotation was higher at all the depths as compared to rice-mustard-mungbean rotation due to higher amount of S added under the former rotation. However, S movement down the depth was more in case of rice-wheat-sorghum rotation. Rice-mustard-mungbean rotation removed more

S from surface soil but at the same time it restricted the downward movement up to only 45 cm.

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

Singh and Singh (2002) carried out a field experiment to see the effect of different S levels (0, 20 and 40 kg ha^{-1}) on rice cv. Swarna and PR 108 in Varanasi, Uttar Pradesh, India. They reported that plant height, tillers m^{-2}, dry matter production, panicle length and grains $panicle^{-1}$ was significantly increased with increasing levels of S up to 40 kg ha^{-1}.

Sarfaraz *et al.* (2002) conducted a field experiment to determine the effect of different S fertilizers at 20 kg ha^{-1} on crop yield and composition of rice cv. Shaheen Basmati in Pakistan. They found that the number of tillers m^{-2}, 1000-grain weight, grain and straw yields were significantly increased with the application of NPK and S fertilizers compared to the control. They also found that NPK concentrations and their uptake in grain and straw significantly increased with the application of NPK + S fertilizers compared to the control. They also found that NPK concentrations and their uptake in grain and straw significantly increased with the application of NPK + S fertilizers compared to the control.

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

Yang *et al.* (2001) studied the effects of sulphur fertilizer and nitrogen sulphur fertilizers with rice cv. Weiyou 63 in Fujian, China and found that in S fertilizer treated plots (6.9 mg available S kg^{-1} soil) fertilized with 20 and 40 kg N ha^{-1}. Plants had a greater number of panicles and higher fertility than control plants without S fertilizer treatment. On the other hand in NS treated plots (receiving N rates of 0, 150 and 210 kg ha^{-1}, and S rates of 0 , 30 and 60 kg ha^{-1}) the highest yield 8850 kg ha^{-1} was obtained with 150 kg N ha^{-1} + 60 kg S ha^{-1}. However, they further stated that the optimum ratio for NS fertilizer was 4:1.

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

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

Vaiyapuri and Chandrasekharan (2001) conducted an experiment on integrated use of green manure (3.5 t ha^{-1}) with graded levels of sulphur (0, 20 and 40 kg ha^{-1}) applied through three different sources in rice cv. ADT 37. They reported that the highest rice yield (5.3 t ha^{-1}) was obtained when green manure was applied along with pyrite at 20 kg S ha^{-1} which was comparable with pyrite applied at 40 kg ha^{-1} in the absence of green manure.

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

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

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

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

Naing *et al.* (2010) conducted a field experiment to investigate the effect of organic (cowdung) and inorganic fertilizers on growth and yield of five upland black glutinous rice varieties and soil property. Soil samples before fertilizer application and after harvesting were analyzed to determine chemical and physical properties. Leaf Area Index (LAI) and shoot dry matter were recorded at 40 days after planting, panicle initiation and flowering stages. Number of tillers and panicles per hill and grains per panicle, thousand grain weight, number of filled and unfilled grains and grain yield were recorded at harvest time. The results indicated that using the combination of FYM, cowdung and inorganic fertilizers increased shoot dry matter, leaf area index (LAI), tiller and panicle number per hill, grain number per panicle and grain yield and soil P and K content.

Yadav *et al.* (2010) conducted a field experiment to find the efficacy of substituting fertilizer N at different proportions (25%, 50% and 75% of total N) with organic N sources i.e., farm yard manure (FYM), green leaf manure (GLM), poultry manure and BGA on nutrient uptake (NPK) and yield of rice variety Sarju 52. In general the maximum uptake of the nutrients and grain yield were obtained with the application of 25% N through green manure + 75% through inorganic urea. GLM is more efficient than other orgnic sources at all the proportions of N.

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

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

Gedam *et al.* (2008) carried out a field experiment to study the residual effect of organic manures on growth, yield attributes and yield of rice in groundnut-rice cropping system. It was observed that residual effect of organic manures significantly affected the grain yield of succeeding rice. Application of poultry manure at the rate of 5 t ha^{-1} to groundnut increased the grain yield of rice significantly over the remaining treatments. The grain yield of rice ranged from 30.54 q ha^{-1} in control plot to 46.52 q ha^{-1} due to residue of poultry manure applied to groundnut. Similarly, the direct effect of fertilizer applied to rice was significant in increasing the yield of rice.

Kumar *et al.* (2008) conducted a field experiment on rice-wheat system revealed that the values of all yield attributes were improve significantly due to integrated use of press mud along with recommended doses of fertilizer (RDF). Rice received 10 t press mud ha^{-1} along with RDF produced significantly higher grain yield.

Vennila (2007) conducted a field experiment in rabi season to develop integrated N management practice for wet seeded rice (cv. ADT 38) + daincha dual cropping systems. They reported that 75% recommended dose of N fertilizer + 25% N as poultry manure increased growth, yield attributes and yield and nutrient uptake of rice higher soil available organic carbon, nitrogen and phosphorus.

Kalaivanan and Oma (2007) conducted a field experiment to investigate the effect of enriched pressmud compost on soil chemical properties like pH, EC, major nutrient availability and yields of rice with five levels of pressmud compost viz. 0, 1.25, 2.50, 3.75 and 5.0 t ha^{-1} in three varieties viz. ADT 36, ADT 43 and a hybrid ADTRH 1 during the kharif season. The results of the field experiment revealed that the hybrid ADTRH 1 manifested higher grain and straw yield, whereas the variety ADT 43 and ADT 36 registered lower grain and straw yields, respectively. Application of 1.25 t ha^{-1} of enriched pressmud compost showed its potentiality by providing more available nutrients to promote higher grain yield and it was comparable with 2.50 t ha^{-1} of enriched pressmud compost.

Singh *et al.* (2006) conducted an experiment during kharif 2004, on an Inceptisol in Varanasi, Uttar Pradesh, India to evaluate the effects of chemical fertilizer (urea), cowdung and biofertilizer (*Azospirillum*) on the yield of rice and physicochemical properties of the soil. Application of chemical fertilizer, cowdung and *Azospirillum*, individually or in combinations, significantly increased the yield attributes (plant height, number of tillers, panicle length, grain yield and straw yield) over the control. The treatment comprising 80 kg N ha^{-1} + *Azospirillum* + 2.5 t cowdung ha^{-1} was superior over all other treatments in terms of rice yield.

Kumar and Singh (2006) conducted a field experiment during kharif season of 2003 and 2004 at J.V. College Baraut, Uttar Pradesh, India to study the effect of organic manures and fertilizer treatments on growth, yield and yield attribute of rice (*Oryza sativa* cv Pusa Basmati). The manure treatments comprised organic manures farmyard manure (FYM), poultry manure (PM) and FYM + PM. Fertilizer treatment included N at 0, 40, 80 and 120 kg ha^{-1}. The maximum mean grain yield (45.4 q ha^{-1}) was recorded FYM + PM with N, P and Zn treatment. Over the years, incorporation of FYM, PM and FYM + PM and zinc application along with N in both the years of study significantly increased grain yield of rice over 40 kg N ha^{-1} and in pooled analysis.

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

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

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

Yaduvanshi and Sharma (2005) conducted a field experiment during 2001–02 and 2002–03 at Bhaini Majra experimental farm of Central Soil Salinity Research Institute, Karnal (Haryana) to evaluate the effect of management of wheat residue with *Sesbania* green manuring and sulphitation pressmud (SPM) on soil properties and yield of rice and wheat crops irrigated with sodic water. The results suggest that incorporation of wheat residue 50 days before rice transplanting with green manuring or with sulphitation pressmud along with the recommended dose of fertilizer is necessary to improve and sustain the productivity of rice-wheat system in areas having sodic water.

Mahavishnan *et al.* (2004) conducted a field study on sandy clay loam soil of Hyderabad Andhra Pradesh, India during the kharif season of 2000 to investigate the effect of nutrient management through organic and inorganic sources on the yield of rice cv. BPT 5204. The treatments included: control, fertilizer rate 75% of the recommended rate of fertilizers (RDF= N: P: K at 120:60:40 kg ha^{-1}), 100% RDF, 125% RDF, 125% RDF + farmyard manure at 10 t ha^{-1}. Rice yield and yield components were higher with the application of 125% RDF + PM compared to the other treatments.

Usman *et al.* (2003) conducted a field experiment to study the effects of organic amendment (FYM, poultry manure) on the performance of rice cv. Basmati-2000 was investigation in Faisalabad, Pakistan. Poultry manure showed the maximum leaf area index (46.46%). The treatment also produced the highest number of grains panicle^{-1}, 1000-grain weight and straw yield.

Channabasavanna and Biradar (2003) observed that grain yield increased with each increment of poultry manure application and maximum in 3 t poultry manure ha^{-1} which was 26 and 19% higher than that of the control during 1998 and 1999 respectively and the increase was significant up to 2 t poultry manure ha^{-1}.

More (2003) reported from a 3 year study that the treatment of 25 t FYM ha^{-1} plus 20 t pressmud ha^{-1} was found to be the best in increasing yield of rice.

Vanaja and Raju (2002) conducted a field experiment for one year during 1996-97, in sandy loam soil having pH of 8.4 at Student's Farm College of Agriculture, Hyderabad. Organic manures (Cowdung, poultry manure) and biofertilizers (BGA, *Azospirillum*) alone and in combination with inorganic fertilizer nitrogen were studied on rice crop. The relationship between total dry matter production at maturity and total uptake of nutrients (N, P and K) was highly significant.

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

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

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

Singh and Prasad (2001) reported that the application of FYM @ 10 t ha^{-1} produced 4.64 % higher grain yield than the control.

Channabasavanna and Biradar (2001) conducted an experiment with four sources of organic manure (FYM 7 t ha^{-1}, rice husk 5 t ha^{-1}, poultry manure 2 t ha^{-1} and press mud 2 t ha^{-1}), one control and 3 levels of zinc (0, 25 and 50 kg $ZnSO_4$ ha^{-1}). Application of poultry manure with 25 kg $ZnSO_4$ ha^{-1} recorded significantly higher yields over rest of the treatments. The residual effect was more prominent when rice husk was applied. They also cited that organic manure increased panicle $hill^{-1}$ and seeds $panicle^{-1}$.

Mannan *et al.* (2000) reported that manuring with cowdung up to 10 t ha^{-1} in addition to recommended inorganic fertilizer with late N application improved grain and straw yields and quality of transplant aman rice over inorganic fertilizers alone.

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

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

Chaudhary *et al.* (2011) conducted a field experiment at Pusa, Bihar to study the effect of inorganic fertilizer in combination with organic sources viz. vermicompost, poultry manure, FYM and green manuring under four dates of transplanting on rice. Maximum grain yield (4.12 t ha^{-1}) was with 75% recommended dose of nitrogen (RDN) + 25% N from dhaincha (*Sesbania aculata L.*) and it was 14.8 and 26.1% higher over 100 and 75% RDN, respectively. The result shows that there was significant reduction in yield attributes, yields and nutrient uptake due to delayed transplanting.

