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FERTILIZER REQUIREMENT OF BINADHAN-10 IN SALINE SOIL AT SATKHIRA

Dedication

Dedicated to my Beloved Parents and brother

FERTILIZER REQUIREMENT OF BINADHAN-10 IN SALINE SOIL AT SATKHIRA

ABSTRACT

An experiment was conducted in saline soils at Debhata Upazila of Satkhira district during the boro season of 2019 to investigate the fertilizer requirement of Binadhan 10. There were six treatment combinations such as T_1: Control (No fertilizers), T_2: $N_{100}P_{15}K_{30}S_{12}Zn_2B_1$, T_3: $N_{120}P_{20}K_{40}S_{14}Zn_2B_1$, T_4: $N_{140}P_{25}K_{50}S_{16}Zn_2B_1$, T_5: $N_{160}P_{30}K_{60}S_{18}Zn_2B_1$ and T_6: $N_{180}P_{35}K_{70}S_{20}Zn_2B_1$. The experiment was laid out in a randomized complete block design with three replications. Nitrogen, P, K, S, Zn and B were supplied through urea, TSP, MoP, gypsum, zinc sulphate and boric acid, respectively. The full doses of TSP, MoP, gypsum, zinc sulphate and boric acid were applied as basal dose during final land preparation while urea was applied in three equal splits. The grain and straw yields of Binadhan-10 were significantly affected due to different treatments. The highest grain yield (5.86 t ha^{-1}) and straw yield (7.00 t ha^{-1}) were obtained in the treatments T_4 ($N_{140}P_{25}K_{50}S_{16}Zn_2B_1$) and T_6 ($N_{180}P_{35}K_{70}S_{20}Zn_2B_1$), respectively. The lowest grain yield (2.73 t ha^{-1}) and straw yield (3.56 t ha^{-1}) were obtained in the treatment T_1 (control). Plant height and 1000-grain weight were higher in the treatment T_4 ($N_{140}P_{25}K_{50}S_{16}Zn_2B_1$). On the other hand, panicle length and filled grains panicle^{-1} were higher in the treatment T_6 ($N_{180}P_{35}K_{70}S_{20}Zn_2B_1$) and number of tillers hill^{-1} were higher in treatment T_2 ($N_{100}P_{15}K_{30}S_{12}Zn_2B_1$). Nitrogen, P, K and S contents and uptake by Binadhan-10 were profoundly influenced due to application of different rates of fertilizers. The highest N, P and K content was found in treatment T_4 ($N_{140}P_{25}K_{50}S_{16}Zn_2B_1$) while the lowest content was obtained in treatment T_1 (control). The highest N, P and K uptake was found in treatment T_4 ($N_{140}P_{25}K_{50}S_{16}Zn_2B_1$) while the highest sulphur uptake was obtained in treatment T_6 ($N_{180}P_{35}K_{70}S_{20}Zn_2B_1$). Considering the yield and benefit-cost ratio, the application of 140 kg N, 25 kg P, 50 kg K, 16 kg S, 2 kg Zn and 1 kg B ha^{-1} might be recommended for Binadhan-10 cultivation in saline areas.

v

CONTENTS

CONTENTS (Contd.)

ISSN 2320-9186

CONTENTS (Contd.)

ISSN 2320-9186

LIST OF TABLES

GSJ: Volume 11, Issue 2, February 2023
ISSN 2320-9186

ISSN 2320-9186

LIST OF FIGURES

x

ISSN 2320-9186

LIST OF APPENDICES

Chapter 1

Introduction

CHAPTER 1

INTRODUCTION

Rice *(Oryza sativa* L.) is grown in more than 100 countries. China, India, Indonesia, Bangladesh, Thailand and Vietnam produce about 80% of the world rice production. Among the leading rice growing countries of the world, Bangladesh ranks fourth in both rice area and production (BRRI, 2007) and third largest (FAPRI, 2009) consumer of rice in the world and it alone provides 76% of calorie and 66% of total protein requirement of daily food intake (Bhuiyan *et al*., 2002). In Bangladesh, rice accounts for 95% of the annual food grain production. In Bangladesh, food security has been remained a major concern because food requirement is increasing at an alarming rate due to increasing population. It is needed to increase the food grain in the limited land area for the fulfillment of our demand. Selection of variety and proper management of fertilization can play important role to increase yield of rice. Rice is not only the staple food but also provides nearly 40% of total national employment (48% of total rural employment), about 75% of the calories and 55% of the protein in the average daily diet of the people of the country.

Agriculture in Bangladesh is characterized by intensive crop production, mainly rice. The soil and climatic conditions of Bangladesh are favorable for rice cultivation throughout the year. In Bangladesh rice crop was grown on 11.53 million hectares of land, with the production was of 33.54 million metric tons (BBS, 2011). But the yield per unit of rice at farmer's level is much lower than the potential yield. The average yield of rice is 3.47 t ha^{-1} (BBS, 2011) which is quite low compared to that of many other rice growing countries like China, Japan, Korea and USA where yields are 6.23, 6.79, 6.59 and 7.04 t ha^{-1}, respectively (FAO, 2004). The reasons for low yield of rice mainly associated with the lacking and use of modern varieties, judicious management of fertilizers, irrigation and other intercultural operations.

Soil salinity is a major concern to agriculture all over the world because it affects almost all plant nutrients. Salinity creates a problem due to its effect on crop species which are predominantly sensitive to the presence of high concentration of salts in the soil. In Bangladesh over 30% of the net cultivable area lies in the coastal zone. Out of 2.80 million hectares of coastal and offshore lands, about 1.056 million hectares are affected by varying degrees of salinity. Further, from the recent soil salinity map it has been found that some of the new land of Satkhira, Patuakhali, Barguna, Barisal, Jahalakathi, Pirojpur, Jessore, Narail, Gopalganj and Madaripur districts are affected by different degrees of soil salinity which reduces the crop productivity in the area (SRDI, 2009). The salinity condition of Satkhira district is very high. Usually 30-50% yield losses occur depending on the level of soil salinity. Rice production is hampered due to high salinity and low nutrient status. The land under saline area remains fallow during the boro season. So, Bangladesh Rice Research Institute (BRRI) and Bangladesh Institution of Nuclear Agriculture (BINA) developed salt tolerant rice varieties eg. BRRI dhan 47, BRRI dhan 53, BRRI dhan 54, Binadhan-8 and Binadhan-10. Among them Binadhan-10 is more tolerant to salt stress than other varieties. Therefore, Binadhan-10 is being introduced in saline areas of Bangladesh. But fertilizer requirement of Binadhan 10 under saline soil is not known.

Plant derives 13 essential nutrients out of 17 from the soil. But soil varies considerably in their inherent capacities to supply nutrients, which are gradually declining over time due to intensive cropping with high yielding rice varieties. Practically no soil can sustain high crop yields for an indefinite period from its own nutrient reserves. Even the most fertile soils can do so only for certain years and at one time the yield will be declined due to deficiency of some nutrients. Nitrogen is a limiting nutrient in almost all soils of Bangladesh. The saline soils are deficient in P and Zn due to high soil pH. Sodium is the dominant cation in saline soil which hampers the uptake of K from soil by plant. A high level of K supplying is, therefore, needed in saline soil than the non-saline soils. About 70% soils of Bangladesh are deficient in available S. Boron deficiency is reported to be deficient in dry land crops. Boron deficiency has

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also been reported in some rice soils of Bangladesh (Islam *et al*. 1997; Mondal *et al*. 1987).

Considering the above points, the present study was undertaken with the following objectives:

- ❖ To determine the fertilizer requirements for Binadhan-10 in saline soil at Satkhira.
- ❖ To develop economically suitable combination of chemical fertilizers for sustainable crop yield.

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ISSN 2320-9186

Chapter 2

Review of Literature

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CHAPTER 2

REVIEW OF LITERATURE

Review of literature forms a bridge between the past and present research works related to problems, it helps an investigator to draw a satisfactory conclusion. Some of the pertinent research works related to the nitrogen, phosphorus, potassium and sulphur application on rice have been reviewed in this chapter.

Effect of nitrogen on rice

Nitrogen remain in soil both in organic and inorganic forms. Plant absorbs nitrogen in the form of NH_4^+ and NO_3^-. Nitrogen can dramatically stimulate plant productivity, especially it encourages above ground vegetative growth of plants. A good supply of nitrogen also stimulates root growth and development, protein content of seed and foliage as well as the uptake of other nutrients. It is essential for carbohydrate use within the plants. It is a major part of all amino acids, enzymes, nucleic acids and chlorophyll.

Khan (2013) conducted an experiment at the Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh during aman season of 2012 to study the effects of reduced rates of different fertilizers on growth and yield of BRRIdhan 49. He observed that application of 50% reduction of N fertilizers from Recommended Fertilizer Dose (100 kg N ha^{-1}, 15 kg P ha^{-1}, 50 kg K ha^{-1}, 15 kg S ha^{-1} and 1.5 kg Zn ha^{-1}) affected non-significantly both in yield contributing characters, nutrient content and nutrient uptake by grain and straw of BRRIdhan 49 compared to RFD.

Dubey *et al.* (2012) conducted an experiment and showed that the application of recommended dose of N, P and K increased the crop yields and substantially improved the available N, P and K over its initial value there by indicating significant contribution towards sustaining the soil health.

Lin *et al.* (2009) conducted an experiment to evaluate nitrogen uptake, yield attributes and yield response of two rice cultivars under varying plant densities and nitrogen application rates. Two management systems including conventional practices or standard rice management and new rice management or the system of rice intensification have been investigated in a two year trial. Trial results indicated that modification in the management practices can positively influence the rice crop outputs.

Chaturvedi *et al.* (2007) performed a field trial to determine the effect of different nitrogenous fertilizers on growth, yield and quality of hybrid rice variety 'Proagro 6207'. The results revealed that all the growth characters, yield parameters and grain nitrogen were increased significantly with an application of sulphur-containing nitrogen fertilizer.

Mazumder *et al.* (2005) reported that different levels of nitrogen influenced grain yield, straw and biological yields with the application of 100% recommended dose (RD) of N (99.82 kg N ha^{-1}) which was 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.

Chen *et al.* (2004) reported that the effects of the ratio of organic to inorganic nitrogen on rice yield and N content in surface water of rice fields. Results showed that under the condition of equal total N (ratio of organic N is 25 to 75%) the yield was higher than that of 100% inorganic N.

Liu *et al.* (2004) reported that the effects of different N management treatments on the agronomic and economic characters of rice hybrid Shanyou 63 were evaluated in Jiangsu, China. The result showed that the grain yield of the control (N omission plots) ranged from 6.8 to 7.4 t ha^{-1}, indicating the high indigenous N supply of the soil.

Wang (2004) conducted a field experiment in Taiwan to investigate the effect of deep placement of fertilizer and nitrogen top dressing on rice yield and to develop a simple method for diagnosing the level of nitrogen top-dressing during panicle initiation stage. The deep placement of nitrogen fertilizer promoted nitrogen uptake, grain nitrogen and nitrogen harvest index, resulted in a higher dry matter production, harvest index, and a higher grain yield of rice plant compared with conventional nitrogen application.

Obiol *et al.* (2003) conducted experiments in Granma, Cuba to study the effect of different nitrogen doses on the yield and yield components of rice varieties (IA Cuba-17, IA Cuba-24 and J-104). Nitrogen was applied at 0, 43, 85, 128, 170 and 215 kg N ha^{-1}, then improved response was obtained with 128-170 kg N ha^{-1}.

Choudhury and Khanif (2002) conducted an experiment in Malaysia during October 1998 to determine the effect of N application on the yield and nutrition of rice cv. MR84. Yield significantly increased with application of 120 kg N ha^{-1} over farmers practice (80 kg N ha^{-1}).

Singh and Singh (2002) conducted a field experiment to study the effect of different nitrogen levels (50, 100 and 150 kg ha^{-1}) on rice cultivars (Swarna and PR-108) in split plot design in Varanasi, Uttar Pradesh, India, during kharif season of 1997. Significant increase in plant height, tillers m^{-2}, dry matter production, panicles m^{-2}, panicle length and grains $panicle^{-1}$ was obtained with increasing levels of nitrogen up to 150 kg N ha^{-1}. The total nitrogen uptake, grain and straw yields significantly improved with increasing levels of nitrogen application being maximum at 150 kg N ha^{-1}.

Zhang and Wang (2002) conducted an experiment to study the agronomic performance of a newly developed site-specific nutrient management (SSNM) technique for nitrogen fertilizer application to directly sown early rice against farmers fertilizer practice (FFM) in Zhejiang, China. Result showed that SSNM increased the rice yield significantly and improved N use efficiency substantially.

Angayarkanni and Ravichandran (2001) conducted a field experiment in Tamil Nadu, India from July to October 1997 to determine the best split application of 150 kg N ha^{-1} for rice cv. IR20. They found that applying of 16.66% of the recommended N as basal, followed by 33.33% N at 10 DAT, 25% N at 20 DAT, and 25% N at 40 DAT recorded the highest grain (6189 kg ha^{-1}) and straw (8649 kg ha^{-1}) yields.

Castro and Sarker (2000) conducted field experiment to find out the effect of N applications as basal (80, 60 and 45 kg N ha^{-1}) and top dressing (10, 30 and 45 kg N ha^{-1}) on the yield and yield components of rice and obtained high effective tiller, percent of ripened grains and high grain yields from 45 kg ha^{-1} (basal) and 45 kg ha^{-1} (top dressing).

Chopra and Chopra (2000) reported that the application of N at the rate of 80 or 120 kg ha^{-1} improved the entire yield attributes compared with the control.

Geethadevi *et al.* (2000) conducted a field trial during the kharif season of 1998 in Karnataka, India to determine the effect of different nitrogen rates (0, 50, 100 and 150 kg ha^{-1}). Among N rates, treatment with 150 kg N ha^{-1} recorded the highest values for plant height (87.20 cm), and total dry matter per plant (57.08 g), filled grains per panicle (134.1) and 1000-grain weight (22.40 g).

Shanmugam and Veeraputhran (2000) reported that the N levels at 187.5 kg ha^{-1} with 25 kg $ZnSO_4$ produced highest yield of rice 5516 kg ha^{-1} and 5376 kg ha^{-1} in 1995-96 and 1996-97, respectively.

Singh *et al.* (2000) stated that each increment dose of N showed significantly higher grain and straw yields of rice over its preceding dose. Consequently the crop fertilized with 100 kg N ha^{-1} gave maximum grain yield (2647 kg ha^{-1}).

Effect of phosphorus on rice

Plants and animals can't grow without phosphorus. Phosphorus is at a premium in natural and agricultural ecosystems. Adequate phosphorus nutrition enhances many aspects of plant physiology, including the fundamental process of photosynthesis, flowering, fruiting (including seed production) and maturation. It is an essential component of the organic compound often called energy currency of living cell.

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 fertilizer utilization efficiency, including the partial factor productivity (PFP), agronomic efficiency (AE), internal efficiency (IE), partial P balance, recovery efficiency 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 for five phosphorus rates (0, 5, 10, 20 and 30 kg P ha^{-1}) were tested 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}.

Pandey *et al.* (2009) conducted a field experiment to study the long term effect of fertilizer on the uptake of nitrogen, phosphorus, potassium and sulphur by rice and wheat in calcareous soil with N, P, K and organic sources under rice-wheat cropping system. After completion of 13^{th} cycle, they reported that the uptake of N, P, K and S by rice increased significantly with graded dose of fertilizer, alone or in combination with compost and crop residue. Nutrient removal by rice at higher level of NPK was relatively higher than that of the lower levels of NPK fertilizer.