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

Balakrishnan *et al.* (2010) conducted a experiments at Port Blair, to evaluate prickly *sesban* (*Sesbania cannabina*) intercropping in wet-seeded rice under island ecosystem. The result was revealed that though chemical fertilizer + dhaincha or prickly sesban gave higher grain yield and also increased the soil organic matter content.

Singh *et al.* (2010) conducted a experiment to study the effect of N, P and K fertilizers with or without FYM, lime, sulphur and boron on yield, nutrient uptake and fertility status of soil available N, P, K and S. The highest grain yield of rice and pea was recorded in the treatment receiving 50% of recommended dose NPK fertilizers along with application of 5 t FYM + 250 kg lime + 20 kg S + 1 kg B ha^{-1}. Application of lime @ 250 kg ha^{-1} in furrows along with 5 t FYM ha^{-1} and 50% RDF significantly improved the pH of soil after harvest of pea crops.

Kabir *et al.* (2009) conducted a experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh in transplanted *Aman* season 2008 to find out the effect of urea super granules (USG), prilled urea (PU) and poultry manure (PM) on the yield and yield attributes of transplant *Aman* rice varieties. Two transplant *Aman* rice varieties viz. BRRI dhan 41 and BRRI dhan 46 and ten levels of integrated nutrient management encompassing USG, PU and PM were tested following randomized complete block design with three replications. It was observed that combined use of chemical fertilizer and manure gave the higher yield of rice and improvement of soil fertility P, K and S content.

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

Naik and Yakadri (2007) conducted a field experiment in Hyderabad Andhra Pradesh, India during 2001 wet season to determine the effect of integrated nutrient management on the yield of rice hybrid DRRH-1. The treatments comprised: in the main plots no organic manure (control), green manuring (*Sesbania rostrata*), 10 t farmyard manure ha^{-1}, 2 t gemini compost/ha, 2 t vermicompost ha^{-1}, and 2 t rice husk ash ha^{-1}, in the subplots 50, 100 and 150 kg N ha^{-1}. In green manuring and 150 kg N ha^{-1} fertilizer gave the highest dry matter at harvest, effective tillers m^{-2}, filled grains $panicle^{-1}$, grain yield, straw yield, organic C content and cost-benefit ratio. Rice treated with in situ green manuring + 150 kg N ha^{-1} fertilizer produced the highest grain yield.

Sreelatha *et al.* (2006) conducted a field experiment during 1997/98, in Srikakulam, Andhra Pradesh, India, to evaluate the effects of different integrated nutrient management (INM) components on the yield and nutrient uptake in mesta (*Hibiscus cannabinus*) - rice cropping system. Recommended fertilizer dose of 75 kg N ha $^{-1}$ with 5 t cowdung ha^{-1}, recorded the highest Mesta fiber yield of 25.32 q ha^{-1} as well as the highest rice grain and total (grain + straw) yields of 28.82 and 64.06 q ha^{-1} respectively. The result also showed that N, P and K content in soil were increased due to application of fertilizer and cowdung.

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

Patra *et al.* (2004) conducted a field experiment in kharif 1999 to determine the influence of top dressing *Sesbania sesban* green manure with urea on the nitrogen (N) content of the soil (Typic Ustochrept) and yield of hybrid rice. Results showed that the application of *S. sesban* green manure consistently maintained a lower floodwater pH than the treatment with urea alone. A lower pH of the floodwater has an important implication in flooded rice soils particularly to lowering NH_3 and thereby reducing NH_3 losses. Results indicated that the top dressing of *S. sesban* along with urea has the potential to enhance the yield and N use efficiency of flooded hybrid rice.

Mahavishnan *et al.* (2004) conducted a field study on the effect of nutrient management through organic and inorganic sources on the yield of rice cv. BPT 5204. Rice yield and yield components were higher with the application of 125% recommended dose of fertilizers RDF + poultry manure (PM) compared to the other treatments.

Vipin-Kumar (2003) carried an experiment in Nigeria to determine the effect of goat manure on upland rice. The applications of 10 t ha^{-1} and 20 t ha^{-1} of goat manure produced 1.49 t ha^{-1} and 1.58 ton ha^{-1} grain yields, respectively in the second year. These yields were as good as those obtained with application of chemical fertilizer only or the application of 10 t ha^{-1} of goat manure + top-dressing with 30 kg N ha^{-1}. The application of 30 t ha^{-1} goat manure produced the highest grain yield increase but resulted in more weed and stem borer infestation in those plots.

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

Rajni Rani *et al.* (2001) conducted a pot experiment in a glasshouse of Varanasi, Uttar Pradesh, India during kharif season to assess the response of rice to different combinations of vermicompost, poultry manure and nitrogen fertilizers. Results showed that all integrated treatments significantly increased plant height, number of effective panicles $pot^{-1}$and dry weight $panicle^{-1}$ over the treatment having full N dose through urea.

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

Chapter III
Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted in the Sher-e-Bangla Agricultural University Farm, Dhaka, under the Agro Ecological Zone of Madhupur Tract, AEZ-28 during the *Aus* season of 2012. For better understanding the site, it is shown in the Map of AEZ of Bangladesh (Fig. 1).

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

3.1 Experimental details of site

3.1.1 Soil

The experiment was carried out in a typical rice growing soil of the Sher-e-Bangla Agricultural University (SAU) Farm, Dhaka, during *Aus* season of 2012. The farm belongs to the General soil type, "Deep Red Brown Terrace Soil" under Tejgaon Series. The land was above flood level and sufficient sunshine was available during the experimental period. The morphological, physical and chemical characteristics of initial soil are presented in Tables 1 and 2.

3.1.2 Crop

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

3.1.3 Land preparation

The experimental field was first opened on 1 March 2012 with the help of a power tiller, later the land was saturated with irrigation water and puddled by three successive ploughing and cross-ploughing. Each ploughing was followed by laddering to have a good puddled field. All kinds of weeds and residues of previous crop were removed from the field. The experimental plots were laid out as per treatment and design.

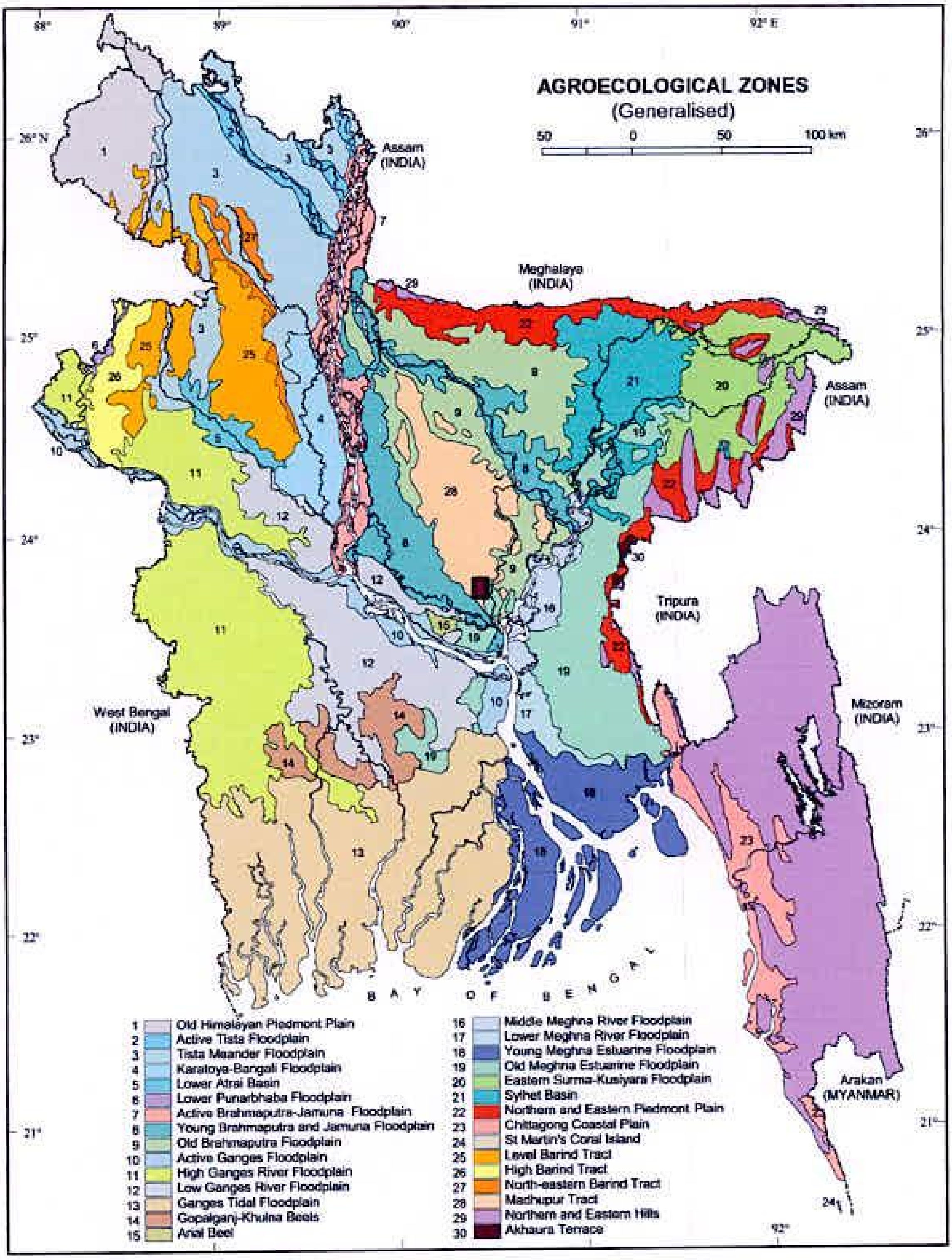


Figure 1. Map showing the experimental site under study

Table 1. Morphological characteristics of the experimental field

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

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

Characteristics	Value
Particle size analysis	
% Sand	28.2
% Silt	41.2
% Clay	30.6
Textural class	Silty-clay
pH	5.6
Bulk Density (g/cc)	1.45
Particle Density (g/cc)	2.52
Organic carbon (%)	0.47
Organic matter (%)	0.81
Total N (%)	0.05
Available P (ppm)	18.1
Exchangeable K (meq/100g soil)	0.10
Available S (ppm)	40

3.1.4 Experimental design

Design: Randomized Complete Block (RCB).

Treatment: 11

Replication: 3

Total number of plots: 33

Plot size: 3.5 m × 2 m

Block to block distance: 2 m

Plot to plot distance: 1 m

3.1.5 Layout of the experiment

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each block was sub-divided into eleven unit plots. The treatments were randomly distributed to the unit plots in each block. The total number of plots was 33 (11×3). The unit plot size was 3.5 m × 2 m. Block to block distance was 2 m and plot to plot distance was 1 m. The layout of the experiment has been shown in Fig. 2.

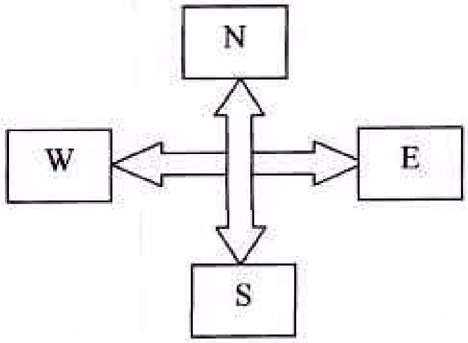
3.1.6 Seed sowing

A standard procedure was followed to sow the seeds of NERICA 10 rice in field. For this purpose, 5 to 7 seeds were sown per stand and later thinned to 4 seedlings at 17 days old. Stand to stand distance was 12 cm.

3.1.7 Collection and preparation of initial soil sample

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

Plot size: 3.5 m x 2 m
Plot to plot distance: 1 m
Block to block distance: 2 m



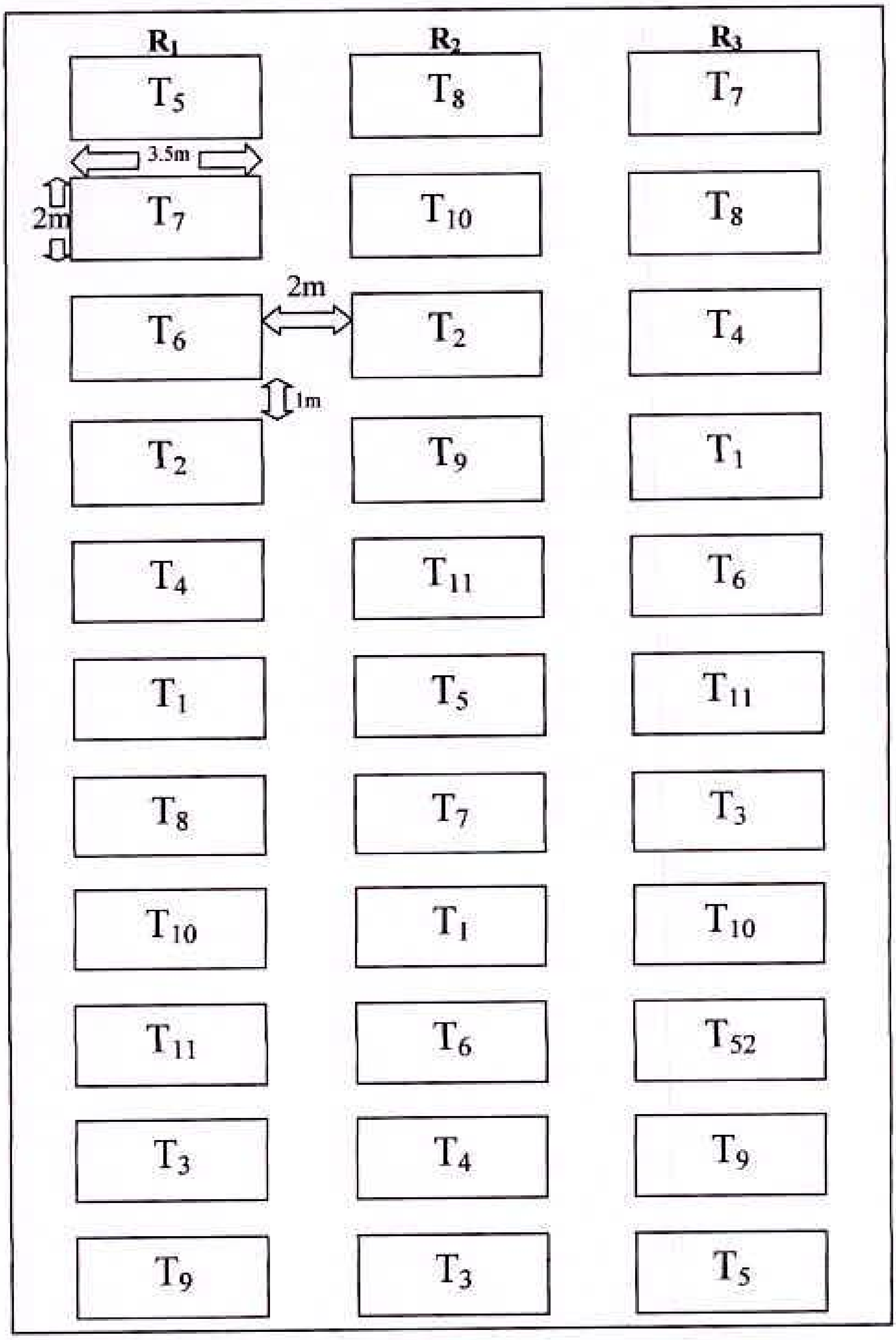


Figure 2. Layout of the experimental field

3.1.8 Treatments

There were 16 treatment combinations. The treatment combinations were as follows:

T_1: No chemical fertilizer, no organic manure (Control)
T_2: 100% recommended N (120 kg nitrogen ha^{-1}) + recommended P,K,S,Zn
T_3: 100 kg N from urea + 20 kg N substituted by vermicompost + recommended P,K,S,Zn
T_4: 100 kg N from urea + 20 kg N substituted by cowdung + recommended P,K,S,Zn
T_5: 80 kg N from urea + 40 kg N substituted by vermicompost + recommended P,K,S,Zn
T_6: 80 kg N from urea + 40 kg N substituted by cowdung + recommended P,K,S,Zn
T_7: 60 kg N from urea + 60 kg N substituted by vermicompost + recommended P,K,S,Zn
T_8: 60 kg N from urea + 60 kg N substituted by cowdung + recommended T_1: P,K,S,Zn
T_9: 40 kg N from urea + 80 kg N substituted by vermicompost + recommended P,K,S,Zn
T_{10}: 40 kg N from urea + 80 kg N substituted by cowdung + recommended P,K,S,Zn
T_{11}: 100% N substituted by equal portion of vermicompost and cowdung + recommended P,K,S,Zn

Note: Urea contain 46% N, Cowdung contain 1% N and Vermicompost contain 2.1% N.

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

Source	Rate ha^{-1}	Time of application
TSP	80 kg	Final land preparation
MP	120 kg	Final land preparation
Gypsum	55 kg	Final land preparation

3.1.9 Application of fertilizers

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

3.1.10 Intercultural operations

The following intercultural operations were done for ensuring the normal growth of the crop. Top dressing of urea was done as per schedule and the normal cultural practices including weeding and insecticides spray were done as and when necessary. There were some incidence of insect attack specially rice hispa, rice stem borer, rice bug, which were controlled by spraying Diazinon pillersuphan, Darsban, and Malathion. Irrigations were also done as and when necessary.

3.1.11 Plant sampling at harvest

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

3.1.12 Harvesting

The crop was harvested at maturity on 22 June, 2012. The harvested crop was threshed plot-wise. Grain and straw yields were recorded separately plot-wise and moisture percentage was calculated after sun drying. Dry weight for both grain and straw were also recorded.

3.1.13 Data collection

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

i) Plant height (cm)
ii) Number of effective and ineffective tillers $hill^{-1}$
iii) Panicle length (cm)
iv) Number of unfilled and filled grains $panicle^{-1}$
v) 1000-grain weight (g)
vi) Grain and straw yields (t ha^{-1})

3.1.13.1 Plant height (cm)

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

3.1.13.2 Number of tillers hill^{-1}

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

3.1.13.3 Panicle length

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

3.1.13.4 Filled and unfilled grains panicle^{-1}

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

3.1.13.5 1000-grain weight

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

3.1.13.6 Grain and straw yields

Grain and straw yields were recorded separately plot-wise and expressed as t ha^{-1} on 14% moisture basis.

3.1.14 Chemical analysis of soil samples

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

3.1.14.1 Particle size analysis

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

3.1.14.2 Soil pH

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

3.1.14.3 Organic carbon

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

3.1.14.4 Total nitrogen

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

3.1.14.5 Available phosphorus

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

3.1.14.6 Exchangeable potassium

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

3.1.14.7 Available sulphur

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

3.1.15 Chemical analysis of plant samples

3.1.15.1 Preparation of plant samples

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

3.1.15.2 Digestion of plant samples with sulphuric acid

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

3.1.15.3 Digestion of plant samples with nitric-perchloric acid mixture

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

3.1.16 Statistical Analysis

The statistical analysis for different character including the nutrient content and uptake were done following the ANOVA technique and the mean results in case of significant F-values were adjusted by the Duncan's Multiple Range Test (DMRT).

Chapter IV

Results and Discussion

CHAPTER IV
RESULTS AND DISCUSSION

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

4.1 Growth and yield components

4.1.1 Plant height

Plant height of NERICA 10 was significantly influenced by cowdung, vermicompost and inorganic nitrogenous fertilizers (Table 4). All the treatment was recorded significantly higher plant height over the control (T_1 treatment). Plant height ranged from 93.21 to 100.3 cm. The tallest plant of 100.3 cm was found in T_5 receiving 80 kg N as a source of urea. Cowdung and vermicompost along with nitrogenous fertilizer performed better in recording plant height compared to other treatment combination except only use of chemical nitrogenous fertilizer in T_5. However, plant height recorded either with single or combined application of nitrogen and manure or vermicompost was higher than that of control treatment. The shortest plant height of 93.21 cm was found in T_1 (control) treatment having no cowdung or vermicompost even any chemical fertilizer. Treatment T_5 receiving 80 kg N from urea fertilizer produced 7.60% higher plant height compared to control treatment (Fig.3). The treatments may be ranked in the order of $T_5 > T_2 > T_{10} > T_{11} > T_9 > T_8 > T_6 > T_7 > T_4 > T_3 > T_1$ treatments. Haque (1999) found that plant height significantly increased with the application of cowdung along with chemical fertilizer. The increased plant height through the application of FYM along with N, P, K and S was also reported by many other scientist (Kobayashi *et al.*, 1989; Maskina *et al.*, 1987). Mostofa *et al.* (2009) observed that the yield contributing characters like plant height was the highest in 100 kg ha^{-1} of K.