Dunn *et al.* (2008) performed 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 noncoated, were compared to an untreated check. Net returns were calculated based on crop price and input costs. At the 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 polymer coated and non coated treatments produced equivalent yields. The 25-lb P_2O_5 coated TSP treatment produced the highest 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 phosphorus. 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.

Chatterjee and Khan (2005) conducted a field experiment during 1999-2000 to evaluate the potential of using Jhamarkotra phosphate rock compacted with different soluble phosphate and sulphur on rice-wheat and rice-rapeseed cropping system in Alfisol. Among the different P sources, single superphosphate and phosphate rock compacted with single superphosphate significantly increased the yield and P uptake by all the crops. The relative agronomic values of the different P sources indicated that phosphate rock compacted with single super phosphate could be used as P sources grown in acidic soils.

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

Do *et al.* (2004) conducted experiments to study the residual effects on P availability to improve the yield of rice cultivated on acid sulphate soil. They found that both organic and inorganic P had a positive effect on the rice yield. Supplying P in both organic and inorganic forms over several crops resulted in an accumulation of P in soil, which became available for rice growth in the following cropping season.

Dongarwar *et al.* (2003) conducted an experiment in Bhandara, Maharastra, India during kharif 2000-2001 to investigate the requirement of phosphorus for rice (KJTRH-1) production. They observed that the highest grain yield (53.05 q ha^{-1}) was obtained with 75 kg P ha^{-1}.

Tripathi *et al.* (2001) conducted a pot experiment to study the effects of various levels of P on the grain and straw yields and on the uptake of P, S, Mn and Fe by rice. They concluded that increasing levels of P significantly enhanced the yield as well as uptake of P, S and Mn whereas it adversely affected Fe uptake and high P level combined with puddling and submergence significantly increased P uptake.

Kumar and Singh (2001) reported that the significant response of rice to P was observed only up to 26.2 kg P ha^{-1} and application of P in all seasons recorded maximum rice equivalent yield (79.6 q ha^{-1}) which was as per with treatment receiving P in both year Rabi (70.8 q ha^{-1}) and treatment receiving P in first year kharif and Rabi (70.8 q ha^{-1}).

Sengar *et al.* (2000) observed that the P uptake by rice grain was increased with the combined application of manure and fertilizer.

Hemalatha *et al.* (2000) studied the influence of organic manures: dhaincha, sunhemp and FYM on rice productivity, quality and soil fertility. They reported that all the sources of organic manures improved the rice yield, quality and soil fertility.

Effect of potassium on rice

One of the most important tools for boosting rice yields is to use potassium fertilizer in appropriate amounts and in proper time. Among the nutrients, potassium is absorbed in greater quantities by rice, especially by high yielding cultivars but the response varies from cultivar to cultivar and year to year. Some of the relevant research works and their findings in connection with the present work have been given below.

Rahman (2012) conducted an experiment at the Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh during aman season of 2011 to investigate the effect of reduced rates of recommended fertilizer on Binadhan-7. The highest grain yield of 5.52 t ha^{-1} and straw yield of 4.99 t ha^{-1} were observed in the treatment T_7 (140% RFD) which was identical to that in treatment T_6 (120% RFD) in both cases. Nitrogen, phosphorus, potassium and sulphur contents of Binadhan-7 were significantly influenced by different treatments used in the experiment.

Wan *et al.* (2010) conducted an experiment to evaluate the effects of application of fertilizer on rice yield, uptake and usage efficiency of potassium, soil K pools, and the non-exchangeable K release under double rice cropping system. The field treatments included CK (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} that obtained with no K application (NP).

Ding et al. (2009) studied the effects of Mg and K interaction on plant growth, nutrient uptake and related physiological characteristics of rice (*Oryza sativa* L. cv. Wuyunjing 7). The results showed that with increasing K concentration of nutrient solution, dry plant weight reduced with low Mg concentration. This trend, however, reverses with higher Mg concentration. Uptake of Mg, K, N and P are remarkably restrained by higher K concentration with low Mg supply, while higher Mg concentration correspondingly enhances uptake of Mg, K, N and P. Leaf chlorophyll content decreases with increasing K concentration under low Mg condition. It is not significantly influenced by increasing K concentration when high concentration of Mg is supplied. With increasing Mg concentration, nitrate reductase activity and total soluble protein content increase, but not evidently enhanced with increased K concentration. Soluble sugar and starch contents of leaves are higher at high Mg concentration than at low Mg supply. Furthermore, soluble sugar and starch contents increase with increased K concentration. The study demonstrates that significant interaction between Mg and K restrains Mg uptake in low Mg with higher K supply in rice.

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

Bahmaniar *et al.* (2007) described the effects of different amount of potassium on yield and yield components of rice cultivar. Four levels of potassium (0, 50, 100 and 150 kg K_2O ha^{-1} from potassium sulphate) were applied. Nitrogen was applied at three different stages of plant growth (1/3 at transplanting, 1/3 at tillering and 1/3 at booting stage) and potassium was applied at two growth stages (1/2 at transplanting and 1/2 at shooting stage). Results indicated that nitrogen application increased plant height, number of tiller, length and width of flag leaf, length of panicle, number of grains per panicle, grain yield, amount of dry matter, biological yield, harvest index, 1000-grain weight and reduced the percentage of sterile grain. Also applied potassium had positive effects on all of above mentioned yield components except harvest index and 1000-grain yield.

Dwivedi *et al.* (2006) conducted an experiment to see the effect of potassium levels on growth, yield and quality of hybrid rice. They observed that 80 kg K_2O ha^{-1} was found better in obtaining higher production. Application of potassium increased the protein content in rice grains significantly.

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. Applied potassium fertilizer with organic manure increased soil K availability, K content and the number of grains $panicle^{-1}$.

Singh *et al.* (2006) conducted an experiment in a silt loam soil to evaluate the effect of potassium levels on growth, yields and seed quality of hybrid rice. They reported that 80 kg K_2O ha^{-1} was found better to obtain higher production and good quality of hybrid rice.

Arivazhagan and Ravichandran (2005) conducted a field experiment with rice cv. IR20 in Annamalainagar, Tamil Nadu,India. There were 6 treatments with 4 different fertilizer schedules (100:50:50, 100:50:75, 150:50:50 and 150:50:75 kg NPK ha^{-1}). Application of 150:50:75 kg NPK ha^{-1} resulted in the highest number of panicles per hill (9.06), panicle length (19.6 cm), 1000-grain weight (20.50g), grain yield (5.06 t ha^{-1}) and straw yield (6.10 t ha^{-1}). Basal application of K_2O resulted in the highest grain and straw yields (5.35 and6.74 t ha^{-1}).

Dunn and Stevens (2005) conducted an experiment on drill-seeded rice grown on silt loams using the delayed flood management system (i.e. folded at the 5 leaf stage, 20 to 30 days after emergence after urea is applied to a dry soil surface) at the University of Missouri, USA. It was found that pre-plant and mid-season K fertilizer applications increased rice yields on soils where K fertilizer application was not previously expected to have that effect.

Kamal *et al.* (2005) reported that K content in grain and straw was significantly affected by K application ranging from 0.22 to 0.34% in grain and 1.09 to 1.20% in straw.

Mukherjee and Sen (2005) conducted an experiment during the kharif season of 1999 to study the effects of rice husk and fertilizer levels of potassium on growth and yield of rice. The application of potassium significantly improved plant height, number of tillers hill^{-1}, dry matter accumulation, chlorophyll content and leaf area index. Rice husk and fertilizer levels had significant and positive effects on grain and straw yields.

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.

Das and Panda (2004) conducted a field experiment to study the effects of N (0, 60, 120 or 180 kg ha^{-1}) and K (0, 40, 80 or 120 kg ha^{-1}) on the growth rate of hybrid rice. Potassium was applied during transplanting. Crop growth rate was greatest at 40-60 DAT and lowest at 20-40 DAT. At 40-60 DAT, the highest CGR was obtained with 80 kg K_2O ha^{-1}. At 60-80 DAT, CGR increased up to 120 kg K_2O ha^{-1}. Crop growth rate in response to N and K rate followed a parabolic path i.e. low at 20-40 DAT increased at 40-60 DAT then decreased at 60-80 DAT.

Hu *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.

Meena *et al.* (2003) conducted a field experiment at the Indian Agricultural Research Institute, New Delhi, India to study the productivity and economics of rice as influenced by K application. The experiment was laid out in split-plot design with 2 levels of potassium, viz. 62.5 and 125 kg K ha^{-1}.

Application of 125 kg K ha^{-1} increased total number of tillers, dry matter accumulation, grain yield and straw yield than the results obtained by application of 62.5 kg K ha^{-1}.

Shen-Weiqi *et al.* (2003) studied the effects of N and K fertilizer on the yield and quality of paddy. Potassium fertilizer significantly improve all quality parameters and yield at 450 kg N ha^{-1} and equal amounts of K fertilizer applied to paddy fields are optimum to obtain high yield.

Mitra *et al.* (2001) conducted an experiment in the alluvial soils (Inceptisol) of Orissa, India, at two locations (Village Siula in Puri district and Village Uttara in Khurda district) for three consecutive years in a rice-groundnut cropping sequence. There were four levels of K_2O (0, 30, 60, 90 for rice and 0, 40, 60, 80 for groundnut). The results showed a significant increase in yield of both rice and groundnut with increased levels of K. Averaged over three cropping cycles, application of 60 kg K_2O was found to be optimum dose for kharif rice. The N, P, K and S uptakes of rice increased significantly with increase in levels of K.

Sahu (2001) pointed out that both grain and straw yields increased with the addition of K. The application of 132 kg K ha^{-1} increased average gain yield by 136% in Jaya, 71% in Pathara, 59% in Mahsuri and 42% in Parijat. The effect of K application on straw yields was similar to that on grain yields. He also reported that the application of liberal doses of K has been found to reduce Fe toxicity and increase yields.

Singh *et al.* (2000a) evaluated the effect of levels of K application on rice at different phases. Results indicated that K application significant enhanced the growth and yield of rice over no application. The highest grain and straw yields of rice were obtained at 90 kg K_2O ha^{-1} in all the cropping seasons.

Singh *et al.* (2000b) evaluated the effect of levels and phases of K application on rice during kharif 1989 to 1991. They observed that plant height and number of shoots were not significantly affected in 1989, while in 1990 and 1991 plant height increased with K_2O up to 60 and 90 kg ha^{-1}, respectively.

Tahir *et al.* (2000) conducted a long term field experiment on rice to assess the relative effectiveness of potassium sources viz. sulphate of potash and muriate of potash each applied at 75 and 150 kg ha^{-1} as K_2O. The results of 5 year (1985-90) trials showed that both the K sources were statistically significant at 75 and 150 kg ha^{-1} in paddy field affected significantly.

Yao-Youli *et al.* (2000) conducted an experiment on the ratio of N : P : K absorption at different yield levels and revealed that, with the increase of grain yield of the cultivars, the absorption of P and K relative to the absorption of N decreased. Absorbed amounts and ratios of N, P and K depended on the cultivars, yield levels and possibly soil of the field.

Effect of sulphur on rice

Sulphur is a macronutrient occurring in soils both in organic and inorganic forms. Organic form provides the major source of sulphur in soils. The main sulphur bearing mineral is gypsum ($CaSO_4.2H_2O$). Plants absorb sulphur in the form of SO_4^{2-}. The element is involved in the synthesis of amino-acids (cystine, cysteine and methionine), coenzyme-A, biotine, thiamine (Vit B_1) and chlorophyll. It is a vital part of ferrodoxins. Considerable amount of works have been done on the effects of sulphur on rice in different parts of the world. Some of them are cited below:

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 favour of stable and high yield 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 non draining conditions in a greenhouse experiment. The highest rice yield was obtained with press mud applied at a rate of 50 and 75 % gypsum.

Bhuvaneswari *et al.* (2007) conducted a field experiment in Tamil Nadu, India, during the kharif season of 2001 to study the effect of sulphur at varying rates, i.e. 0, 20, 40 and 60 kg ha^{-1}, with different organics, 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 organics compared to the control. The highest grain (5065 kg ha^{-1}) and straw yields (7523 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 sulphitation press mud. S use efficiency was highest at 20 kg ha^{-1} and higher in the presence of organics. The physical optimum of S worked out through the Mitscherlich and Bray approach showed that 38.8 kg S ha^{-1} was needed to obtain 87.5% yield and in the presence of organics, it ranged from 14.4 to 32.3 kg S ha^{-1} resulting in S savings of approximately 6.5-24.4 kg S ha^{-1}.

Bhuvaneswari and Sriramachandrasekharan (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, sulphitation pressmud and lignite fly ash) applied at 12.5 t ha^{-1} each. The sulphur and organic fertilizers significantly enhanced yield and nutrient uptake. The highest grain (5065 kg ha^{-1}) and straw (7524 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 sulphitation pressmud, 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.

Sukla and Lal (2002) reported that the present status of Indian soils indicates that the sulphur and zinc deficiency is increasing. Approximately 25 and 50% of the total cultivated area of this country was estimated to be affected by deficiency of sulphur and zinc, respectively. The rice and coarse cereal based cropping systems experimented in acid, semi-acid, humid and coastal ecosystems have proved that the deficiencies of S and Zn in the soils are responsible for slow growth in food grains production in the country. The economic analysis of different cropping systems showed a net return of RS. 1776 to RS. 7633 by investing one rupee on S. The profit ranges between RS. 1441 ha^{-1} to RS. 7262 ha^{-1} with application of S at the rate of 25 kg ha^{-1} in various cropping sequences.

Babu and Hegde (2002) carried out field studies in Andhra Pradesh, India to evaluate the direct and residual response of sulphur on rice-sunflower cropping system. The direct effect of sulphur through single superphosphate on hybrid rice resulted in a significant increase of 21% in grain with S use efficiency at 45 kg S ha^{-1}. The residual effect of this on succeeding sunflower crop resulted in 37% increase in seed yield and 45% increase in oil yield. The value cost ratio (VCR) for direct and residual effects were 35 and 23 with a cropping system VCR of 58.

Sarfraz *et al.* (2002) conducted a field experiment to determine the effect of different sulphur fertilizers at 20 kg ha^{-1} on crop yield and chemical 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 by grain and straw significantly increased with the application of NPK + S fertilizers compared to the control.

Peng *et al.* (2002) carried out a field experiment where one hundred and sixteen soil samples were collected from cultivated soils in Southest Fujian, China. The average content of available S in this soil sample was 21.7 mg kg^{-1}. The soil with available S content was lower than the critical value of 16 mg kg^{-1} accounted for 57.8%. Field experiment showed that there was a different yield increasing efficiency by applying S at the doses of 20-60 kg ha^{-1} to rice plant. The increasing rate of rice was 2.9-15.5% over control. A residual effect was also observed.

Sen *et al*. (2002) carried out extensively studied on application of sulphur through single super phosphate in a sulphur deficient area of Murshidabad in a rice-mustard cropping sequence. The recorded significant yield increases in rice with application of sulphur at 30 kg ha^{-1}.

Vaiyapuri and Sriramachandrasekharan (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 on nutrient content of rice grain (cv. BR3) at various growth stages (tillering, flowering and harvesting). Nitrogen was applied as urea and S as gypsum at 0, 5, 10 and 20 kg ha^{-1}. The combined application of these two elements increased the straw S content only at tillering stage, the uptake of nutrient in the straw and grain improved significantly, which was reflected in the straw and grain yields.