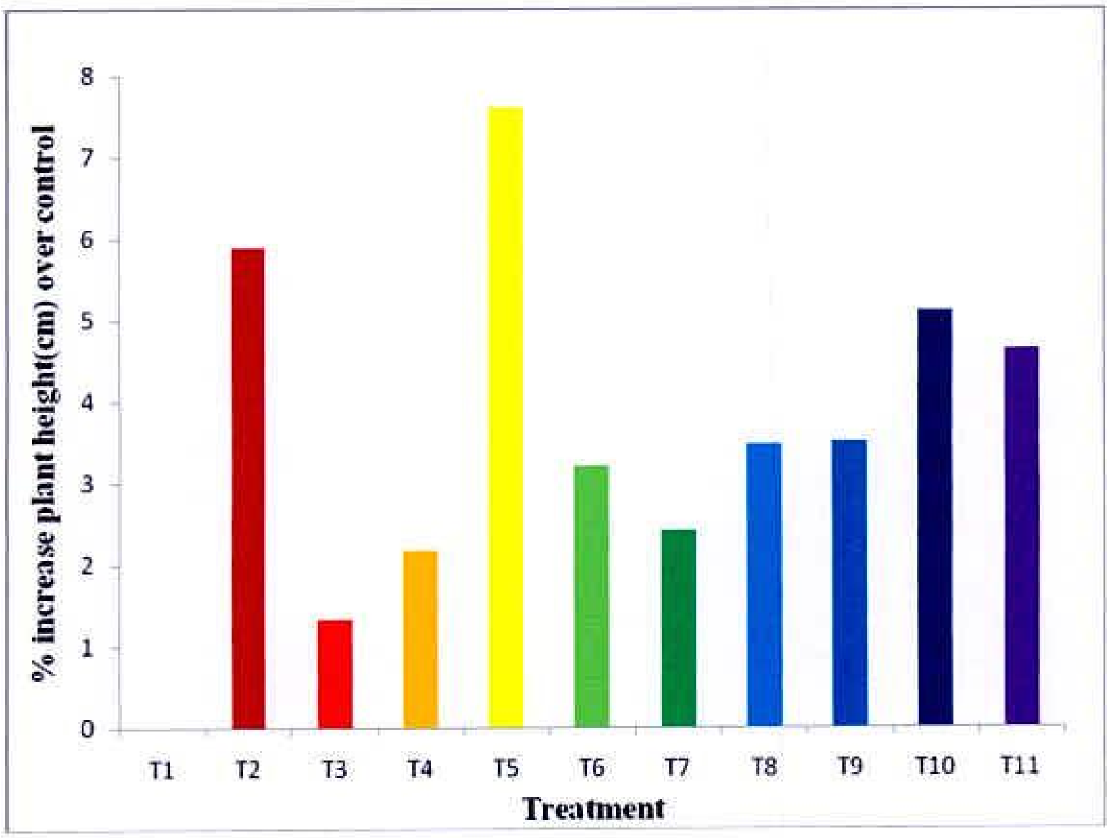


Fig. 3 . Effect of Integrated Nutrient Management on percent increase plant height over control of NERICA 10

4.1.2 Panicle length

The effects of different treatments on panicle length are shown in Table 4. The tallest panicle length (21.34 cm) was found in T_{10} treatment which was statistically identical with almost all other treatments except T_3, T_5, T_8 and T_1 treatments. The shortest panicle (19.32 cm) was observed in T_1 (control). The treatments may be ranked in the order of $T_{10} > T_2 > T_4 > T_7 > T_9 > T_{11} > T_6 > T_3 > T_5 > T_8 > T_1$ in terms of panicle length. Morteza *et al.* (2011) also observed that the panicle length was increased with the application of inorganic fertilizers and manures. Krishnappa *et al.* (2006) reported that increasing K rates increased panicle length. Treatment T_{10} produced 10.45% higher panicle length than control treatment (Fig. 4).

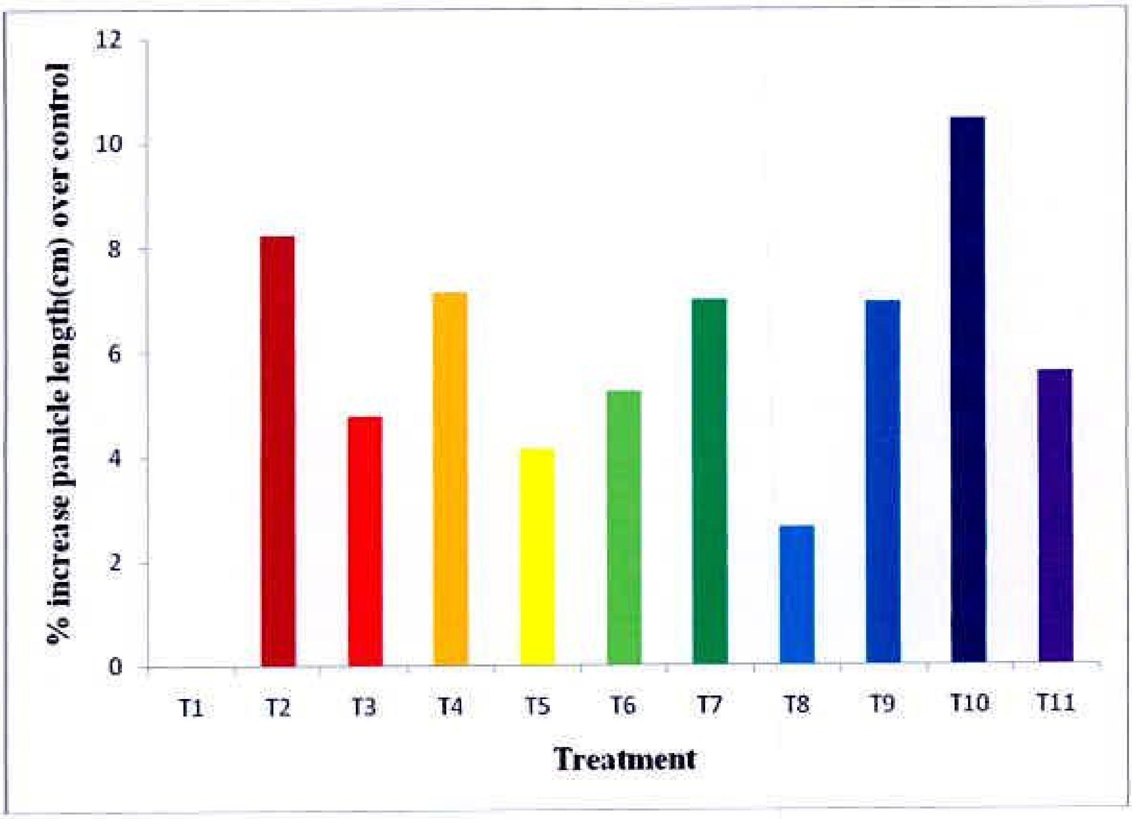


Fig. 4. Effect of Integrated Nutrient Management on percent increase panicle length over control of NERICA 10

4.1.3 Effective tillers hill^{-1}

There was a significant effect of the treatments on number of effective tiller per hill (Table 4). All the treatments significantly produced higher number of effective tiller per hill over control (T_1 treatment). The effective tiller per hill ranges from 8.3 to 12.9. The highest number of effective tiller hill^{-1} (12.9) was found in T_{10} receiving 40 kg N as a source of urea and the lowest was found in T_1 (8.3) treatment. The treatments may be ranked in the order of $T_{10} > T_9 > T_8 > T_7 > T_5 > T_6 > T_4 > T_3 > T_2 > T_{11} > T_1$ in terms of effective tiller hill^{-1}. These results were corroborated with the findings of Uddin *et al.* (2009) who found increased number of effective tiller hill^{-1} with the integrated use of manures and fertilizers. Treatment T_{10} produced 55.42% higher number of effective tiller per hill than control treatment (Fig. 5).

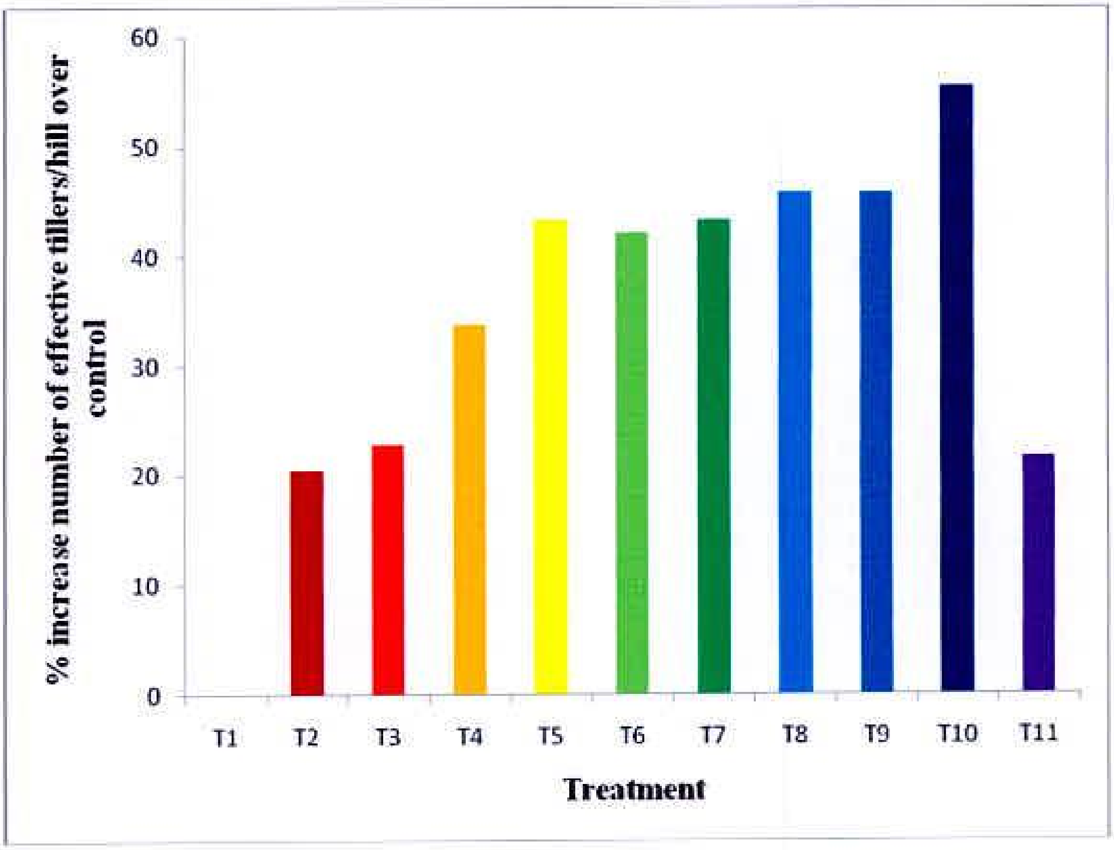


Fig. 5. Effect of Integrated Nutrient Management on percent increase number of effective tillers hill^{-1} over control of NERICA 10

4.1.4 Filled grains panicle^{-1}

There was a significant effect of the treatments on number of filled grains per panicle (Table 4). The number of filled grain panicle^{-1} ranged from 80 to 95. The maximum number of filled grains per panicle (95/panicle) was noted when 100% N substituted by equal portion of vermicompost and cowdung (T_{11}) was applied. The minimum number of filled grains per panicle (80/panicle) was recorded in T_1 treatment receiving no chemical fertilizer and manure. The treatments may be ranked in the order of $T_{11}>T_3>T_6>T_2>T_7>T_8>T_5>T_4> T_{10}>T_9>T_1$ with the respect of the number of filled grain panicle^{-1}. Wang *et al.* (2011) showed that the application of N, P and K fertilizer significantly increased the number of filled grain panicle^{-1}and the highest the number of filled grain panicle^{-1} was found under the combined application of N, P and K fertilizer. Treatment T_{11} produced 18.75% higher number of filled grains per panicle (Fig. 6).

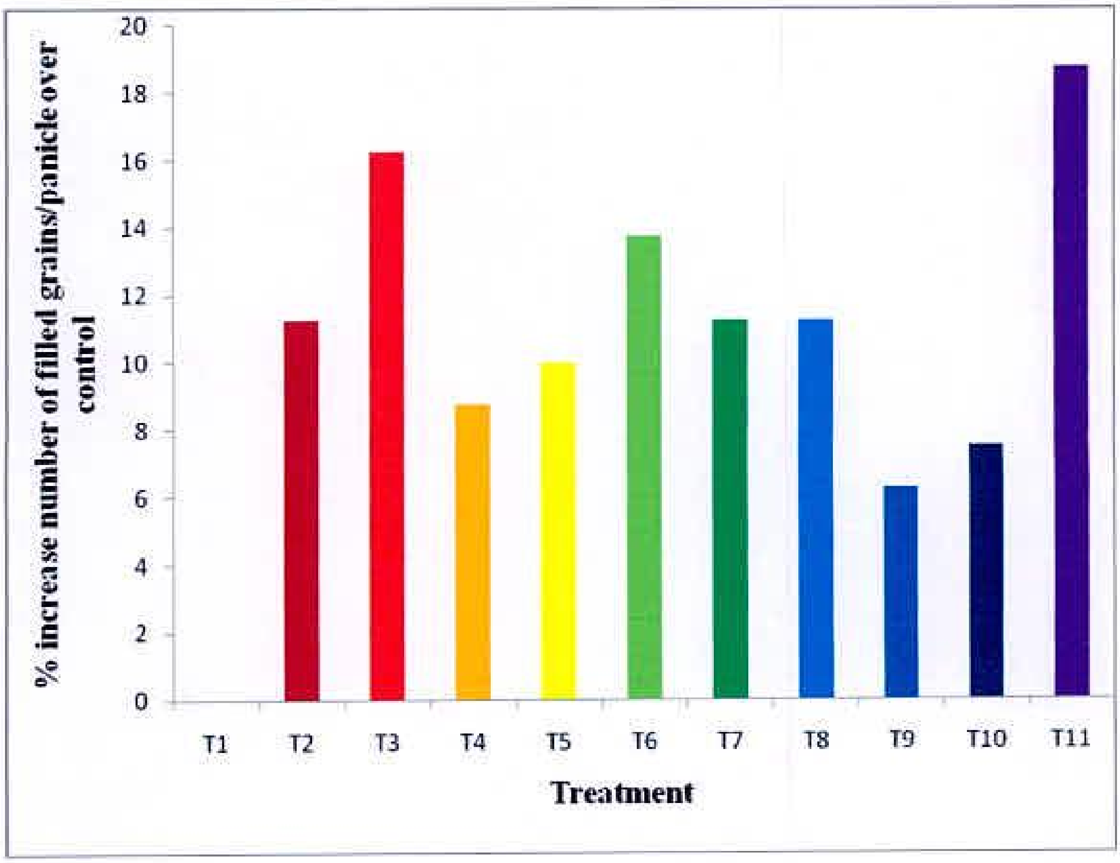


Fig. 6. Effect of Integrated Nutrient Management on percent increase number of filled grains panicle^{-1} over control of NERICA 10

4.1.5 Unfilled grains panicle^{-1}

The effects of different treatments on number of unfilled grains per panicle are shown in Table 4. The number of unfilled grain per panicle ranged from 29 to 36. The highest number of unfilled grains per panicle (36/panicle) was noted in treatment T_1 (Control). The lowest number of unfilled grains per panicle (29/panicle) was recorded in T_5 treatment receiving 80 kg N from urea and 40 kg N/ha from vermicompost. The treatments may be ranked in the order of $T_1>T_4>T_9>T_2> T_{11}>T_6>T_{10}>T_7> T_3>T_8>T_5$ with respect of the number of unfilled grains per panicle. These results were corroborated with the findings of Sarkar and Singh (2002) who found increased the number of filled grains per panicle and decreased the number of unfilled grains per panicle significant increased with the application of N, P, K and S.

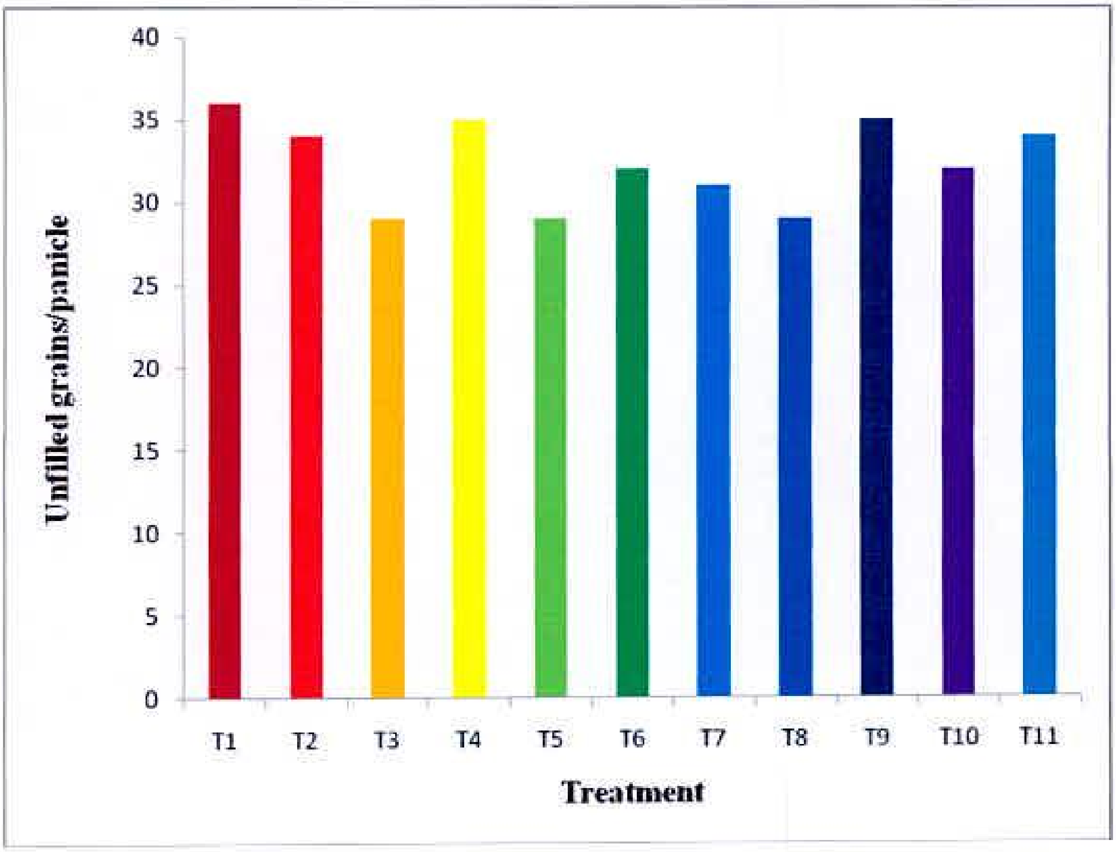


Fig. 7. Effect of Integrated Nutrient Management on number of unfilled grains panicle^{-1} of NERICA 10

4.1.6 1000-grain weight

A significant difference in 1000-grain weight was observed at different levels of nitrogen along with cowdung and vermicompost (Table 4). The 1000-grain weight ranged from 26 to 32.5 g. The highest weight of 1000-grain weight (32.5 g) observed when 100% N substituted by equal portion of vermicompost and cowdung (T_{11} treatment) was applied and the lowest weight of 1000-grain weight (26 g) was observed in T_1 treatment receiving no chemicals or manures. The treatments may be ranked in the order of $T_{11}>T_8>T_9>T_7>T_{10}>T_4>T_6>T_3>T_5>T_2$ with respect of 1000-grain weight. Debiprasad *et al.* (2010) found that application of 120 kg N ha^{-1} through chemical fertilizer with the combination of press mud and cowdung increased 1000-grain weight.

Table 4. Effect of Integrated Nutrient Management on plant height, panicle length, effective tillers hill^{-1}, filled grains panicle^{-1}, unfilled grains panicle^{-1} and 1000-grain weight of NERICA 10.

Treatment	Plant height (cm)	Panicle length (cm)	Effective tillers hill^{-1}(no.)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000-grain weight (g)
T_1	93.21f	19.32d	8.3e	80e	36a	26f
T_2	98.71b	20.91ab	10d	89bcd	34abc	26.5ef
T_3	94.45ef	20.24bcd	10.2d	93ab	29d	27de
T_4	95.23de	20.70abc	11.1c	87cd	35ab	29c
T_5	100.3a	20.12bcd	11.9b	88cd	29d	27de
T_6	96.20cd	20.33abcd	11.8b	91abc	32bcd	27.5d
T_7	95.45de	20.67abc	11.9b	89bcd	31cd	30.5b
T_8	96.45cd	19.83cd	12.1b	89bcd	29d	32a
T_9	96.47cd	20.66abc	12.1b	85d	35ab	31b
T_{10}	97.97b	21.34a	12.9a	86d	32bcd	29c
T_{11}	97.54bc	20.40abc	10.1d	95a	34abc	32.5a
$LSD_{0.05}$	1.445	1.040	0.533	4.364	3.609	0.502
CV (%)	0.88	2.99	2.81	2.90	6.55	1.02

Means in a column followed by same letter(s) are not significantly different at 5% level of significance by LSD.

T_1: No chemical fertilizer, no organic manure (Control)
T_2: 100% recommended N (120 kg nitrogen ha^{-1}) + recommended P,K,S,Zn
T_3: 100 kg N from urea + 20 kg N substituted by vermicompost + recommended P,K,S,Zn
T_4: 100 kg N from urea + 20 kg N substituted by cowdung + recommended P,K,S,Zn
T_5: 80 kg N from urea + 40 kg N substituted by vermicompost + recommended P,K,S,Zn
T_6: 80 kg N from urea + 40 kg N substituted by cowdung + recommended P,K,S,Zn
T_7: 60 kg N from urea + 60 kg N substituted by vermicompost + recommended P,K,S,Zn
T_8: 60 kg N from urea + 60 kg N substituted by cowdung + recommended T_1: P,K,S,Zn
T_9: 40 kg N from urea + 80 kg N substituted by vermicompost + recommended P,K,S,Zn
T_{10}: 40 kg N from urea + 80 kg N substituted by cowdung + recommended P,K,S,Zn
T_{11}: 100% N substituted by equal portion of vermicompost and cowdung + recommended P,K,S,Zn

4.2 Yields

4.2.1 Grain yield

The grain yield of NERICA 10 varied significantly due to application of different rates of fertilizer treatments (Table 5). The grain yield ranged from 1.50 to 4.35 t ha^{-1}. The highest grain yield (4.35 t ha^{-1}) was observed in T_3 treatment receiving 100 kg N from urea and 20 kg N substituted by vermicompost. The lowest value (1.50 t ha^{-1}) was recorded in T_1 (control) treatment. The treatment T_3 produced the highest grain yield than other treatments. Second highest yield (4.20 t ha^{-1}) was found in T_8 treatment receiving 60 kg N from urea which was identical with T_6, T_4, T_{11}, T_9, T_2, T_5 and T_{10} treatments. The treatments may be ranked in the order of $T_3>T_8> T_6>T_4> T_{11}>T_9>T_2>T_5>T_{10}>T_7>T_1$ with respect of grain yield. The percent increase in grain yield over control ranged from 133.33 to 190.00% where the highest increase was obtained in T_3 treatment and the lowest was obtained in T_7 treatment (Fig. 8). Yadav *et al.* (2010) reported that grain yield was significantly increased due to application of chemical fertilizers and residual effects of organic manures.