Combined effect of N, P, K and S on rice

Ali *et al*. (2013) carried out a field experiment with Potato-Boro-T. aman pattern at Pirgonj, Rangpur in the Tista Meander Floodplain Soils (AEZ 3) of North-West Bangladesh. Results indicated that application of different fertilizers significantly affected the grain yield at all of the locations. The highest grain yield and straw yield was found in treatment T_6 (T_1 + 25% NPK). The highest total N, P and K uptake was observed in treatment T_6. The highest uptake of total S was observed in treatment T_3. Fertilizers @ $N_{181}P_{10}K_{148}S_{12}Zn_2B_1$-$N_{183}P_{10}K_{81}S_{10}Zn_1B_{0.5}$-$N_{81}P_{7.5}K_{35}S_8$ kg ha^{-1} was recommended for Potato-Boro-T. aman cropping pattern in the Tista Meander Floodplain Soils at Pirgong (Rangpur) in North-West Bangladesh.

Sarker *et al.* (2013) described the economic rate of nutrients was determined with eight different fertilizer treatment applied on T. aman rice (var.Binadhan 7) in Old Brahmaputra Floodplain Soil (AEZ 9) at Trisal, Mymensingh. Results revealed that the average highest grain (4.86 t ha^{-1}) was recorded in T_6 (N_{80} $P_{17.5}$ K_{35} S_6Zn_1) treatment and straw yield (5.34 t ha^{-1}) was recorded in treatment T_3 ($N_{80}P_{17.5}$ K_{28} S_6Zn_1) which is 132.54% and 86.06%, respectively higher over control treatment. The second highest grain yield (4.77 t ha^{-1}) was obtained in T_3 treatment and straw (5.18 t ha^{-1}) was recorded in T_6 treatment. Average nutrient uptake (grain and straw) was the highest in T_3 treatment.

Muangsri *et al.* (2008) reported that the effect of rice straw and rice hull in combination with nitrogen, phosphorus and potassium fertilizer on yield of rice grown on Phimai soil series. The treatments consisted of the control (without fertilizer), NPK fertilizer, rice straw at the rate of 0.75, 1.5 and 3.0 g kg^{-1} soil in combination with NPK fertilizer and rice hull at the rate of 0.75, 1.5, 3.0 and 4.5 g kg^{-1} soil in combination with NPK fertilizer. 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.

Kumar *et al.* (2007) conducted a field experiment during the kharif season (July-October) of 2003 in New Delhi, India. The agronomic nitrogen use efficiency, apparent nitrogen recovery of applied N, P and K uptake were greater in rice hybrid PRM 10 than in the high yielding aromatic cultivar Pusa 1121. Nitrogen, P and K uptake by grain, straw and the total nutrient uptake increased significantly as the level of N increased from 50 kg ha^{-1}. However, agronomic nitrogen use efficiency and apparent nitrogen recovery declined as the N level decreased. Pusa 1121 recorded a higher nitrogen efficiency ratio compared to PRH 10. PRH 10 utilized the applied N more efficiently than Puss 1121. With regard to the N source, Pusa neem golden urea and neem bitter coated urea resulted in greater N uptake, ANUE and ANR than aromatic cultivar and hybrid rice production.

Nakashgir *et al.* (2000) conducted an experiment at Sher-i-Kashmir Agricultural University Farm, Shalimar, Srinagar (India), to study the effect of K in presence of different levels of NH_4-N on the rice yield during year 1995-1997. The combined significant mean grain yield 59.66 q ha^{-1} was obtained with combination of N_{99} and K_{60} without the basal application of any form of organic manure. The increase in potassium and nitrogen uptake by the rice crop ranged from 24.14 to 57.58 and 4.73 to 11.53 kg ha^{-1}, respectively.

Singh and Singh (2000) observed that the highest value to yield attributes, yield, N and K uptake were recorded at 60 kg K ha^{-1}.

Effect of organic and inorganic fertilizers on rice

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 and it was 14.8 and 26.1% higher over 100 and 75% RDN, respectively. The result showed that there was significant reduction in yield attributes, yields and nutrient uptake due to delayed transplanting.

Rahman *et al*. (2011) conducted field experiments over three years at BAU farm, Mymensingh and OFRD farm, Rangpur, respectively, using farm yard manure (FYM), dhaincha and mungbean residue along with inorganic fertilizers. Integrated use of manure and inorganic fertilizers (IPNS basis) produced comparable seed yield of maize with the chemical fertilizers alone irrespective of moderate or high, yield goal basis (MYG or HYG) in both locations. After harvest of maize, mungbean and dhaincha seeds were sown as per treatments. At both locations, the incorporation of *Sesbania* biomass and mungbean residue along with inorganic fertilizers for MYG gave identical grain yields of T. aman rice with the fertilizers alone applied for HYG. There was an inverse relationship between the higher dose of fertilizer application and marginal benefit cost ratio at both the locations. Considering gross margin and marginal benefit-cost ratio legume residue incorporation along with inorganic fertilizers (IPNS basis) was found to be the best treatment (T_3).

Islam *et al.* (2010) conducted an experiment at Bangladesh Institute of Nuclear

Agriculture (BINA) experimental field, Mymensingh for two years to introduce green manuring in Boro-T. aman rice cropping pattern for maintainance of soil fertility as well as increased crop productivity. The highest grain of Boro 7.21 (t ha^{-1}) was recorded in treatment T_4 (N_{140}, P_{45}, K_{85}, S_{35}, Zn_4 and B_2 kg ha^{-1}) which was statistically identical with T_2 (7.18 t ha^{-1}), T_6 (7.17 t ha^{-1}), and T_7 (7.12 t ha^{-1}). Nutrient uptake of the cropping pattern found to follow the order: N > K >P and S. Application of cowdung in first crop (kharif season) of the pattern and incorporation of dhaincha as green manure 5 -6 days before transplanting of T. aman rice along with recommended inorganic fertilizers may substantially increase the production of Boro -T. aman rice as well as improve the soil fertility.

Saha *et al.* (2007) carried out a seven year long field trial on integrated nutrient management for dry season rice (Boro)-green manure (GM)-wet season rice (T. aman) cropping system at the Bangladesh Rice Research Institute (BRRI) farm, Gazipur during 1993-1999. Five packages of inorganic fertilizers, cow dung and dhaincha were evaluated for immediate and residual effect on crop productivity, nutrient uptake, soil-nutrient balance sheet and soil-fertility status. Plant height, active tiller production, grain and straw yields were significantly increased as a result of the application of inorganic fertilizer and organic manure. Usually, the soil-test-based fertilizer dose for a high-yield goal produced the highest grain yield of 6.39 t ha^{-1} (average of 7 years) in Boro rice. A positive effect of GM on the yield of T. aman rice was observed.

Somado *et al.* (2007) conducted two experiments to study the dynamics of extractable P (P extracted by Bray-1–extracting solution) of an Ultisol amended with or without GM residues of contrasting P concentrations in the absence of growing plants. In two experiments, GM residues of *Aschynomene afraspera* (a flood tolerant legume) and *Crotalaria micans* (upland) with varying P concentrations were added to an acidic soil amended with a triple superphosphate

(TSP) in plastic bottles. The amendment with GM residues alone significantly increased Bray-1-P over the unamended control in the case of the inorganic P-fertilized GM residues. In case of PR concentrations P extracted by Bray-1 solution did not significantly change in the presence or absence of GM.

Babu and Seshaiah (2006) conducted a pot experiment to evaluate the effect of three levels of P (0, 30 and 60 kg P_2O_5 ha^{-1}) applied as single superphosphate and phosphate rock and their mixture (1:1) and two types of organic manures viz., FYM and green manure (dhaincha) applied at 5 tones ha^{-1}, on yield and nutrient uptakes in rice. The grain and straw yields decreased with increase in P levels irrespective of the source. Single super phosphate was found to be more effective than phosphate rock. Application of 30 kg P_2O_5 as SSP + 30 kg P_2O_5 as PR ha^{-1} was less effective than 60 kg P_2O_5 ha^{-1} applied through SSP. The effectiveness of P sources enhanced, when they were applied with organic manures. Phosphorus application alone or in combination with organic manures resulted in a significant increase in uptake of the nutrients in grain and straw.

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 the 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}.

Kumar *et al.* (2004) conducted an experiment to evaluate the performance of rice cv. ADT 36 under different manure and fertilizer schedules adopted in the permanent rice monoculture. Nitrogen, P and K were supplied @ 120, 60 and 60 kg ha^{-1}, respectively, while organic manures were supplied @ 12.5 t ha^{-1}. Potassium content in straw was higher in treatments receiving one of the organic manures with K @ 60 kg ha^{-1} compared to other treatments. Potassium uptake was higher in treatments receiving 120 kg N ha^{-1} with one of the manures compared to 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 performs well and were followed by PR (34/74) with iron pyrites and green manure. Thus, PR (34/74) performs 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.

Vipin and Prasad (2003) conducted a field experiment to find out the effect of green manuring by summer green gram, green gram straw incorporation and NPK on the efficiencies of applied nutrients in calcareous soils under rice-wheat cropping system. Grain and straw yields of rice increased significantly with the graded levels of fertilizer application. Maximum grain and straw yields of rice were recorded in the NPK treatment + green manuring. Apparent potassium recovery and agronomic use efficiency by rice were decreased with increasing levels of potassium fertilizers.

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

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Chapter 3

Materials and Methods

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CHAPTER 3

MATERIALS AND METHODS

The materials used and methods followed in this experiment have been presented in this chapter. This contains a brief description of experimental site, soil, climate, crop, treatments, experimental design, land preparation, transplanting of seedling, intercultural operations, harvesting, data recording, collection and preparation of soil and plant samples and the methods for the chemical and statistical analysis. The details of the materials and methods are presented below.

Field experiment

Experimental site and season

The experiment was set up at the farmer's field at Debhata upazila of Satkhira during the Boro season of 2013 and the period was from 28 January to 15 May, 2019. The field is located at 22.34' N Latitude and 89.00' E Longitude belonging to Alluvial Floodplain soil under the Ganges Tidal Floodplain Agro Ecological Zone (AEZ 13).

Climate

The experimental area has a sub-tropical climate, which is characterized by high temperature, high humidity and high rainfall with occasional gusty winds in the kharif season (April-September) and low rainfall associated with moderately low temperature during rabi season (October-March).

Soil sampling and preparation

Soils were collected at a depth of 0-15 cm from the 10 spots of the experimental plot. After collection the soils were made free from the plant roots and unnecessary materials and dried under the sunlight for four days. Then the soils were mixed up thoroughly and 500 g soil was taken for initial physical and chemical analysis. The morphological, physical and chemical characteristics of the soil are presented in Table 3.1.

Table 3.1 Morphological, physical and chemical characteristics of soil

A. Morphological characteristics of the experimental field

Agro-ecological zone	Ganges Tidal Floodplain (AEZ 13)
Land type	Medium low land
General Soil Type	Alluvial floodplain
Parent material	Ganges River Floodplain
Topography	Fairly level
Drainage	Moderately well drained
Flood level	High risk of flood
Vegetation	Mungbean during rabi season and T. Aman during kharif season.

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B. Physical and chemical properties of the soil of the Experiment

Constituents	Value
Physical characteristics	
% Sand (2.0-0.05mm)	42.50
% Silt (0.05-0.002mm)	46.01
% Clay(<0.002mm)	11.49
Textural class	Silt loam
Chemical characteristics	
pH (Soil: Water =1:2.5)	7.8
Organic matter (%)	2.10
EC (ds/m)	4.6
Total N (%)	0.14
Available P (mg kg^{-1})	14.2
Available S (mg kg^{-1})	18.5
Exchangeable K (me/100g soil)	0.29
Exchangeable Na (me/100g soil)	7.40
Exchangeable Ca (me/100g soil)	7.09

Crop

Rice variety used for the Boro rice as the test crop in this experiment was Binadhan-10. It is a high yielding, duration of this rice variety is 125-135 days from seed sowing to ripening and developed by Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. This variety is somewhat resistant to pests and diseases especially stem rot, sheath blight and leaf blight.

Treatments, design and replication

Different types of chemical fertilizers-urea, triple super phosphate, muriate of potash, gypsum, zinc sulfate and boric acid were used in the study following Randomized Complete Block Design including 6 treatments with 3 replications. The treatment combinations were as follows:

T_1: Control (No fertilizers)

T_2: $N_{100}P_{15}K_{30}S_{12}Zn_2B_1$

T_3: $N_{120}P_{20}K_{40}S_{14}Zn_2B_1$

T_4: $N_{140}P_{25}K_{50}S_{16}Zn_2B_1$

T_5: $N_{160}P_{30}K_{60}S_{18}Zn_2B_1$

T_6: $N_{180}P_{35}K_{70}S_{20}Zn_2B_1$

The subscript refers to the rate of nutrients. The control treatment did not receive any fertilizers.

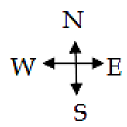
Land preparation

Land preparation was started on 18 November, 2018. The land was prepared thoroughly by ploughing and cross ploughing with a power tiller. Every ploughing was followed by laddering to have a good tilth. Weeds and stubbles of the previous crop were collected and removed from the plot. After uniform leveling, the plots were laid out as per as treatments and design of the experiment.

ISSN 2320-9186

Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design. The entire experimental area was divided into three blocks representing three replications to reduce soil heterogenetic effects and each block was divided into 6 unit plots with raised bonds as per treatments. Thus the total number of unit plots was 18. The size of each unit plot was 5m x 4m and plots were separated from each other by drains (0.5m). Unit block was separated from one another by 1 m ails. The treatments were randomly distributed to the plots in each block. The layout of the experiment is shown in Fig. 3.1



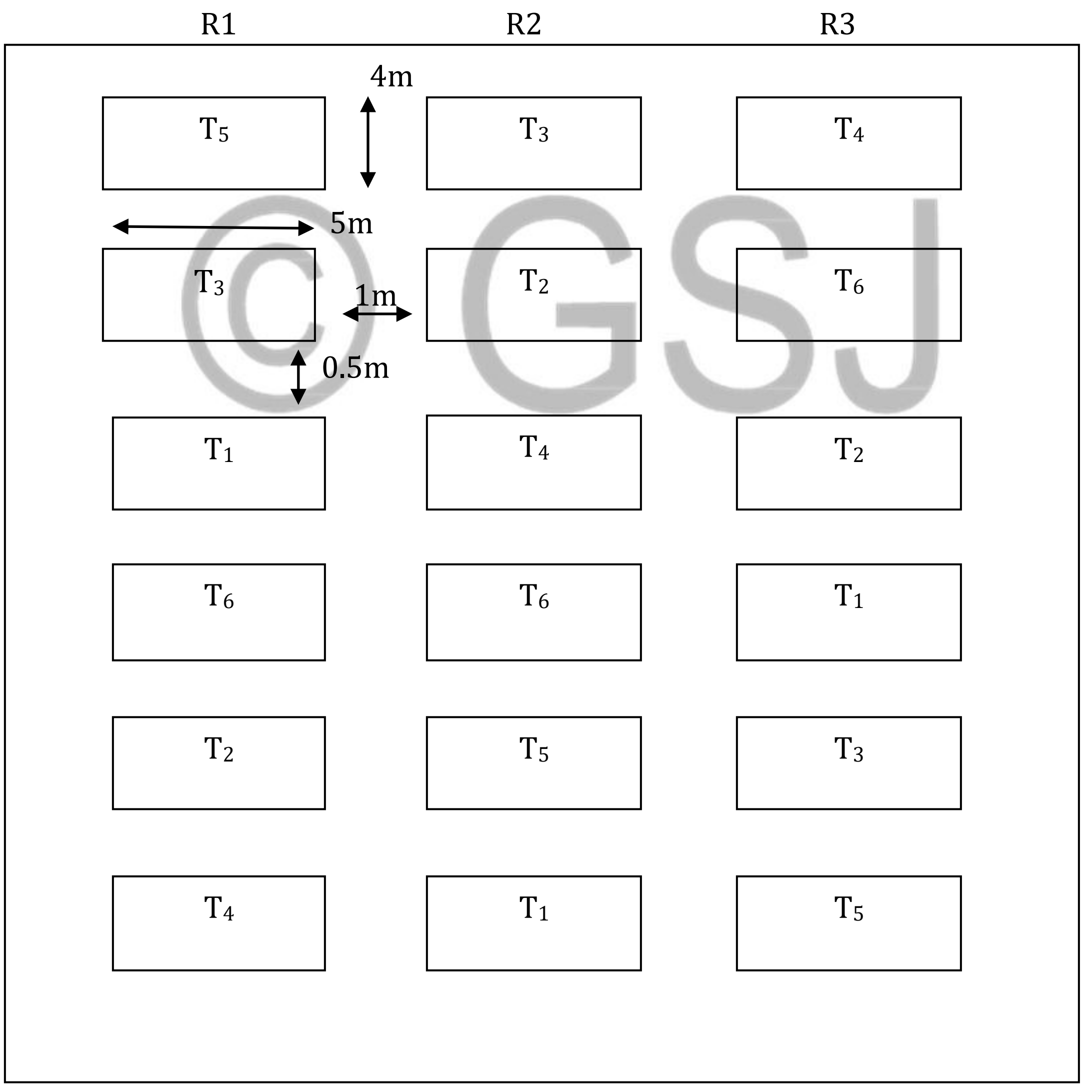


Fig. 3.1 Layout of the experiment

Fertilizer application

Fertilizers were applied to each plot as per treatment. Fertilizers such as urea, TSP, MoP, gypsum, zinc sulphate and boric acid were used as sources for N, P, K, S, Zn and B respectively. Except urea, other fertilizers were applied to the individual plots during final land preparation according to the treatments used. Urea was applied in three equal splits: first split was applied at 10 days after transplanting, second split of urea was applied at 30 days after transplanting i.e. at maximum tillering stage and the third split was applied at 55 days after transplanting i.e. at panicle initiation stage.