4.2.2 Straw yield

Straw yield of NERICA 10 also varied significantly by different treatments under study (Table 5). The yields of straw ranged from 2.18 to 5.35 t ha^{-1}. The highest straw yield of 5.35 t ha^{-1} was obtained in T_3 treatment (100 kg N from urea and 20 kg N substituted by vermicompost) which was statistically differed with other treatments except T_{10}, T_6, T_{11}, T_4 and the lowest value of 2.18 t ha^{-1} was noted in T_1 (control) treatment. The treatment may be ranked in the order of $T_3>T_{10}> T_6>T_{11}>T_4>T_8>T_2>T_7>T_5>T_9>T_1$ in terms of straw yield. Regarding the percent increase of straw yield, maximum straw yield increase over control (154.76%) was noted in T_3 treatment and the minimum (104.76%) was found in T_{11} treatment (Fig. 9). Saha *et al.* (2007) reported that the straw yield was significantly increased due to application of chemical fertilizers and residual effects of organic manures.

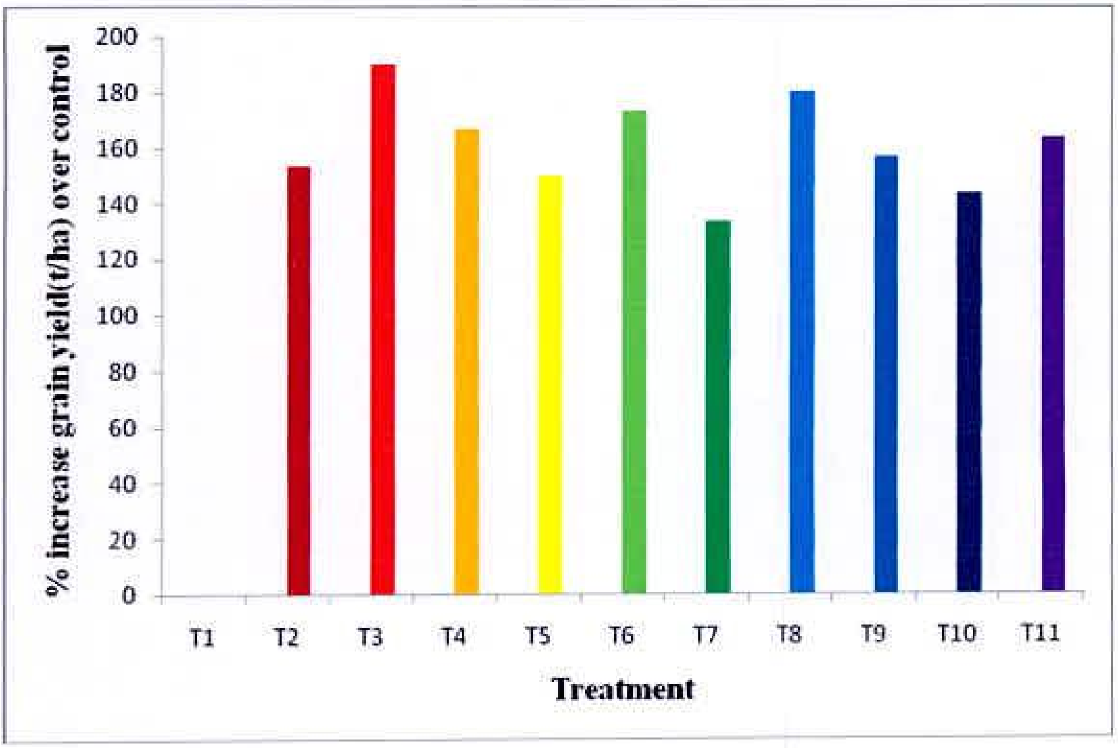


Fig. 8. Effect of Integrated Nutrient Management on percent increase grain yield ($t\ ha^{-1}$) over control of NERICA 10

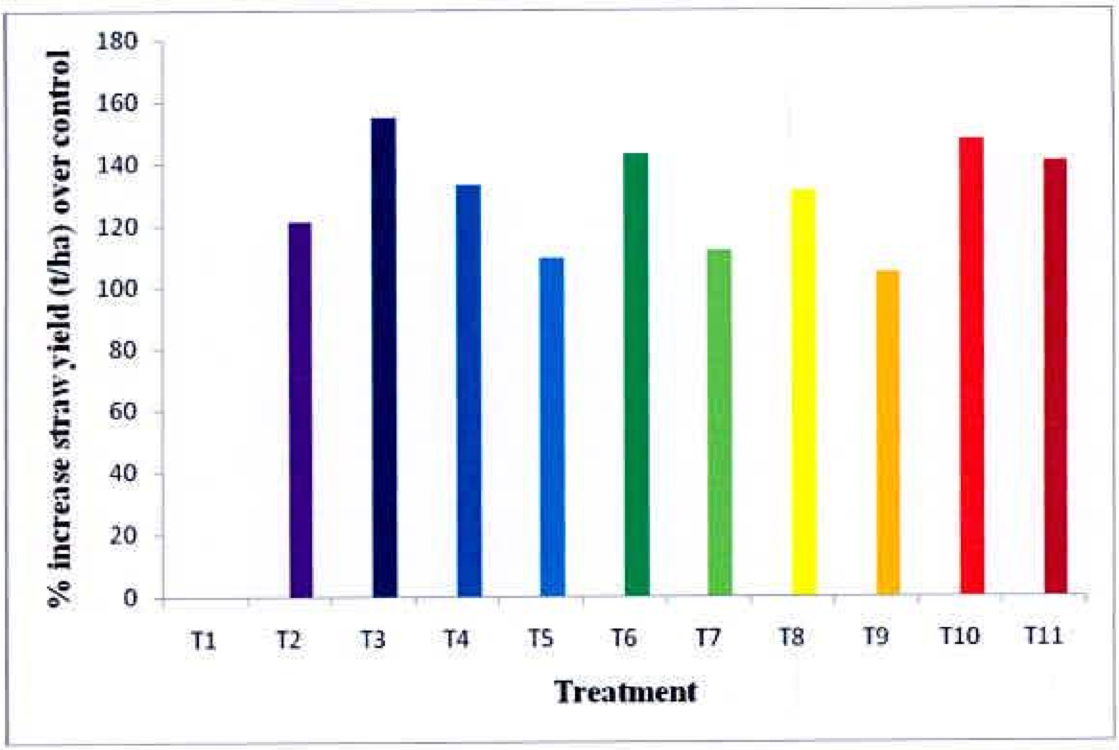


Fig. 9. Effect of Integrated Nutrient Management on percent increase straw yield ($t\ ha^{-1}$) over control of NERICA 10

Table 5. Effect of Integrated Nutrient Management on the grain and straw yields ($t\ ha^{-1}$) of NERICA 10

Treatment	Grain yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)
T_1	1.50d	2.10g
T_2	3.80abc	4.65cdef
T_3	4.35a	5.35a
T_4	4.00abc	4.90abcd
T_5	3.75bc	4.40ef
T_6	4.10ab	5.10abc
T_7	3.50c	4.45def
T_8	4.20ab	4.85bcde
T_9	3.85abc	4.30f
T_{10}	3.65bc	5.20ab
T_{11}	3.95abc	5.05abc
$LSD_{0.05}$	0.557	0.469
CV (%)	8.86	6.02

Means in a column followed by same letter(s) are not significantly different at 5% level of significance by LSD.

T_1: No chemical fertilizer, no organic manure (Control)
T_2: 100% recommended N (120 kg nitrogen ha^{-1}) + recommended P,K,S,Zn
T_3: 100 kg N from urea + 20 kg N substituted by vermicompost + recommended P,K,S,Zn
T_4: 100 kg N from urea + 20 kg N substituted by cowdung + recommended P,K,S,Zn
T_5: 80 kg N from urea + 40 kg N substituted by vermicompost + recommended P,K,S,Zn
T_6: 80 kg N from urea + 40 kg N substituted by cowdung + recommended P,K,S,Zn
T_7: 60 kg N from urea + 60 kg N substituted by vermicompost + recommended P,K,S,Zn
T_8: 60 kg N from urea + 60 kg N substituted by cowdung + recommended T_1: P,K,S,Zn
T_9: 40 kg N from urea + 80 kg N substituted by vermicompost + recommended P,K,S,Zn
T_{10}: 40 kg N from urea + 80 kg N substituted by cowdung + recommended P,K,S,Zn
T_{11}: 100% N substituted by equal portion of vermicompost and cowdung + recommended P,K,S,Zn

4.3 Nutrient content in grain and straw

The grain and straw samples of NERICA 10 were analyzed for estimating N, P, K and S content. The results of N, P, K and S contents of grain and straw have been discussed under the following sub-sections.

4.3.1 Nitrogen content

The N content in rice grain varied significantly in different treatments (Table 6). The highest N content of 1.02% was observed in T_3 treatment receiving 100 kg N from urea and 20 kg N substituted by vermicompost. The lowest N content of 0.90% was noted in T_{11} treatment. The N content in rice grain markedly which was identical with T_6, T_{10}, T_1 and T_4 treatments.

In the straw, the N content varied significantly due to different treatments (Table 6). The N content in the straw ranged from 0.39% to 0.57%. The maximum N content in straw (0.57%) was found in T_3 treatment receiving 100 kg N from urea which was statistically similar to T_7 and T_{11} treatment. Treatment along with chemical nitrogen performed better in recording nitrogen content in straw over other treatments including organic manure even control. This might be due to the application of urea fertilizer which supplied adequate nitrogen produced protein or amino acid which was converted to nitrogen and ultimately increased nitrogen content in straw. The lowest nitrogen content in straw (0.39%) was found in T_1 (control) treatment.

A significant increase in N content in rice grain and straw due to the application of chemical fertilizers and residual effects of organic manures has been reported by Mann *et al.* (2006). Gupta *et al.* (2000) revealed that the combined application of urea and FYM significantly enhanced N content in rice straw and grain.

4.3.2 Phosphorus content

Phosphorus content in grain was varied significantly due to the influence of inorganic and organic fertilizer (Table 6). The P content in grain varied from 0.16% to 0.23%. The highest P content of 0.23% was observed in T_5 treatment which was statistically similar to T_{11}, T_3, T_2, T_4, and T_{10} treatments in recording P content in grain but superior to the rest of the treatments of NERICA 10. The lowest P content of 0.16% was observed in T_6 treatment.

Phosphorus content in rice straw was influenced significantly due to the integrated effects of organic manures chemical fertilizers. The highest P content in straw (0.12%) was observed in T_7 treatment which is statistically similar to T_3, T_6, T_9 and T_{11} treatment. The lowest value (0.090%) was recorded in T_4 treatment.

An increase in P content both in rice grain and straw due to the application of chemical fertilizers and residual effects of organic manures was reported by Indrani *et al.* (2008). Solaiman *et al.* (2011) showed that the P content was significantly increased where urea, cowdung, poultry manure and urban wastes are applied together.

4.3.3 Potassium content

Potassium content in grain was varied significantly due to the influence of inorganic and organic fertilizer (Table 6). The K content in rice grain ranged from 0.15 to 0.24%. The highest K content of 0.24% was observed in T_3 treatment which was statistically similar to T_4, T_1, T_7, T_8, and T_{10} treatments. This might be due to the application cowdung along with urea fertilizer which supplied sufficient K for growth and development of crop resulting increase in K content in grain. The lowest K content of 0.15% was observed in T_6 treatment.

Potassium content in rice straw was influenced significantly due to the integrated effects of organic manures chemical fertilizers. The highest K content in straw (1.47%) was observed in T_9 treatment which is statistically similar to T_3, T_{10}, T_6, T_{11}, T_8 and T_5 treatments. The lowest value (1.27%) was recorded in T_1 (control).

These results are in agreement with Krishnappa *et al.* (2006) who revealed that K content in grain and straw were increased due to application of chemical fertilizers and residual effects of organic manures. Shen *et al.* (2003) found that K content in grain and straw were increased due to combined application of chemical fertilizers and organic manures.

4.3.4 Sulphur content

Sulphur content in grain was varied significantly due to the influence of inorganic and organic fertilizer (Table 6). The S content in rice grain ranged from 0.09 to 0.35%. The highest K content of 0.35% was observed in T_7 treatment which was statistically similar to T_1, T_4, T_{11} and T_8 treatments. The lowest K content of 0.09% was observed in T_6 treatment.

In case of straw, the highest S content (0.12%) was obtained in T_{11} treatment and the lowest value (0.08%) was noted in T_6 (control) treatment. Sulphur content varied insignificantly due to application of manures and fertilizers.

Mann *et al.* (2006) reported that application of chemical fertilizers and residual effects of organic manures increased the S content both in grain and straw of rice. Bhuvaneswari *et al.* (2007) showed that sulphur use efficiency was highest and sulphur content was higher in the presence of organic fertilizers.

Table 6. Effects of integrated nutrient management on N, P, K and S content (%) of NERICA 10

Treatment	Grain				Straw			
	N	P	K	S	N	P	K	S
T_1	0.97abc	0.18d	0.21abc	0.11ab	0.39c	0.10bc	1.27c	0.08c
T_2	0.93bc	0.21bc	0.17bcd	0.10b	0.51abc	0.10bc	1.34bc	0.09bc
T_3	1.02a	0.22ab	0.24a	0.09b	0.57a	0.12a	1.46a	0.08c
T_4	0.96abc	0.21bc	0.22ab	0.11ab	0.52abc	0.09c	1.35bc	0.09bc
T_5	0.90c	0.23a	0.15d	0.10b	0.48abc	0.09c	1.37abc	0.08c
T_6	1.00ab	0.16e	0.15d	0.09b	0.46abc	0.11ab	1.42ab	0.080c
T_7	0.93bc	0.17de	0.21abc	0.35a	0.56a	0.12a	1.34bc	0.08c
T_8	0.93bc	0.17de	0.20a-d	0.12ab	0.48abc	0.09c	1.38ab	0.10b
T_9	0.93bc	0.17de	0.17bcd	0.09b	0.41bc	0.11ab	1.47a	0.09bc
T_{10}	1.00ab	0.20c	0.19a-d	0.10b	0.53ab	0.10bc	1.43ab	0.08c
T_{11}	0.90c	0.22ab	0.16cd	0.11ab	0.56a	0.11ab	1.38ab	0.12a
$LSD_{0.05}$	0.076	0.170	0.054	0.247	0.131	0.170	0.107	0.170
CV(%)	4.59	10.09	12.82	116.78	15.39	14.31	4.84	22.11

Means in a column followed by same letter(s) are not significantly different at 5% level of significance by LSD.

T_1: No chemical fertilizer, no organic manure (Control)
T_2: 100% recommended N (120 kg nitrogen ha^{-1}) + recommended P,K,S,Zn
T_3: 100 kg N from urea + 20 kg N substituted by vermicompost + recommended P,K,S,Zn
T_4: 100 kg N from urea + 20 kg N substituted by cowdung + recommended P,K,S,Zn
T_5: 80 kg N from urea + 40 kg N substituted by vermicompost + recommended P,K,S,Zn
T_6: 80 kg N from urea + 40 kg N substituted by cowdung + recommended P,K,S,Zn
T_7: 60 kg N from urea + 60 kg N substituted by vermicompost + recommended P,K,S,Zn
T_8: 60 kg N from urea + 60 kg N substituted by cowdung + recommended T_1: P,K,S,Zn
T_9: 40 kg N from urea + 80 kg N substituted by vermicompost + recommended P,K,S,Zn
T_{10}: 40 kg N from urea + 80 kg N substituted by cowdung + recommended P,K,S,Zn
T_{11}: 100% N substituted by equal portion of vermicompost and cowdung + recommended P,K,S,Zn

4.4 Nutrient uptake

The results of N, P, K and S uptake by grain and straw of NERICA 10 have been presented and discussed below:

4.4.1 Nitrogen uptake

Nitrogen uptake by grain was significantly influenced by the application of different levels of cowdung and vermicompost along with chemical nitrogenous fertilizer (Table 7). The N uptake by grain ranged from 14.55 to 43.50 kg ha^{-1}. The highest N uptake by grain (43.50 kg ha^{-1}) observed in T_{10} treatment receiving 40 kg N from urea which was statistically superior to the rest of the treatments which is identical with T_6 and T_8 treatment. The lowest N uptake by grain (14.55 kg ha^{-1}) observed in T_1 (control) treatment.

Nitrogen fertilizer along with cowdung and vermicompost significantly increased N uptake by straw (Table 7). The maximum N uptake of 29.96 kg ha^{-1} by straw was noted in T_{11} treatment which is identical with T_3, T_{10}, T_4, T_7, T_2 and T_{11} treatment. The lowest N uptake by straw (8.50 kg ha^{-1}) observed in T_1 (control) treatment.

Jacqueline *et al.* (2008) reported that the N uptake by rice grain and straw increased significantly with the combined application of organic manure and chemical fertilizers. Vennila (2007) reported that 75% recommended dose of N fertilizer + 25% N as poultry manure increased N uptake in rice. Sarfaraz *et al.* (2002) found that NPK concentrations and their uptake in grain and straw significantly increased with the application of NPK + S fertilizers compared to the control.

4.4.2 Phosphorus uptake

Phosphorous uptake by grain was significantly influenced by the application of different levels of cowdung and vermicompost along with chemical nitrogenous fertilizer (Table 7). The P uptake by grain ranged from 2.7 to 8.7 kg ha^{-1}. The highest P uptake by grain (8.7 kg ha^{-1}) observed in T_{10} treatment receiving 40 kg N from urea which is identical with T_{11}, T_5, T_4, T_3 and T_2 treatment. The lowest P uptake by grain (2.7 kg ha^{-1}) observed in T_1 (control) treatment.

Effect of cowdung and vermicompost along with nitrogen fertilizer on phosphorous uptake by straw was significant (Table 7). The P uptake by straw ranged from 2.19 to 6.06 kg ha^{-1}. The highest P uptake by straw (6.06 kg ha^{-1}) observed in T_3 treatment which is identical with T_{11}, T_6, T_7 and T_{10} treatment. The lowest P uptake by straw (2.19 kg ha^{-1}) observed in T_1 (control) treatment.

Moula (2005) reported that nutrient content as well as nutrient uptake by rice over other treatments due to combined application of organic and inorganic fertilizers. Zhang *et al.* (1998) reported that organic manures increased labile, moderately stable and stable organic P contents in soil and uptake by plants.

4.4.3 Potassium uptake

A significant variation in potassium uptake by grain was observed due to the application of different levels of nitrogenous fertilizer along with organic manures (Table 7). The k uptake by grain ranged from 3.15 to 8.80 kg ha^{-1}. The highest K uptake by grain (8.80 kg ha^{-1}) observed in T_4 treatment which is identical with T_3, T_8, T_{10} and T_7 treatment. The lowest K uptake by grain (3.15 kg ha^{-1}) observed in T_1 (control) treatment.

Effect of cowdung and vermicompost along with nitrogen fertilizer on phosphorous uptake by straw was significant (Table 7). The K uptake by straw ranged from 27.84 to 74.28 kg ha^{-1}. The highest K uptake by straw (74.28 kg ha^{-1}) observed in T_{10} treatment which is identical with T_3, T_{11}, T_6 and T_8 treatment. The lowest K uptake by straw (27.84 kg ha^{-1}) observed in T_1 (control) treatment.

It was found that the K uptake by grain was much lesser than that by straw. The results are in agreement with Sreelatha *et al.* (2006) who reported that application of organic manure and chemical fertilizers significantly increased the K uptake by rice.

4.4.4 Sulphur uptake

Sulphur uptake by grain was significantly influenced by the application of different levels of cowdung and vermicompost along with chemical nitrogenous fertilizer (Table 7). The S uptake by grain ranged from 1.65 to 5.04 kg ha^{-1}. The highest S uptake by grain (5.04 kg ha^{-1}) observed in T_8 treatment and the lowest S uptake by grain (1.65 kg ha^{-1}) observed in T_1 (control) treatment.

Effect of cowdung and vermicompost along with nitrogen fertilizer on phosphorous uptake by straw was significant (Table 7). The S uptake by straw ranged from 1.74 to 6.42 kg ha^{-1}. The highest S uptake by straw (6.42 kg ha^{-1}) observed in T_{11} treatment. The lowest S uptake by straw (1.74 kg ha^{-1}) observed in T_1 (control) treatment.

Bhuvaneswari and Chandrasekharan (2006) observed that application of organic manure and chemical fertilizers increased the sulphur uptake significantly by rice. Azmi *et al.* (2004) found increasing fertility levels significantly increased the crop yield and S uptake.

Table 7. Effect of integrated nutrient management on N, P, K and S uptake (kg ha^{-1}) by NERICA 10

Treatment	Grain				Straw			
	N	P	K	S	N	P	K	S
T_1	14.55f	2.7e	3.15d	1.65h	8.50e	2.19f	27.68d	1.74c
T_2	35.34cde	7.98ab	6.46bc	3.80de	23.71a-d	4.65b-e	62.31c	4.18b
T_3	37.23b-e	8.03a	8.76a	3.28f	28.78ab	6.06a	74.08a	4.04b
T_4	38.40bcd	8.4a	8.80a	4.42b	25.48abc	4.41cde	66.15bc	4.41b
T_5	33.75de	8.625a	5.62c	3.75e	21.12cd	3.96e	60.28c	3.52b
T_6	41.00ab	6.56cd	6.15bc	3.69e	23.46a-d	5.61abc	72.42ab	4.08b
T_7	32.55e	5.95d	7.35ab	2.80g	24.92abc	5.34a-d	59.63c	3.56b
T_8	39.06abc	7.14bc	8.40a	5.04a	23.28bcd	4.36de	66.93abc	4.85b
T_9	35.80cde	6.54cd	6.54bc	3.46ef	17.63d	4.73b-e	63.21c	3.87b
T_{10}	43.50a	8.7a	8.26a	4.35c	27.56abc	5.20a-d	74.36a	4.16b
T_{11}	35.55cde	8.69a	6.32bc	4.34c	29.96a	5.88ab	73.83ab	6.42a
$LSD_{0.05}$	5.062	0.880	1.696	0.331	6.533	1.239	7.818	1.410
CV(%)	8.45	7.16	14.44	5.01	16.59	15.27	7.20	20.30

Mean in a column followed by same letter(s) are not significantly different at 5% level of significance by LSD.