Seedling raising and transplanting

The seedling should be uprooted from the seedbed when they are suitable for transplanting. Thirty five days old healthy seedlings of Binadhan-10 were transplanted in the plots on 28 January 2013. The spacing of transplanting was 20 cm x 20 cm, and three seedlings were transplanted in each hill. After one week of transplanting, all plots were checked for any missing hill, which was filled up with extra seedlings, wherever required.

Intercultural operations

Intercultural operations were done for ensuring and maintaining the normal growth of the crop. The detailed intercultural operations were recorded in the Table 3.3. The following intercultural operations were done as and when required. Top-dressing of urea was done as per schedule and the normal cultural practices including weeding and insecticide spray was done as and when required.

Table 3.3 Ploughing and Intercultural operations done during field study

Ploughing and Intercultural operations	Date
First ploughing of the field	20.01.2019
Second ploughing and laddering	23.01.2019
Third ploughing and laddering	26.01.2019
Final ploughing plot preparation and application of fertilizer (TSP, MOP, gypsum, zinc sulphate and boric acid)	27.01.2019
Transplanting of seedlings (Binadhan-10)	28.01.2019
First weeding	12.02.2019
First split application of urea	17.02.2019
Second weeding	22.02.2019
Second split application of urea	27.02.2019
Third weeding	04.03.2019
Third split application of urea	24.03.2019
Harvesting	15.05.2019
Threshing	20.05.2019

Irrigation

Alter transplanting, 5 to 6 cm water was maintained in each plot throughout the growing period. EC of irrigation water were maintained at optimum level.

Weeding

The experimental plots were infested with some common weeds, which were removed twice by uprooting.

Insect and pest control

There was no infestation of insect pests and diseases in the field during the experimental period and no control measures were adopted.

Harvesting and threshing

The crop was harvested at full maturity on 15.05.2019. The harvested crop of each plot was bundled separately and brought to the threshing floor. Then harvested crop was threshed plot wise on 20.05.2019.

Plant sample collection

Five hills were randomly selected from each plot at maturity to record the yield contributing characters like, number of effective tiller hill^{-1}, number of filled grain panicle^{-1} and weight of 1000-grains.

Data collection

Plant height

The height of the plant in cm was measured from the ground level to the top of the panicle.

Panicle length

Panicle length in cm was measured from basal node of the rachis to apex.

Effective tillers hill^{-1}

Effective tillers were counted per hill from 5 hills of each plot.

Number of grains panicle^{-1}

The number of grains panicle^{-1} of all fertile tillers was counted.

1000-grain weight

Thousand grains from each plot were counted and weighed in an electrical balance.

Grain yield

After harvesting of the crop, grain from each unit plot was dried and weighed. The result was expressed as ha on 14% moisture basis.

Straw yield

After harvesting of the crop, straw yield from each unit plot was dried and weighed. The result was expressed as t ha^{-1}.

Biological yield

Biological yield is the summation of grain yield and straw yield. It was calculated by the following formula:

Biological yield = (Grain yield + Straw yield).

Physical and chemical analysis of soils

Collection and preparation of soil sample

The initial soil sample was collected from 0-15 cm depth from the experimental site at Debhata in Satkhira. The soil sample was air-dried, crushed and sieved through 2mm sieve and kept in polythene bags for chemical analysis.

Soil analysis

Soil samples were analyzed for both physical and chemical characteristics. The soil samples were analyzed following the standard methods as follows:

Textural class

Mechanical analysis of soil was done by hydrometer method and the textural class was determined by fitting the values for % sand, % silt and % clay to the Marshall's triangular co-ordinate following USDA system.

Soil pH

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

Organic matter

Organic carbon in soil sample was determined volumetrically by wet oxidation method of Walkley and Black (1934). The organic matter content was calculated by multiplying the percent organic carbon with the Van Bemmelen factor of 1.73.

Cation exchange capacity

Cation exchange capacity of the soil was determined by sodium saturation method as outlined by Jackson (1962). The soil samples were saturated with 1 N NH_4OAc solution followed by replacing Na^+ from the saturated samples by 1N NH $_4OAc$ at pH 7.0. The amount of Na^+ in the solution was then determined by flame photometer.

Total nitrogen

Total N content of soil was estimated following the micro-Kjeldahl method. The soil was digested with H_2O_2 and conc. H_2SO_4 in presence of a catalyst mixture (K_2SO_4: $CuSO_4.5H_2O$: Se in the ratio of 100:10:1) and the nitrogen in the digest was determined by distillation with 40% NaOH followed by titration of distillate trapped in H_3BO_3 with 0.01 N H_2SO_4 (Page *et al.,* 1982).

Available phosphorus

Available P was extracted from the soil with 0.5 M $NaHCO_3$ solution, pH 8.5 (Olsen *et al.,* 1954) Phosphorus in the extract was then determined by developing blue color with reduction of phosphomolybdate complex and the color intensity was measured colorimetrically at 660 nm wavelengths. The P concentration of extract was calculated by fitting the absorbance reading to the standard curve.

Exchangeable K, Na and Ca

Exchangeable K, Na and Ca were determined by flame photometer on the neutral ammonium acetate extract (Black, 1965). In this method the soil sample was saturated with NH_4OAc solution and the supernatant clear solution was separated and

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collected. Then NH_4OAc solution was added again to make the final volume up to 100 for each sample. For the above three cations (K^+, Na^+ and Ca^{++}) the flame photometer was separately adjusted and different standard curves were prepared to find out the concentration of the cations but the extracting solution used for each sample was same. From each reading the concentration of each ion was obtained from their respective standard curves and was expressed as me 100 $g^{-1}$of soil.

Available sulphur

Available sulphur in soil was determined by extracting the soil samples with0.15% $CaCl_2$ solution. The S content in the extract was determined turbidimetrically and the intensity of turbid was measured by Spectrophotometer at 420 nm wavelengths as described by Page *et al.,* (1982).

Chemical analysis of grain and straw

Preparation of plant samples

The collected grain sample from each plot was dried in an oven at 65^0C for about 24 hours after which they were ground by a grinding mill. Later the ground samples were sieved through 20-mesh sieve. The ground plant materials were stored in paper bags or in a desiccator. The grain and straw samples were analyzed for determination of N, P, K and S concentrations.

Digestion of samples with sulphuric acid

An amount of 0.1 g oven dry, ground sample was taken in a dry clean digestion vessel. Into the vessel, 1.1 g catalyst mixture (K_2SO_4: $CuSO_4.5H_2O$: Se in the ratio of 100:10:1), 2.5 ml H_2O_2, and 5ml conc. H_2SO_4, were added. The vessel was swirled and allowed to stand for 10 minutes, followed by heating at 200 ˚C. Heating was continued until the digest become clear and colorless. After cooling, the content was taken into a 100 ml volumetric flask and the volume was made with deionised water. A reagent blank was also prepared in a similar manner. This digestion was performed for nitrogen determination.

Digestion of samples with nitric - perchloric acid

A sub sample weighing 0.5 g was transferred into a dry clean digestion vessel. Ten ml of di-acid (HNO_3: $HClO_4$ in the ratio 5: 1) added to the vessel. After leaving for a while, the vessels were heated at a temperature slowly raised to 185^0C. Heating was stopped when the dense white fumes of $HClO_4$ occurred. The contents of the vessel were boiled until they became clear and colorless. After cooling, the contents were taken into a 50 ml volumetric flask and the volume was made with deionised water. This digest was used for estimating P, K and S.

Estimation of elements

The elements viz. N, P, K and S in the digest were determined in the same method as used in soil chemical analysis.

Statistical analysis

The analysis of variance for various crop characters and also for various nutrients concentrations and nutrient uptake was done following the F-test. Mean comparisons of the treatments were made by the Duncan's Multiple Range Test (DMRT).

Economic analysis

For economic analysis, variable costs have only been considered and fixed costs were ignored. Variable costs included variable money costs and variable opportunity costs. Net return was calculated by subtracting the control total variable cost from the other total variable cost. Variable money cost was the purchasing price of fertilizers and variable opportunity cost included the amount of money paid for carrying and broadcasting the fertilizers.

Chapter 4

Results

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CHAPTER 4
RESULTS

This chapter presents the effect of different rates of fertilizer on growth and yield of Binadhan-10. Four sections are contained by this chapter such as yield components, yield, nutrient content and nutrient uptake by Binadhan-10. The nutrient contents under study were N, P, K and S. The results have been presented in various Tables, Figures and discussed under the following subsections.

Yield components of Binadhan-10

The yield components include the plant height, panicle length, number of tillers hill^{-1}, grains panicle^{-1} and 1000-grain weight. The data on these parameters have been presented in Table 4.1

Plant height

Plant height of Binadhan-10 was significantly affected due to different treatments (Table 4.1). Plant height varied from 85.1 cm in T_1 (Control) treatment to 97.6 cm in T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) treatment. The tallest plant (97.6 cm) was recorded in the treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) which was statistically similar to those observed in treatments T_2 (N_{100} P_{15} K_{30} S_{12} Zn_2 B_1), T_3 (N_{120} P_{20} K_{40} S_{14} Zn_2 B_1), T_5 (N_{160} P_{30} K_{60} S_{18} Zn_2 B_1) and T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1) with the values of 91.1, 96.0, 91.6 and 94.2 cm, respectively. The shortest plant (85.1 cm) was obtained in the treatment T_1 (control) which was significantly inferior to all other treatments.

Panicle length

Panicle length of Binadhan-10 was significantly influenced by different treatments (Table 4.1). Panicle length due to different treatments varied from 19.27 cm in T_1 (control) to 21.93 cm in T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1). The values for panicle length of all the treatments were higher than that of the control. The panicle length of T_2 (N_{100} P_{15} K_{30} S_{12} Zn_2 B_1) to T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1) treatments were about 1.40 to 2.66 cm taller than that found in treatment T_1 (control).

Effective tillers hill^{-1}

There was a significant effect of different fertilizer treatments on the production of effective tillers hill^{-1} of rice plants (Table 4.1). The number of tillers hill^{-1} due to different treatments varied from 10.20 to 12.53. The highest number of tillers hill^{-1} (12.53) was found in the treatment T_2 (N_{100} P_{15} K_{30} S_{12} Zn_2 B_1) which was statistically similar to those recorded in all other treatments except T_1 (control). It might be due to smaller reduction of the fertilizers did not affect the growth and development of plants remarkably. The minimum number of tillers hill^{-1} (10.20) was found in the treatment T_1 (control).

Filled grains panicle^{-1}

Results presented in the Table 4.1 showed a significant effect of different rates of N, P, K and S supplied from respective fertilizers on the number of filled grains panicle^{-1} of Binadhan-10. The number of filled grains particle^{-1} of different treatments ranged from 68.0 to 94.8. The highest number of filled grains panicle^{-1} of 94.8 was obtained from T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1) treatment, which was statistically similar to those recorded in the treatments T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1), T_5 (N_{160} P_{30} K_{60} S_{18} Zn_2 B_1) and T_2 (N_{100} P_{15} K_{30} S_{12} Zn_2 B_1) with values of 93.3, 94.3 and 91.6, respectively. The lowest number of filled grains panicle^{-1} (68.0) was obtained from the treatment T_1 (control).

1000-grain weight

Analysis of variance of data showed significant variation regarding thousand-grain weight of Binadhan-10 presented in Table 4.1. It appears that the application of different fertilizer levels increased the 1000-grain weight of Binadhan-10. The 1000-grain weight ranged from 19.66 to 22.68 g. All the treatments showed significant increase in 1000-grain weight over control. The highest 1000-grain weight (22.68 g) was recorded from T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1), while the lowest 1000-grain weight (19.66 g) was obtained in the treatment T_1 (control).

Table 4.1 Effect of fertilizers on the yield contributing characters of Binadhan-10 in saline soil at Satkhira

Treatments	Plant height (cm)	Panicle length (cm)	Effective tillers $hill^{-1}$ (no.)	Filled grains $panicle^{-1}$ (no.)	1000 grain wt. (g)
T_1	85.1 b	19.27 b	10.20 b	68.0 c	19.66 c
T_2	91.1 ab	20.67 a	12.53 a	91.6 a	22.39 a
T_3	96.0 a	21.13 a	12.33 a	85.0 b	22.32 a
T_4	97.6 a	21.20 a	12.47 a	93.3 a	22.68 a
T_5	91.6 ab	21.27 a	11.97 a	94.3 a	21.50 b
T_6	94.2 a	21.93 a	12.50 a	94.8 a	21.83 ab
SE (±)	1.99	0.399	0.292	1.60	0.479
Level of significance	**	**	**	**	**

In a column the figures having common letter(s) do not differ significantly at 5% level of significance.

SE (±) = Standard error of means

T_1 = Control, $T_2 = N_{100}\ P_{15}\ K_{30}\ S_{12}\ Zn_2\ B_1$, $T_3 = N_{120}\ P_{20}\ K_{40}\ S_{14}\ Zn_2\ B_1$,

$T_4 = N_{140}\ P_{25}\ K_{50}\ S_{16}\ Zn_2\ B_1$, $T_5 = N_{160}\ P_{30}\ K_{60}\ S_{18}\ Zn_2\ B_1$, $T_6 = N_{180}\ P_{35}\ K_{70}\ S_{20}\ Zn_2\ B_1$

Yield of Binadhan-10

Data on grain, straw and biological yields of Binadhan-10 as affected by different treatments have been presented in Table 4.2.

Grain yield

Grain yield of Binadhan-10 responded significantly to different treatments (Table 4.2). The grain yields due to various treatments ranged from 2.73 to 5.86 t ha^{-1}. All the treatments showed higher grain yield over control. The highest grain yield (5.86 t ha^{-1}) was obtained in the treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) which was statistically similar to those observed in the treatments T_3 (N_{120} P_{20} K_{40} S_{14} Zn_2 B_1), T_5 (N_{160} P_{30} K_{60} S_{18} Zn_2 B_1) and T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1) with values of 5.43, 5.40 and 5.76 t ha^{-1}, respectively. The lowest grain yield (2.73 t ha^{-1}) was obtained in the treatment T_1 (control) which was statistically different from all other treatments. This implies that these nutrients had significant role on grain yield. The percentages of increased grain yield over control due to different treatments were also presented in the Table 4.2. The highest percentage (114%) increase in grain yield over control was recorded in the treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1). The lowest percentage (75%) of increased grain yield over control was recorded in the treatment T_2 (N_{100} P_{15} K_{30} S_{12} Zn_2 B_1). The grain yield obtained from different treatments ranked in the order of $T_4 > T_6 > T_3 > T_5 > T_2 > T_1$.

Table 4.2 Effect of fertilizers on grain, straw and biological yields of Binadhan-10 in saline soil at Satkhira

Treatments	Yield (t ha^{-1})		% Increased over control		Biological yield (t ha^{-1})
	Grain	Straw	Grain	Straw	
T_1	2.73 c	3.56 d			6.30 d
T_2	4.80 b	5.73 c	75	60	10.53 c
T_3	5.43 a	6.06 bc	98	70	11.50 bc
T_4	5.86 a	6.76 ab	114	89	12.63 a
T_5	5.40 a	6.86 ab	97	92	12.27 ab
T_6	5.76 a	7.00 a	110	96	12.77 a
SE (±)	0.171	0.254			0.315
Level of significance	**	**			**

In a column the figures having common letter(s) do not differ significantly at 5% level of significance.

SE (±) = Standard error of means

T_1 = Control, T_2 = N_{100} P_{15} K_{30} S_{12} Zn_2 B_1, T_3 = N_{120} P_{20} K_{40} S_{14} Zn_2 B_1,

T_4 = N_{140} P_{25} K_{50} S_{16} Zn_2 B_1, T_5 = N_{160} P_{30} K_{60} S_{18} Zn_2 B_1, T_6 = N_{180} P_{35} K_{70} S_{20} Zn_2 B_1

Straw yield

Result presented in the Table 4.2 showed that straw yield of Binadhan-10 was significantly influenced by different treatments under study. The straw yield obtained from different treatments ranged from 3.56 to 7.00 t ha^{-1}. All the treatments gave higher straw yield over control. It was observed that the treatments T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1) gave the highest straw yield (7.00 t ha^{-1}) which was statistically identical to that in the treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) and T_5 (N_{160} P_{30} K_{60} S_{18} Zn_2 B_1) with values of 6.76 and 6.86 t ha^{-1}, respectively. It was also observed that the treatments T_2 (N_{100} P_{15} K_{30} S_{12} Zn_2 B_1) and T_3 (N_{120} P_{20} K_{40} S_{14} Zn_2B1) gave the straw yield 5.73 and 6.06 t ha^{-1}, respectively. The lowest straw yield (3.56 t ha^{-1}) was recorded in the treatment T_1 (Control). The highest percentage (96%) increased straw yield over control was noted in the treatment T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1). The straw yield due to different treatments ranked in the order of $T_6 > T_5 > T_4 > T_3 > T_2 > T_1$.

Biological yield

Biological yield of Binadhan-10 responded significantly to different treatments (Table 4.2). The biological yield due to various treatments ranged from 6.30 to 12.77 t ha^{-1}. All the treatments showed higher biological yield over control. The highest biological yield (12.77 t ha^{-1}) was obtained in the treatment T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1) which was statistically similar to those observed in the treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) and T_5 (N_{160} P_{30} K_{60} S_{18} Zn_2 B_1) with values of 12.63 and 12.27 t ha^{-1}, respectively. The lowest biological yield (6.30 t ha^{-1}) was obtained in the treatment T_1 (control) which was statistically different from all other treatments.

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Correlation matrix between yield and yield parameters

In order to examine the interrelationship among the yield and yield components, a correlation matrix was performed. The value of correlation coefficient (r) is given in the following figures. It appeared that the grain yield was positively correlated with the plant height (r=0.776), panicle length (r=0.790), number of tillers hill^{-1} (r=0.786), filled grains panicle^{-1} (r=0.852) and 1000-grain weight (r=0.693). (Fig 4.1-4.5)

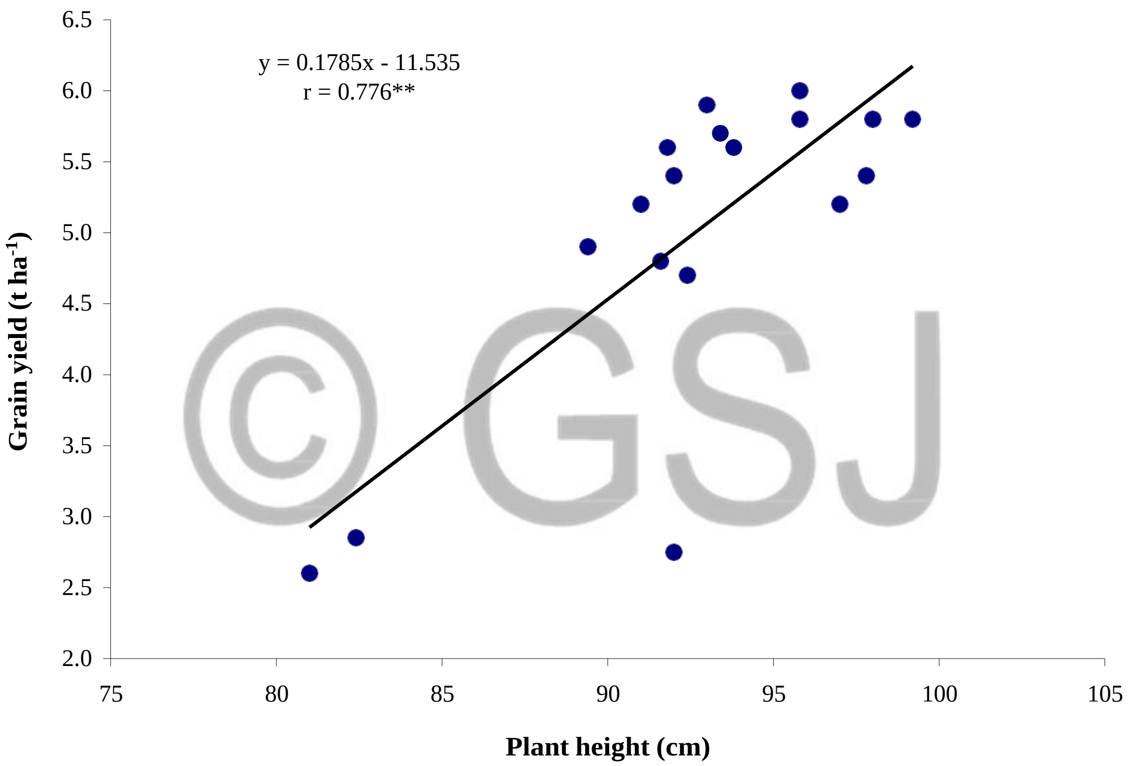

Fig. 4.1 Relationship between plant height vs. grain yield

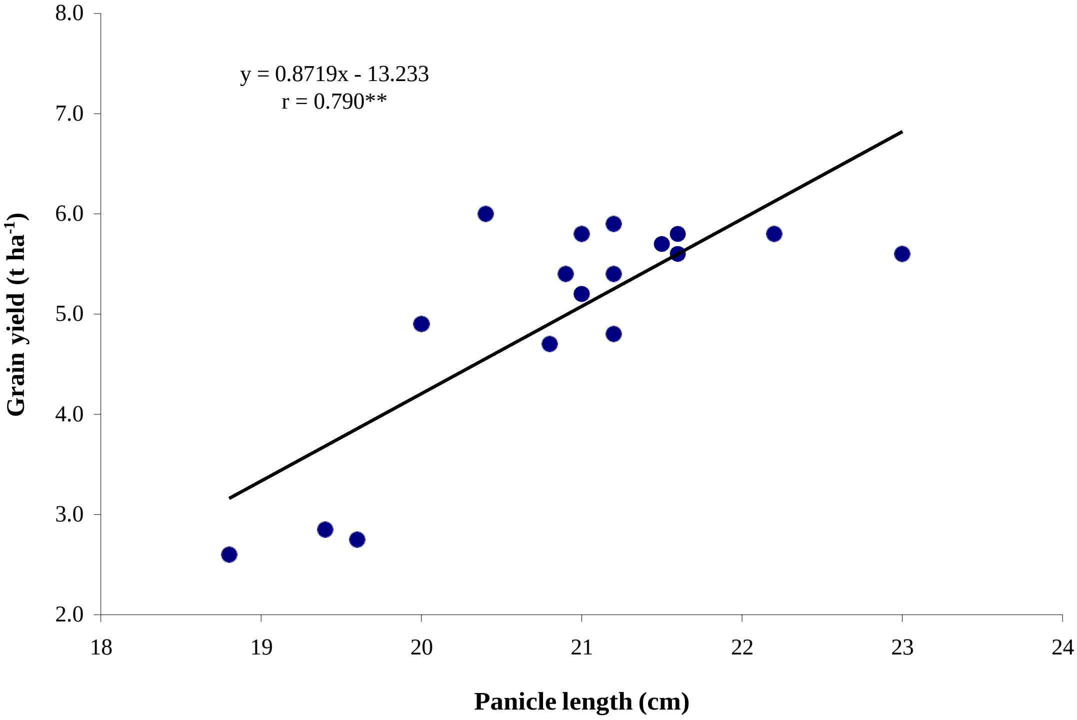

Fig. 4.2 Relationship between panicle length vs. grain yield

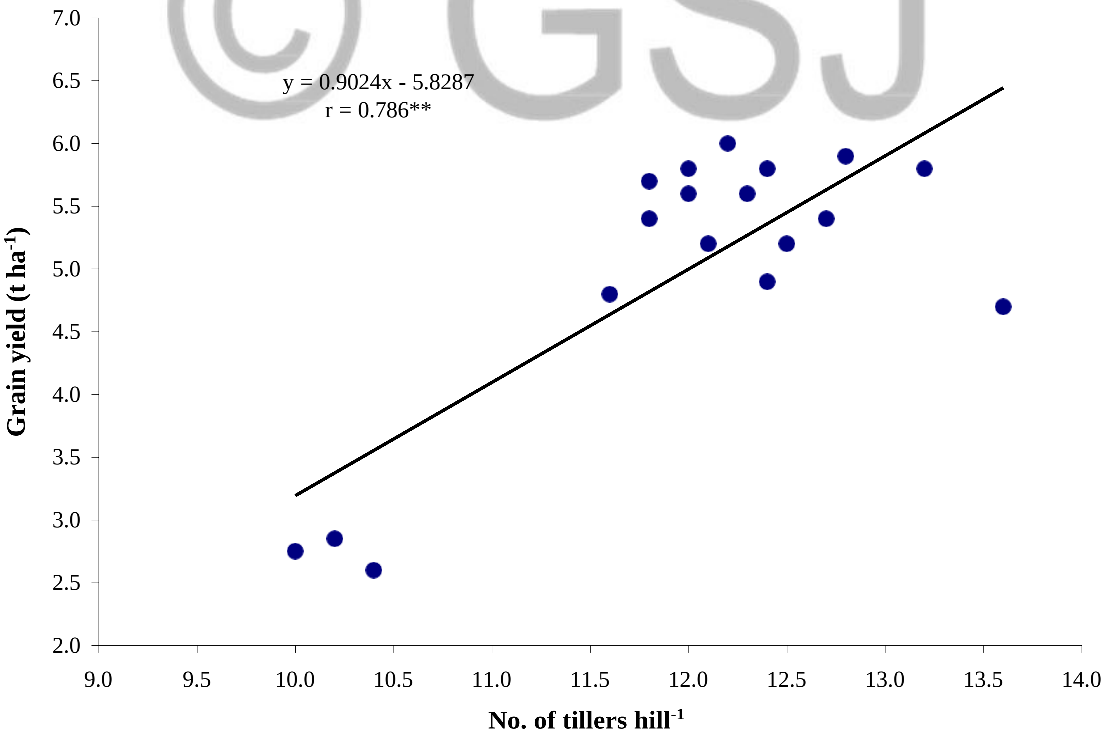

Fig. 4.3 Relationship between number of tillers hill^{-1} vs. grain yield

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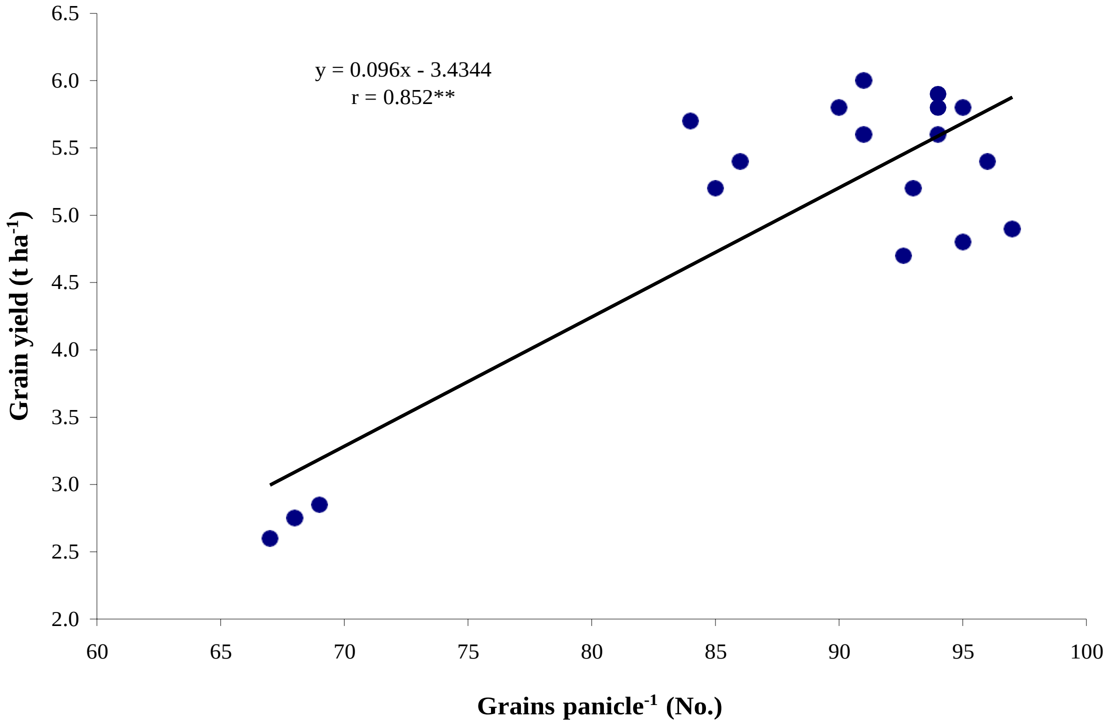