T_1: No chemical fertilizer, no organic manure (Control)
T_2: 100% recommended N (120 kg nitrogen ha^{-1}) + recommended P,K,S,Zn
T_3: 100 kg N from urea + 20 kg N substituted by vermicompost + recommended P,K,S,Zn
T_4: 100 kg N from urea + 20 kg N substituted by cowdung + recommended P,K,S,Zn
T_5: 80 kg N from urea + 40 kg N substituted by vermicompost + recommended P,K,S,Zn
T_6: 80 kg N from urea + 40 kg N substituted by cowdung + recommended P,K,S,Zn
T_7: 60 kg N from urea + 60 kg N substituted by vermicompost + recommended P,K,S,Zn
T_8: 60 kg N from urea + 60 kg N substituted by cowdung + recommended T_1: P,K,S,Zn
T_9: 40 kg N from urea + 80 kg N substituted by vermicompost + recommended P,K,S,Zn
T_{10}: 40 kg N from urea + 80 kg N substituted by cowdung + recommended P,K,S,Zn
T_{11}: 100% N substituted by equal portion of vermicompost and cowdung + recommended P,K,S,Zn

4.5 Nutrient content in post harvest soil

4.5.1 Total nitrogen

The combined effect of different levels of cowdung and vermicompost with the association chemical nitrogenous fertilizer on total nitrogen of post harvest soil was significant (Table 8). The highest total nitrogen of post harvest soil (0.08%) was recorded in T_6 treatment through the application of 80 kg N from urea and 40 kg N substituted by cowdung. It was statistically similar with T_4, T_8 and T_9 treatment but superior to the rest of the treatment of post harvest soil. The lowest total nitrogen of post harvest soil (0.06%) was recorded in T_1 (control) treatment.

4.5.2 Available phosphorous

A significant difference in available phosphorous content of post harvest soil was observed at different levels of cowdung and vermicompost along with nitrogenous fertilizer as the source of urea (Table 8). The highest available P (19.91 ppm) in the post harvest soil was recorded in T_6 treatment and the lowest available P (15.23 ppm) was noted in T_1 (control) treatment.

4.5.3 Exchangeable potassium

There was significant difference among the treatments in recording exchangeable potassium content of post harvest soil (Table 8). The maximum exchangeable potassium of post harvest soil (0.157 meq/100g soil) was found in T_6 treatment which is statistically superior to the rest of the treatment under study. The lowest available K (0.112 meq/100g soil) was noted in T_1 (control) treatment.

4.5.4 Available sulphur

A significant difference in available sulphur content of post harvest soil was observed at different levels of cowdung and vermicompost along with nitrogenous fertilizer as the source of urea (Table 8). The highest available S (30.86 ppm) in the post harvest soil was recorded in T_7 treatment and the lowest available S (19.11 ppm) was noted in T_1 (control) treatment.

Table 8. Effect of integrated nutrient management on N, P, K and S content in post harvest soil of NERICA 10

Treatment	Total N (%)	Available P (ppm)	Exchangeable K (meq/100g soil)	Available S (ppm)
T_1	0.06c	15.23e	0.112d	19.11i
T_2	0.07b	16.46d	0.134c	21.6h
T_3	0.07b	18.97ab	0.142b	22.09g
T_4	0.08a	17.03d	0.141b	22.57f
T_5	0.07b	18.52b	0.149b	26.12e
T_6	0.08a	19.91a	0.157a	28.97d
T_7	0.07b	18.23bc	0.142b	30.86a
T_8	0.08a	18.42b	0.148b	29.49c
T_9	0.08a	17.29cd	0.149b	30.27b
T_{10}	0.07b	18.62b	0.147b	30.12b
T_{11}	0.07b	17.14cd	0.139c	29.94bc
$LSD_{0.05}$	0.17	1.096	0.17	0.45
CV (%)	14.36	3.61	5.12	1.00

Mean in a column followed by same letter(s) are not significantly different at 5% level of significance by LSD.

T_1: No chemical fertilizer, no organic manure (Control)
T_2: 100% recommended N (120 kg nitrogen ha^{-1}) + recommended P,K,S,Zn
T_3: 100 kg N from urea + 20 kg N substituted by vermicompost + recommended P,K,S,Zn
T_4: 100 kg N from urea + 20 kg N substituted by cowdung + recommended P,K,S,Zn
T_5: 80 kg N from urea + 40 kg N substituted by vermicompost + recommended P,K,S,Zn
T_6: 80 kg N from urea + 40 kg N substituted by cowdung + recommended P,K,S,Zn
T_7: 60 kg N from urea + 60 kg N substituted by vermicompost + recommended P,K,S,Zn
T_8: 60 kg N from urea + 60 kg N substituted by cowdung + recommended T_1: P,K,S,Zn
T_9: 40 kg N from urea + 80 kg N substituted by vermicompost + recommended P,K,S,Zn
T_{10}: 40 kg N from urea + 80 kg N substituted by cowdung + recommended P,K,S,Zn
T_{11}: 100% N substituted by equal portion of vermicompost and cowdung + recommended P,K,S,Zn

Chapter V

Summary & Conclusion

CHAPTER V
SUMMARY

To evaluate the effects of integrated nutrient management of cowdung and vermicompost along with nitrogen as the source of urea were conducted in Aus season during the period from March 8, 2012 to June 24, 2012 at the research farm of Sher-e-Bangla Agricultural University, Dhaka-1207.

The experiment was carried out to assess the integrated nutrient management on NERICA 10 in Aus season.

The results of the experiment revealed that yield and yield contributing characters and nutrients content and uptake by rice were increased due to the application of varied levels of cowdung and vermicompost along with nitrogen from urea. However, combined application of cowdung and nitrogen at the rate of 100 kg N from urea along with 20 kg N as the source of vermicompost (T_3 treatment) performed best in recording yield and yield contributing characters and nutrients content and uptake by grain and straw of NERICA 10.

In post harvest soil total nitrogen, available phosphorus, exchangeable potassium and available sulphur were increased due to application of cowdung and vermicompost as compared to initial soil. Soil pH insignificantly decreased slightly as compared to that of initial soil. Fertilized with urea-nitrogen alone decreased the values of organic matter, total nitrogen, available phosphorus, exchangeable potassium and available sulphur in post harvest soil.

The maximum plant height and unfilled grain panicle^{-1} was recorded in T_5 (80 kg N from urea + 40 kg N from vermicompost) treatment, highest panicle length and effective tillers hill^{-1} was recorded in T_{10} (40 kg N from urea + 80 kg N from cowdung) treatment, maximum filled grain panicle^{-1} and 1000-grain weight was recorded in T_{11} (100% N from equal portion of cowdung and vermicompost) treatment.

The maximum grain and straw yield of NERICA 10 was recorded in T_3 (100 kg N from urea + 20 kg N from vermicompost) treatment.

In case of nutrient content in grain, the highest N and K content was found in T_3 (100 kg N from urea + 20 kg N from vermicompost) treatment, and the highest P and S content was recorded in T_5 (80 kg N from urea + 40 kg N from vermicompost) and T_7 (60 kg N from urea + 60 kg N from vermicompost) treatment respectively. In straw, the highest N content was found in T_3 (100 kg N from urea + 20 kg N from vermicompost) treatment, P content in T_7 (60 kg N from urea + 60 kg N from vermicompost) treatment, K content in T_9 (40 kg N from urea + 80 kg N from vermicompost) treatment and S content in T_{11} (100% N from equal portion of cowdung and vermicompost) treatment.

In case of nutrient uptake in grain, the highest N and P content was found in T_{10} (40 kg N from urea + 80 kg N from cowdung) treatment, and the highest K and S content was recorded in T_4 (100 kg N from urea + 20 kg N from cowdung) and T_8 (60 kg N from urea + 60 kg N from cowdung) treatment. In straw, the highest N and S content was found in T_{11} (100% N from equal portion of cowdung and vermicompost) treatment, P content in T_3 (100 kg N from urea + 20 kg N from vermicompost) treatment, K content in T_{10} (40 kg N from urea + 80 kg N from cowdung) treatment.

CONCLUSION

Total time required from sowing to harvesting of NERICA 10 was 108 days is Aus season. So, farmers can easily cultivate Aman rice after harvesting of NERICA 10.

From the present study finally it can be concluded that the organic manures (cowdung and vermicompost) along with nitrogenous fertilizer had varying degree of integrated effects on NERICA 10. Combined application of 100 kg N as the source of urea along with 20 kg N as the source of vermicompost performed the best in recording yield and yield contributing characters of NERICA 10. Among the organic sources, vermicompost performed the best in recording yield and yield attributing characters as well as NPKS content and uptake by NERICA 10. Cowdung and vermicompost alone or with the combination of nitrogenous fertilizer insignificantly decreased (slight) soil pH than in initial soil. Nitrogen, Phosphorus and Sulphur content in rice grain was higher than the rice straw. Potassium content in rice straw was about 6-8 times higher than rice grain. Organic manuring slightly increased total N, available P and S and exchangeable K in post harvest soil compared to initial soil. Increasing trend in cowdung and vermicompost content was observed in soil where organic manures were applied.

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

I. Combined application of 100 kg N as the source of urea along with 20 kg N as the source of vermicompost performed the best in recording yield and yield contributing characters of NERICA 10

II. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performances;

Chapter VI
References

CHAPTER VI

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Appendices

APPENDICES

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

Sources of variation	df	Plant height (cm)	Panicle length (cm)	Effective tillers hill^{-1} (no.)	Filled Grain/ Panicle (no.)	Un-filled Grain/ Panicle (no.)	1000-seed weight (g)	Grain weight (t/ha)	Straw Weight (t/ha)
Replication	2	1.708	0.564	0.004	15.364	13.091	1.313	0.346	0.027
Factor A	10	12.137 **	0.892 *	5.359 **	48.764 **	20.564 **	15.873 **	1.771 **	2.261 **
Error	20	14.398	0.373	0.098	6.564	4.491	0.087	0.107	0.076

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

Sources of variation	df	Grain				Straw			
		N	P	K	S	N	P	K	S
Replication	2	0.001	0.002	0.001	0.018	0.001	0.001	0.001	0.001
Factor A	10	0.005 *	0.002 **	0.003 **	0.0017 **	0.011 *	0.001 NS	0.011 *	0.001 NS
Error	20	0.002	0.001	0.001	0.021	0.006	0.001	0.004	0.001

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

Appendix III. Analysis of variance of the data on N,P,K and S uptake (kg ha^{-1}) of NERICA 10

Sources of variation	df	Grain				Straw			
		N	P	K	S	N	P	K	S
Replication	2	23.165	8.434	1.063	49.910	0.042	0.007	1.603	0.043
Factor A	10	170.384 **	9.567 **	8.487 **	2.513 **	105.614 **	3.543 **	518.911 **	3.573 **
Error	20	8.834	0.267	0.991	64.489	14.712	0.529	21.070	0.685

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

Sources of variation	df	Grain			
		N (%)	P (ppm)	K (meq./100g soil)	S (ppm)
Replication	2	0.001	1.120	0.001	0.001
Factor A	10	0.001 NS	5.181 **	0.001 **	56.055 **
Error	20	0.001	0.414	0.001	0.070

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