Fig. 4.4 Relationship between filled grains panicle^{-1} vs. grain yield

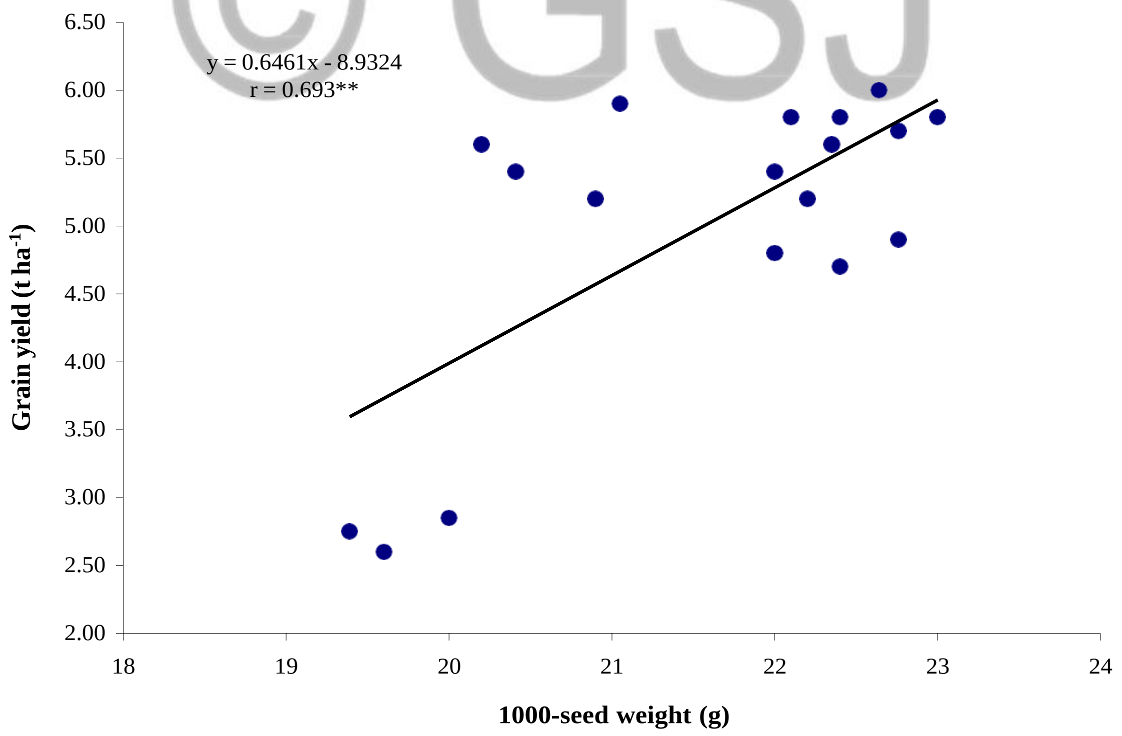

Fig. 4.5 Relationship between 1000-grain weight vs. grain yield

Relationship between grain and straw yields

There was a positive correlation (r=0.953) between grain and straw yields (Fig. 4.6). The relationship is described by the yield response function y=0.8645x – 0.1871 where y indicates grain yield, which varied with the straw yield levels x.

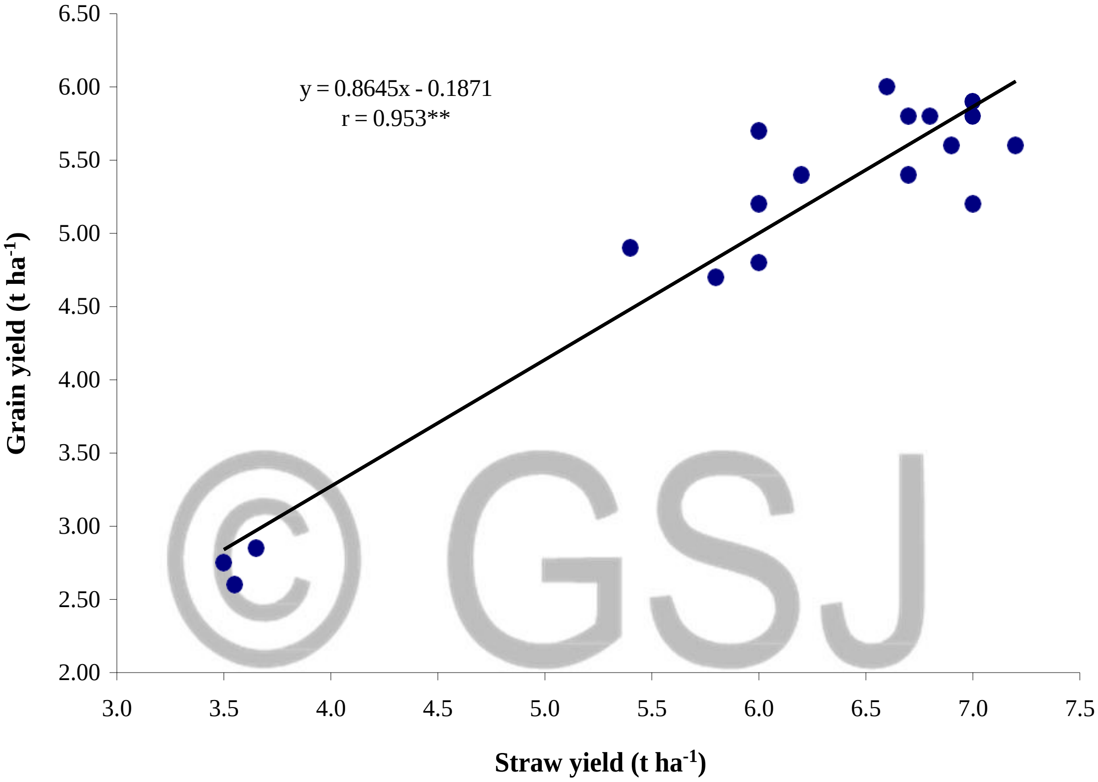

Fig. 4.6 Relationship between straw yield vs. grain yield

Nutrient content in grain and straw

The results on N, P, K and S content of grain and straw have been presented in Table 4.3.

Nitrogen content

There was significant effect of different treatments on N concentration of both rice grain and straw (Table 4.3). The N content in grain varied from 0.903 to 1.223%. The treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) resulted the maximum N content in grain (1. 223%). The minimum value (0.903%) was recorded in the treatment T_1 (control). The N content in straw due to different treatments ranged from 0.390 to 0.493% (Table 4.3). The highest N value (0.493% N) was found in the treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1). The lowest value (0.390%N) was noted in the treatment T_1 (control). The fertilizer dose increased the N content both in grain and straw of rice but smaller reduction of N, P, K and S fertilizers affected the N content of grain and straw significantly. It indicates that the fertilizer dose had pronounced effect on N content in both grain and straw and the reduction of the fertilizer doses affected significantly in N content.

Phosphorus content

Results presented in Table 4.3 indicated that phosphorus content in both grain and straw of Binadhan-10 was significantly influenced by different treatments under study. The P content in grain ranged from 0.113 to 0.163%. The highest P value (0.163%) was recorded in the treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1). The lowest P value (0.113%) was noted in the treatment T_1 (control). The phosphorus content in straw varied from 0.060% to 0.090% (Table 4.3). All the treatments showed increased P content in grain and straw over T_1 (control). The highest P value (0.090%) was found in the treatment T_3 (N_{120} P_{20} K_{40} S_{14} Zn_2 B_1), T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) and T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1). The lowest P value (0.060%) was observed in the treatment T_1 (control). The P content in grain was higher than that of straw in all the treatments. It indicates that the recommended fertilizer dose has pronounced effect on P content in both grain and straw.

Potassium content

Potassium content in both grain and straw was significantly affected by different treatments (Table 4.3). Potassium content in grain varied from 0.290 to 0.370%. The highest K content (0.370%) was found in the treatment T_5 (N_{160} P_{30} K_{60} S_{18} Zn_2 B_1). The lowest K content (0.290%) was recorded in the treatment T_1 (control). The potassium content in straw due to different treatments varied from 1.01 to 1.26% (Table 4.3). The highest K content (1.26%) was found in the treatment T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1). The lowest K content (1.01%) was observed in the treatment T_1 (control). It is observed that K content in straw was higher than that of grains in all the treatments and the reduction of the fertilizers dose affected significantly in K content. The application of increased fertilizer dose performed better in increasing K content both in grain and straw of Binadhan-10.

Sulphur content

Results in the Table 4.3 indicated that sulphur content in both grain and the straw of Binadhan-10 was significantly influenced by different treatments used in the experiment. Sulphur content in grain ranged from 0.078 to 0.112%. The maximum S content (0.112%) in grain was found in the treatment T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1) and the lowest S content (0.078%) was recorded in the treatment T_1 (control). In case of straw, sulphur content varied from 0.053 to 0.070%. The highest S content (0.070%) was recorded in the treatment T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1). The lowest S content (0.053%) was noted in the treatment T_1 (control). It indicates that the recommended fertilizer dose had pronounced effect on S content in both grain and straw and the reduction of the fertilizers dose significantly decreased S content of rice grain and straw.

Table 4.3 Effect of fertilizers on N, P, K and S contents in grain and straw of Binadhan-10 in saline soil at Satkhira

Treatments	%N		%P		%K		%S	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1	0.903 d	0.390 c	0.113 e	0.060 c	0.290 c	1.01 c	0.078 c	0.053 b
T_2	1.013 c	0.457 ab	0.150 b	0.073 b	0.323 b	1.21 ab	0.101 ab	0.066 a
T_3	1.140 ab	0.477 ab	0.140 bc	0.090 a	0.360 a	1.12 b	0.084 c	0.065 a
T_4	1.223 a	0.493 a	0.163 a	0.090 a	0.353 a	1.24 a	0.101 ab	0.066 a
T_5	1.203 a	0.480 ab	0.133 cd	0.077 b	0.370 a	1.19 ab	0.098 b	0.069 a
T_6	1.060 bc	0.433 bc	0.127 d	0.090 a	0.330 b	1.26 a	0.112 a	0.070 a
SE (±)	0.0003	0.0148	0.0039	0.0032	0.0070	0.0271	0.0040	0.0019
Level of significance	**	**	**	**	**	**	**	**

In a column the figures having common letter(s) do not differ significantly at 5% level of significance.

SE (±) = Standard error of means

T_1 = Control, $T_2 = N_{100}\ P_{15}\ K_{30}\ S_{12}\ Zn_2\ B_1$, $T_3 = N_{120}\ P_{20}\ K_{40}\ S_{14}\ Zn_2\ B_1$, $T_4 = N_{140}\ P_{25}\ K_{50}\ S_{16}\ Zn_2\ B_1$, $T_5 = N_{160}\ P_{30}\ K_{60}\ S_{18}\ Zn_2\ B_1$, $T_6 = N_{180}\ P_{35}\ K_{70}\ S_{20}\ Zn_2\ B_1$

Nutrient uptake by Binadhan-10

Nutrient uptake by Binadhan-10 was calculated by multiplying the yield data with respective nutrient concentrations in grain and straw. Total uptake has been calculated as the sum total of grain and straw uptake.

Nitrogen uptake

Results in Table 4.4 indicated that the N uptake by grain and straw of Binadhan-10 was significantly affected due to different treatments. The N uptake by grain varied from 24.66 to 71.67 kg ha^{-1}. The highest N uptake (71.67kg ha^{-1}) by grain was recorded in the treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) which was significantly different from all other treatments. The lowest N uptake (24.66 kg ha^{-1}) by grain was obtained in the treatment T_1 (control) which was statistically different from all other treatments. In straw, the N uptake ranged from 13.91 to 33.39 kg ha^{-1} (Table 4.4). The highest N uptake (33.39 kg ha^{-1}) by straw was observed in the treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) which was statistically identical to that recorded in the treatments T_5 (N_{160} P_{30} K_{60} S_{18} Zn_2 B_1) and T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1) with N uptake of 32.95 and 30.31 kg ha^{-1}, respectively. The lowest N uptake (13.91 kg ha^{-1}) by straw was recorded in the treatment T_1 (control) which was statistically different from all other treatments. In case of total N uptake, Binadhan-10 was significantly influenced by different treatments. The total N uptake due to different treatments ranged from 43.81 to 116.9 kg ha^{-1} (Table 4.4). The highest total N uptake (116.9 kg ha^{-1}) was recorded in the treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) which was significantly higher than all other treatments. The lowest total N uptake (43.81 kg ha^{-1}) was noted in the treatment T_1 (control).

Table 4.4 Effect of fertilizers on N and P uptake (kg ha^{-1}) by Binadhan-10 in saline soil at Satkhira

Treatments	N uptake			P uptake		
	Grain	Straw	Total	Grain	Straw	Total
T_1	24.66 d	13.91 d	43.81 d	3.093 c	2.140 d	5.233 e
T_2	48.63 c	26.22 c	84.49 c	7.207 b	4.213 c	11.42 d
T_3	61.91 b	28.90 bc	101.6 b	7.600 b	5.460 b	13.06 bc
T_4	71.67 a	33.39 a	116.9 a	9.583 a	6.090 ab	15.67 a
T_5	64.97 b	32.95 a	108.7 b	7.200 b	5.260 b	12.46 c
T_6	61.06 b	30.31 ab	103.0 b	7.300 b	6.307 a	13.61 b
SE (±)	1.73	1.02	2.20	0.185	0.255	0.306
Level of significance	**	**	**	**	**	**

In a column the figures having common letter(s) do not differ significantly at 5% level of significance.

SE (±) = Standard error of means

T_1 = Control, T_2 = N_{100} P_{15} K_{30} S_{12} Zn_2 B_1, T_3 = N_{120} P_{20} K_{40} S_{14} Zn_2 B_1,

T_4 = N_{140} P_{25} K_{50} S_{16} Zn_2 B_1, T_5 = N_{160} P_{30} K_{60} S_{18} Zn_2 B_1, T_6 = N_{180} P_{35} K_{70} S_{20} Zn_2 B_1

Phosphorus uptake

The phosphorus uptake in both grain and straw of Binadhan-10 was significantly influenced due to various treatments used in the experiment (Table 4.4). The ranges of P uptake in grain were 3.093 to 9.583 kg ha^{-1}. The maximum P uptake (9.583 kg ha^{-1}) by grain was recorded in the treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) which was significantly different from all other treatments. The minimum P uptake (3.093 kg ha^{-1}) by grain was observed in the treatment T_1 (control). In case of straw, the P uptake varied from 2.140 to 6.307 kg ha^{-1} (Table 4.4). The highest P uptake (6.307 kg ha^{-1}) was recorded in the treatment T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1) which was statistically identical to that recorded in the treatments T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1). The lowest P uptake (2.140 kg ha^{-1}) was found in the treatment T_1 (control).The total P uptake by grain and straw was also significantly affected by the different treatments (Table 4.4). The total P uptake by Binadhan-10 varied from 5.233 to 15.67 kg ha^{-1}. The highest total P uptake (15.67 kg ha^{-1}) was recorded in the treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1). The lowest value of total P uptake (5.233 kg ha^{-1}) was noted in the treatment T_1 (control) which was statistically inferior to all other treatments.

Potassium uptake

Potassium uptake by Binadhan-10 in both grain and straw was significantly influenced by various treatments (Table 4.5). The K uptake by grain varied from 7.927 to 20.73 kg ha^{-1}. The highest K uptake (20.73 kg ha^{-1}) by grain was noted in the treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) which was statistically identical to that recorded in the treatment T_5 (N_{160} P_{30} K_{60} S_{18} Zn_2 B_1) with K uptake of 19.97 kg ha^{-1}. The lowest K uptake (7.927 kg ha^{-1}) by grain was obtained in the treatment T_1 (control) which was statistically different from all other treatments. In case of straw, K uptake ranged from 36.02 to 88.16 kg ha^{-1} (Table 4.5). The highest K (88.16 kg ha^{-1}) was observed in the treatment T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1) which was statistically identical to that recorded in the treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) with K uptake of 83.91 kg ha^{-1}. The lowest K uptake (36.02 kg ha^{-1}) by straw was obtained in the treatment T_1 (control). It was observed that K uptake by rice straw was much higher than that of K uptake by rice grain. The total K uptake by grain and straw was also significantly affected by the different treatments (Table 4.5) and the total K uptake by Binadhan-10 varied from 43.95 to 107.2 kg ha^{-1}. The highest total K uptake (107.2 kg ha^{-1}) was recorded in the treatment T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1) which was statistically identical to that recorded in the treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) with K uptake of 104.6 kg ha^{-1}. The lowest value of total K uptake (43.95 kg ha^{-1}) was noted in the treatment T_1 (control) which was statistically different from all other treatments.

Table 4.5 Effect of fertilizers on K and S uptake (kg ha^{-1}) by Binadhan-10 in saline soil at Satkhira

Treatments	K uptake			S uptake		
	Grain	Straw	Total	Grain	Straw	Total
T_1	7.927 d	36.02 d	43.95 d	2.137 e	1.893 c	4.030 d
T_2	15.51 c	69.18 c	84.69 c	4.850 d	3.797 b	8.647 c
T_3	19.54 b	67.95 c	87.49 c	4.547 d	3.927 b	8.470 c
T_4	20.73 a	83.91 ab	104.6 ab	5.927 b	4.490 a	10.42 b
T_5	19.97 ab	81.69 b	101.7 b	5.310 c	4.717 a	10.03 b
T_6	19.04 b	88.16 a	107.2 a	6.477 a	4.900 a	11.38 a
SE (±)	0.329	1.41	1.67	0.128	0.162	0.227
Level of significance	**	**	**	**	**	**

In a column the figures having common letter(s) do not differ significantly at 5% level of significance.

SE (±) = Standard error of means

T_1 = Control, T_2 = N_{100} P_{15} K_{30} S_{12} Zn_2 B_1, T_3 = N_{120} P_{20} K_{40} S_{14} Zn_2 B_1,

T_4 = N_{140} P_{25} K_{50} S_{16} Zn_2 B_1, T_5 = N_{160} P_{30} K_{60} S_{18} Zn_2 B_1, T_6 = N_{180} P_{35} K_{70} S_{20} Zn_2 B_1

Sulphur uptake

Sulphur uptake by Binadhan-10 in both grain and straw was significantly influenced by various treatments (Table 4.5). The S uptake by grain varied from 2.137 to 6.477 kg ha^{-1}. The highest S uptake (6.477 kg ha^{-1}) by grain was noted in the treatment T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1) which was statistically different from all other treatments. The lowest S uptake (2.137 kg ha^{-1}) by grain was obtained in the treatment T_1 (control). In straw, S uptake ranged from 1.893 to 4.900 kg ha^{-1} (Table 4.5). The highest S uptake (4.900 kg ha^{-1}) was observed in the treatment T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1) which was statistically identical to that recorded in the treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) and T_5 (N_{160} P_{30} K_{60} S_{18} Zn_2 B_1) with S uptake of 4.490 and 4.717 kg ha^{-1}, respectively. The lowest S uptake (1.893 kg ha^{-1}) by straw was obtained in the treatment T_1 (control). The total S uptake by grain and straw was also significantly affected by the different treatments (Table 4.5) and the total S uptake by Binadhan-10 varied from 4.030 to 11.38 kg ha^{-1}. The highest total S uptake (11.38 kg ha^{-1}) was recorded in the treatment T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1). The lowest value of total S uptake (4.030 kg ha^{-1}) was noted in the treatment T_1 (control).

Economic analysis

Gross income was calculated at the total value of grain and straw yield of rice. Data in Table 4.6 shows the cost and benefit of different treatments used in the experiment. The highest gross income of Tk. 94,660 ha^{-1} was obtained in T_4. Among the treatments, T_4 treatment gave the highest benefit-cost ratio (3.05). The minimum benefit-cost ratio was found in treatment T_1 (1.69).

Table 4.6 Economics of fertilizer use analysis of Binadhan-10

Treatments	Economic yield (kg ha^{-1})		Total cost of production	Gross income	Net income	Benefit cost ratio (BCR)
	Grain	Straw	(Tk. ha^{-1})	(Tk. ha^{-1})	(Tk. ha^{-1})	
T_1	2730	3560	25,500	43,120	17,620	1.69
T_2	4800	5730	29,320	77,730	48,410	2.65
T_3	5430	6060	30,170	87,510	57,340	2.90
T_4	5860	6760	31,020	94,660	63,640	3.05
T_5	5400	6860	31,870	87,860	55,990	2.76
T_6	5760	7000	32,720	93,400	60,680	2.85

Soil salinity level at Debhata in Satkhira

The soil salinity level at Debhata in Satkhira is increasing from January to April (boro season) and shown in Table 4.7. The soil salinity in 13 January, 2013 was 4.65 dS/m. The soil salinity increased steadily from 4.65 on 13 January to 9.50 dS/m on 27 April.

Table 4.7 Soil salinity level of boro rice growing period during 2013 at Debhata in Satkhira

Period	13 January	28 January	13 February	1 March	17 March	12 April	27 April
Salinity (dS/m)	4.65	5.55	6.50	7.25	8.15	9.05	9.50

Chapter 5

Discussion

CHAPTER 5

DISCUSSION

The present study investigated the growth and yield responses of Binadhan-10 as influenced by the different rates of N, P, K and S in Ganges Tidal Floodplain Agro Ecological Zone (AEZ 13). Besides, nutrient content and uptake by grain was also investigated under this study. Among the yield and yield contributing characters, plant height is a key yield contributing trait which is directly related with straw yield. The plant height of Binadhan-10 was significantly affected due to different rates of fertilizer whereas the tallest plant was recorded in the treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) which was statistically similar with all other treatments (T_2, T_3, T_5 and T_6) except control (T_1). Panicle length was also affected significantly where the longest panicle was found in T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1) which was statistically similar with all other treatments (T_2, T_3, T_4 and T_5) except control (T_1). Similarly, treatment T_2 (N_{100} P_{15} K_{30} S_{12} Zn_2 B_1) was more effective in producing effective tillers hill^{-1} which was statistically similar with all other treatments (T_3, T_4, T_5 and T_6) except control (T_1). Number of filled grains panicle^{-1} had also more significant in treatment T_2 (N_{100} P_{15} K_{30} S_{12} Zn_2 B_1) which was statistically similar to those recorded in the treatments (T_4, T_5 and T_6). Similar results were also obtained by Mondal *et al.* (1990) and Halder *et al.*
(2000). Thousand-grain weight of Binadhan-10 also increased in T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) treatment over control. Grain and straw yields of Binadhan-10 showed similar effect whereas greater performance was obtained in T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) which was 114.67% yield increase over control. These results revealed that treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) was more efficient to produce higher production of Binadhan-10 due to its higher nutrient supply in soil than other treatments these type of findings were also reported by Chaudhary *et al.* (2011).

Among the nutrient content, N content by grain and straw were higher in

treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1). Higher N uptake by grain, straw and total was also observed in treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1). Similar results were also noted by Kadu *et al.* (1991). Phosphorus content and uptake showed significant variation. As a result, T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) obtained the higher P content by grain while T_3 (N_{120} P_{20} K_{40} S_{14} Zn_2 B_1), T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) and T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1) obtained the higher P content by straw. The maximum P uptake by grain was recorded in the treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) and the highest P uptake by straw was recorded in the treatment T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1). The highest total P uptake was recorded in the treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1). The comparative sequence of treatments for total P uptake were found as T_4> T_6> T_3> T_5> T_2> T_1. Observation of K content by grain was higher in T_5 (N_{160} P_{30} K_{60} S_{18} Zn_2 B_1) while T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1) also recorded the higher content by straw. Similar findings were also found by Sachdev *et al.* (1983). In case of K uptake, T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) recorded the higher K uptake by grain and T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1) showed the higher K uptake by straw. Similar findings were also found by Velu *et al.* (1987). Sulphur content and uptake showed significant variation. Treatment T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1) obtained the higher S content by both grain and straw. The higher S uptake by grain, straw and total was recorded in the treatment T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1). Sakal (1995) reported that concentration of S in grain and straw and its corresponding uptake increased with increasing rates of sulphur. The comparative sequence of treatments for total S uptake were found as T_6> T_4> T_5> T_2> T_3> T_1.

Finally, from the above results and discussion it is clear that T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) was more efficient than other treatments for better growth, higher yield and greater increment of different nutrient content and uptake by grain and straw due to its proper nutrient supplying to soil. As a result, higher increment of maximum nutrient content and uptake were obtained by T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) for better growth and yield of Binadhan-10 in saline soil at Satkhira.

Chapter 6

Summary

CHAPTER 6

SUMMARY

The present study was made to investigate (1) fertilizer requirements of Binadhan-10 in saline soil at Satkhira, and (2) developed economically suitable combination of chemical fertilizers for sustainable crop yield. The field experiment was conducted at the farmer's field at Debhata in Satkhira during the Boro season of 2013. The experimental soil belongs to the alluvial floodplain soil under the Ganges Tidal Floodplain Agro Ecological Zone (AEZ-13). Characteristically, the soil was silt loam having pH 7.8, organic matter content 2.10%, total N 0.14%, available P 14.2 mg kg^{-1}, exchangeable K 0.29 me/100g soil, available S 18.5 mg kg^{-1}, exchangeable Na 7.40 me/100g soil and exchangeable Ca 7.09 me/100g soil. The experiment was designed with six (6) treatments and laid out in Randomized Complete Block Design (RCBD) with three replications. The unit plot size was 5m x 4m. The treatments used in the experiment were T_1: Control, T_2: $N_{100}P_{15}K_{30}S_{12}Zn_2B_1$, T_3: $N_{120}P_{20}K_{40}S_{14}Zn_2B_1$, T_4: $N_{140}P_{25}K_{50}S_{16}Zn_2B_1$, T_5: $N_{160}P_{30}K_{60}S_{18}Zn_2B_1$ and T_6 : $N_{180}P_{35}K_{70}S_{20}Zn_2B_1$. Nitrogen, phosphorus, potassium, sulphur, zinc and boron were supplied through urea, TSP, MOP, gypsum, zinc sulphate and boric acid, respectively. Except urea, other fertilizers were applied to the individual plots during final land preparation according to the treatments used. Urea was applied in three equal splits: first split was applied at 18 days after transplanting, second split of urea was applied at 30 days after transplanting and the third split was applied at 55 days after transplanting. The seedlings of 35 days old were transplanted in the experimental plots on 28 January 2013. Intercultural operations were done as and when necessary. The crop was harvested at full maturity on 15 May 2013. Five hills were randomly selected from each plot to record the yield contributing characters. Grain and straw yields were recorded plot wise. Grain and straw samples were dried, grind, sieved and kept for chemical analysis.

All the data were statistically analyzed and mean comparison was made by Duncan's Multiple Range Test (DMRT).

Yield contributing characters like plant height, effective tillers hill^{-1}, panicle length, filled grains panicle^{-1} and 1000-grains weight were significantly influenced by treatments at different fertilizers rate. Among the treatment, treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) produced the tallest plant (97.6 cm) and highest 1000-grain weight (22.68 g) whereas plant height was statistically similar to all other treatments except T_1 (control) and 1000-grain weight was statistically similar with treatment T_2 (N_{100} P_{15} K_{30} S_{12} Zn_2 B_1), T_3 (N_{120} P_{20} K_{40} S_{14} Zn_2 B_1) and T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1). The shortest plant height and 1000-grain weight were observed in the treatment T_1 (control) with the values of 85.1 cm and 19.66 g. Panicle length and filled grains panicle^{-1} was higher (21.93 and 91.6 cm, respectively) in the treatment T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1) whereas among all other treatments except control were statistically similar to panicle length and filled grains panicle^{-1} production. Number of tillers hill^{-1} was higher in the treatment T_2 (N_{100} P_{15} K_{30} S_{12} Zn_2 B_1) which was statistically similar to all other treatments except T_1 (control). There was also significant effect of different rate of fertilizers on the grain and straw yield of rice. The grain yield due to various treatments ranged from 2.73 to 5.86 t ha^{-1}. The maximum grain yield (5.86 t ha^{-1}) was observed in the treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) whereas it was statistically similar to those recorded in the treatments T_3 (N_{120} P_{20} K_{40} S_{14} Zn_2 B_1), T_5 (N_{160} P_{30} K_{60} S_{18} Zn_2 B_1) and T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1) with the values of 5.43, 5.40 and 5.76 t ha^{-1} respectively. The lowest grain yield (2.73 t ha^{-1}) was obtained in the treatment T_1 (control) which was statistically different from other treatments. Yield of straw ranged from 3.56 to 7.00 t ha^{-1}. The treatment T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1) gave the highest straw yield (7.00 t ha^{-1}) while it was statistically similar to those recorded in the treatments T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) and T_5 (N_{160} P_{30} K_{60} S_{18} Zn_2 B_1) with the values of 6.76 and 6.86 t ha^{-1} respectively. The lowest straw yield (3.56 t

ha^{-1}) was produced from the treatment T_1 (control) which was statistically different from other treatments.

Nitrogen, phosphorus, potassium and sulphur contents of Binadhan-10 were significantly influenced due to different rates of fertilizer treatments under this study. Among the nutrient content, N content by grain and straw were higher in treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1). The higher N uptake by grain, straw and total were also observed in treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1). Phosphorus content and uptake showed significant variation. As a result, T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) obtained the higher P content by grain while T_3 (N_{120} P_{20} K_{40} S_{14} Zn_2 B_1), T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) and T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1) had higher P content by straw. The maximum P uptake by grain was recorded in the treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) and the highest P uptake by straw was recorded in the treatment T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1). The highest total P uptake was recorded in the treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1). Observation of K content by grain was higher in T_5 (N_{160} P_{30} K_{60} S_{18} Zn_2 B_1) while T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1) also recorded the higher content by straw. In case of K uptake, T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) obtained the higher K uptake by grain and T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1) obtained the higher K uptake by straw and total. Treatment T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1) obtained the higher S content by both grain and straw. The higher S uptake by grain, straw and total was recorded in the treatment T_6 (N_{180} P_{35} K_{70} S_{20} Zn_2 B_1). A close relationship between nutrient uptake and grain yield was observed. Nutrient uptake increased with increasing grain yield of Binadhan-10.

Chapter 7

Conclusion

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CHAPTER 7

CONCLUSION

In Bangladesh, food security has been remain a major concern because food requirement is increasing at an alarming rate due to increasing population. It is needed to increase the food grain in the limited land area for the fulfillment of our demand. Rice production is hampered due to high salinity and low nutrient status. So, selection of potential variety and proper management of fertilization can play a crucial role to increase grain yield and national income.

From above discussion it can be concluded that:

- Treatment T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) fertilizer dose produced higher grain yield in saline soil at Satkhira than other treatments.
- Cultivation of Binadhan-10 in saline soil at Satkhira can be grown successfully by applying T_4 (N_{140} P_{25} K_{50} S_{16} Zn_2 B_1) treatment.

References

REFERENCES

Ali MM, Sobhan N, Rahman MH, Khan MK 2013: Crop response to fertilization in Potato-Boro-T. aman pattern at Tista Meander Floodplain Soils. *Bangladesh Journal of Environmental Science* **25** 21-25.

Angayarkanni A, Ravichandran M 2001: Judicious fertilizer N split for higher uses efficiency in transplanted rice. *Indian Journal of Agricultural Research* **35(4)** 278-280.

Arivazhagan K, Ravichandran M 2005: Interaction effect of nitrogen and potassium on yield and yield attributes in rice cv. IR 20. *Advances in Plant Science* **18(1)** 425-427.

Babu GK, Seshaiah BV 2006: Effect of phosphates on yield and nutrient uptake in paddy. *Agropedology* **16(1)** 50-53.

Babu SNS, Hegde DM 2002: Delineation of sulphur deficient soil and evaluation of oilseed crop response to sulphur. *Fertilizer Marketing News* **33(3)** 9-17.

Bahmaniar MA, Ranjbar GA, Ahamafian SH 2007: Effects of N and K applications on agronomic characteristics of two Iranian and landrace rice *(Oryza sativa* L.) cultivars. *Journal of Biological Science* **10(6)** 880-886.

BBS (Bangladesh Bureau of Statistics) 2011: National estimates of area and production of different crops, June, 2011. Statistics Division, Ministry of Planning, Government People's Republic of Bangladesh. pp. 47-159.

Bhuiyan NI, Paul DNR, Jabber MA 2002: Feeding the extra millions by 2025- Challenges for rice research and extension in Bangladesh, National Workshop on Rice Research and Extension in Bangladesh, Bangladesh Rice Research Institute, Gazipur.

Bhuvaneswari R, Sriramachandrasekharan MV, Ravichandran M 2007: Effect of organic sulphur and graded levels of sulphur on rice yield and sulphur use efficiency. *Journal of International Academicia* **2(2)** 51-54.

Bhuvaneswari R, Sri ramachandrasekharan MV 2006: Influence of organic manures in conjunction with sulphur on yield and nutrient uptake by rice. *Advances in Plant Science* **19(2)** 543-545.

Black CA 1965: Methods of Soil Analysis. Part 1 & 2. American Society of Agronomic Inc. Publication, Madison, Wisconsin, USA.

BRRI (Bangladesh Rice Research Institute) 2007: Adunik Dhaner Chash (in Bengali), 14th Edition. Bangladesh Rice Research Institute, Joydebpur, Gazipur. pp. 17-30.

Castro R, Sarker ABS 2000: Rice growth response to different proportion of applied nitrogen fertilizers. *Cultivation Tropicales* **21(4)** 57-62.

Chaturvedi I, Lahori P 2007: Effect of nitrogen fertilizers on growth, yield and quality of hybrid rice *(Oryza sativa). Journal of Agricultural Science* **6(4)** 45-52.

Chatterjee AK, Khan SK 2005: Evaluation of phosphate rocks compacted with different soluble phosphate and sulphur in rice *(Oryza sativa)*-wheat(*Triticum aestivum*) and rice-rapeseed (*Brassica compestris var.* yellow sarson) crop sequences in Alfisol. *Indian Journal of Agricultural Science* **75(8)** 493-495.

Chaudhary SK, Singh JP, Jhair S 2011: Effect of integrated nitrogen management on yield, quality and nutrient uptake of rice *(Oryza sativa)* under different dates of planting. *Indian Journal of Agronomy* **56(3)** 228-231.

Chen LG, Shen M, Yao Y, Shen X, Liu F, Wu T 2004: Effects of the ratio of organic to inorganic nitrogen on rice yield, quality and environment. *Jiangsu Journal of Agricultural Science* **20(4)** 249-253.

Chopra NK, Chopra N 2000: Effect of row spacing and N level on growth, yield and seed quality of scented rice *(Oryza sativa)* under transplanted conditions. *Indian Journal of Agronomy* **45(2)** 304-308.

Choudhury ATMA, Khanif YM 2002: Effect of nitrogen, copper and magnesium fertilization on yield and nutrition of rice. *Pakistan Journal of Scientific and Industrial Research* **45(2)** 102-107.

Das LK, Panda SC 2004: Effect of varied doses of nitrogen and potassium on crop growth rate of hybrid rice at different growth stages. *Environmental Ecology* **22(3)** 540-542.

Das T, Sinha AC 2006: Effect of organic and inorganic sources of nutrients on growth and yield of rice *(Oryza sativa)* under terai region of West Bengal. *Journal of Interacademicia* **10(1)** 16-19.

Ding YC, Luo W, Xu GH 2009: Effect of magnesium and potassium interaction on growth, nutrient uptake and related physiological characteristics of rice. *Chinese Journal of Ecology and Agriculture* **16(2)** 340-344.

Do TTR, Tran KT, Ngauyen TNM, Tran BL 2004: Applying mixed manure and inorganic phosphorus fertilizer to improve rice yield on acid sulfate soil (Hydraquentic Sulfaquept). *Australian Journal of Soil Science Research* **42(5/6)** 693-698.

Dongarwar UR, Pantankar MN, Pawar WS 2003: Response of rice to different fertility levels. *Journal of Soils and Crops* **13(1)** 102-122.

Dubey V, Patel AK, Shukla A, Shukla S, Singh S 2012: Impact of continuous use of chemical fertilizer. *Indian Journal of Fertilizer* **3** 13-16.

Duhan BS, Singh M 2002: Effect of green manuring and nitrogen on the yield and uptake of micronutrient by rice. *Journal of the Indian Society Soil Science* **50(2)** 178-180.

Dunn DJ, Stevens G 2005: Response of rice yields to phosphorus fertilizer rates and polymer coating. *Journal of Agricultural Science* **42(3)** 34-37.

Dwivedi AP, Dixit RS, Singh GR 2006: Effect of potassium levels on growth, yield and quality of hybrid rice, Department of Agronomy, N. D. University of Agricultural Technology, Uttar Pradesh, India.

FAO (Food and Agriculture Organization) 2004: Selected indicators of FAO in Asia-pacific region corporate document Repository. pp. 87 - 91.

FAPRI 2009: The Agricultural Outlook 2009. World Rice. Food and Agricultural Policy Research Institute.

Geethadevi T, Andani G, Krishnappa M, Babu BTR, Gowda A 2000: Effect of nitrogen and spacing on growth and yield of hybrid rice. Current Research, University of Agricultural Sciences, Bangalore. **29(5-6)** 73-75.

Halder KP, Chowdhury MJU, Ahmed N 2000: Effect of planting methods and nitrogen rates on the yield and yield components of aus rice grown under rainfed condition at the coastal area of Bangladesh. *Bangladesh Journal of Agricultural Science* **27(1)** 59-64.

Hemalatha M, Thirumurugan V, Balsubramanian R 2000: Effect of organic sources of nitrogen on productivity, quality of rice and soil fertility in single crop wetlands. *Indian Journal of Agronomy* **45(3)** 564-567.

Hu H, Wang GH, Zhang Q 2004: Potassium uptake and use efficiency of rice under low potassium stress field conditions. *Chinese Journal of Rice Science* **18** 527-532.

Islam MF, Haque MQ, Rahman MH, Khan MR, Rahman MM 2010: Restoration of soil fertility and sustenance crop productivity in the Boro - T. Aman rice cropping pattern. *Journal of Agroforestry and Environment* **4(1)** 159-162.

Islam MR, Riasat TM and Jahiruddin M 1997: Direct and residual effects of S, Zn and B on yield, nutrient uptake in a rice-mustard cropping system. *Journal of Indian Society of Soil Science* **45(10)** 126-129.

Islam MR, Saha PK, Zaman MJ, Uddin SK 2010: Phosphorus fertilization in inbred and hybrid rice. *Journal of Biological Science* **19(2)** 181-187.

Jackson ML 1962: Soil Chemical Analysis. Constable and Company Limited, London.

Ji-ming W, Qing H, Tian Y, Jin H, Chu X 2011: Effects of long-term green manure application on rice yield and soil nutrients in paddy soil. *Journal of Plant Nutrients and Fertilizer Science* **42(12)** 145-155.

Kadu PB, Bhoyar VS, Thakare RS 1991: Effect of NPK-FYM blended manurial mixtures on performance of rice. *Journal of Soil Crops* **1(2)** 172-174.

Kamal MP 2005: Effect of different levels of potassium application on Boro-Fallow- T. aman rice cropping pattern in level Barind Tract. MS Thesis, Department of Soil Science, Bangladesh Agricultural University, Mymensingh.

Khan MMK 2013: Effects of reduced rates of N, P, K, S and Zn on the growth and yield of BRRIdhan 49. MS Thesis, Department of Soil Science,

Bangladesh Agricultural University, Mymensingh.

Khan MR, Haque MQ, Tasnim S, Rahman MH 2009: Effect of potassium application on crop productivity in Boro-Fallow-T. aman rice cropping pattern. *Bangladesh Journal of Crop Science* **20(2)** 215-221.

Krishnappa M, Gowda KN, Shankarnarayan V, Maharudrappa K, Khan MM 2006: Effect of graded levels and split application of potassium on its availability and yield of rice. *Journal of Potassium Research* **6(4)**156-161.

Kumar PSS, Geetha SA, Kumaiaway K 2004: Effect of different manure-fertilizer schedules on the yield and potassium uptake by rice. *Crop Research* **5(2/3)** 148-152.

Kumar S, Shivay YS, Kumar D, Prasad R, Devakurnar C 2007: Effect of levels and sources of nitrogen on N, P and K concentrations and uptake and N use indices by a high yielding variety and a hybrid of rice. *Indian Journal of Fertilizer* **2(11)** 53-56.

Kumar S, Singh RS 2001: Phosphorus management in rice wheat cropping system. *Journal of Research Birsa Agricultural University* **13(1)** 51-56.

Li YF, Luo AC, Wei XH, Yao XG 2007: Genotypic variation of rice in phosphorus acquisition from iron phosphate, contributions of root morphology and phosphorus uptake kinetics. *Russain Journal* **54(2)** 230-236.

Lin XQ, Zhu HZ, Chen SH, Cheng S and Uphoff N 2009: Effect of plant density and nitrogen fertilizer rates on grain yield and nitrogen uptake of hybrid rice *(Oryza sativa). Journal of Agricultural Biotechnology and Sustainable Development* **1(2)**44-53.

Liu LJ, Sang DZ, Lui CL, Wang ZQ, Yang JC and Zhu QS 2004: Effect of real time and site specific nitrogen managements on rice yield and nitrogen use efficiency. *Agricultural Science China* **3(4)** 262-268.

Mandal R, Roy PC, Ahmed Z 2000: Effect of nitrogen and sulphur on macronutrient contents of HYV rice (BR3). *Journal of Physiological Research* **13(1)** 27-33.

Mazumder MR, Bhuiya MSU, Hossain SMA 2005: Effect of N level and split application of *Sesbania rostrata* as green manure on the performance of transplanted aman rice cv. BRRI dhan 31. *Bangladesh Journal of Agricultural Science* **31(2)** 183-188.

Meena SL, Singh S, Shivay YS 2003: Response of rice *(Oryza sativa)* to N and K application in sandy clay loam soils. *Indian Journal of Agricultural Science* **73(1)** 8-11.

Mitra GN, Sahoo D, Rout KK 2001: Effect of N-K interaction on yield, nutrient uptake and grain quality of rice-groundnut cropping sequence in the alluvial soil of Orissa. *Journal of Potassium Research* **17(1-4)** 71-78.

Mondal BK, Das DK and Santa GH 1987: Influence of boron on the yield and attributes of rice at submerged conditions. *Environmental Ecology* **5(3)** 534-536.

Mondal SS, Joyaram D, Pradhan BK 1990: Effect of fertilizer and farmyard manure on the yield components of rice (*Oryza sativa* L.). *Environmental Ecobiology* **8(1)** 223-226.

Mostofa TM 2009: Effect of potassium level on the growth, yield and K uptake by BRRI dhan 29. MS Thesis, Department of Soil Science, Bangladesh Agricultural University, Mymensingh.

Moula S M 2005: Comparative performance of rock phosphate and TSP on T. Aman rice in Old Brahmaputra Flood plain and Old Himalayan Piedmont plain soils. M S Thesis, Department of Soil Science, Bangladesh Agricultural

ISSN 2320-9186

University, Mymensingh.

Muangsri M, Chanchareonsook J, Sarobol E 2009: Effect of rice straw and rice hull in combination with nitrogen, phosphorus and potassium fertilizer on yield of rice grown on Phimai soil series. Proceeding of the 46th Kasetsart University Annual Conference, Kasetsart 29 January to l February 2008, Subject: Plant. 2008. pp. 82-89.

Mukherjee D, Sen A 2005: Influence of rice husk and fertility levels on the nutrient content of rice *(Oryza sativa).* Department of Agronomy, Institute of Agricultural Science, Varanasi. *Indian Agricultural Science Digest* **25(2)** 151-152.

Nair CS, Rajasree B 2004: Efficiency of phosphate concentrate (34/37) and super phosphate at two levels on yield characters of rice in the neutral to alkaline soils of Chittoorpalaghat Kerala. *Indian Journal of Agronomy* **46(3)** 98-104.

Nakashgir GH, Handoo GM, Wani SA 2000: Transformation, availability and relative response of rice to applied K in presence of ammonical-nitrogen in Alfosols of Kashmir. *Journal of Potassium Research* **16(1-4)** 55-58.

Natarajan S, Ganapfthy M, Arivazhagan K, Manivannan K 2005: Effect of different levels of nitrogen and potassium on growth, nutrient uptake and yield of rice hybrids. *Indian Journal of Ecobiology* **17(6)** 593-595.

Obiol T, Gonzalez LM, Akila J 2003: Response of new rice varieties with a medium cycle to different doses of nitrogen. *Soils and Fertilizers* **66(3)** 566.

Olsen SR, Cole CV, Watanabe FS, Dean LA 1954: Estimation of available phosphorus in soils by extraction with Sodium bicarbonate. United

ISSN 2320-9186

States Department of Agricultural Circle. pp. 939.

Panday AK, Singh Rajeshwar Prasad 2009: To study the long term effects of fertilizer on the uptake of nitrogen, phosphorus, potassium and sulphur by rice and wheat in calcareous soil. *Environmental Ecology* **27(4B)** 1903-1906.

Patel KP, Bhajan S, Chhibba LM 2010: Crop yields and properties of a sodic soil as influenced by S-containing amendments under draining and non-draining conditions. *Arid Soil Research* **4(3)** 173-180.

Page AL, Miller RH, Keeney DR 1982: Methods of Soil Analysis Part 2. 2nd edition American Society of Agronomy Inc. Publication. Madison, Wisconsin, USA.

Peng JG, Zhang MQ, Lin Q, Yang J, Zhang QF 2002: Effect of sulphur on the main cereal and oilseed crops and cultivated soil available S status in Southeast Fujian. *Fujian Agricultural Science* **17(1)** 52.

Rahman F 2012: Effects of reduced rates of recommended fertilizer dose on cultivation of Binadhan 7. MS Thesis, Department of Soil Science, Bangladesh Agricultural University, Mymensingh.

Rahman MH, Islam MR, Jahiruddin M, Haque MQ 2011: Economics of fertilizer use in the Maize-Mungbean/Dhaincha-T.aman rice cropping pattern. *Journal of Bangladesh Agricultural University* **9(1)** 37-42.

Sachdev MS, Mittal RB, Sachdev P 1983: Utilization of sulphur by rice from gypsum and its balance sheet in soil using 35 S. *Nuclear Agricultural Biology* **6(1)** 11-14.

Saha PK, Ishaque M, Saleque MA, Miah AM, Panaullah GM, Bhuiyan NI 2007:

Long-term integrated nutrient management for rice-based cropping pattern, effect on growth, yield, nutrient uptake, nutrient balance sheet and soil fertility. *Soil Science Plant Analysis* **38(5/6)** 579-610.

Sahu SK 2001: Relationship between applied potassium and iron toxicity in rice. *International Rice Research Notes* **26(2)** 52-53.

Sakal R 1995: Soil sulphur deficiencies and crop response to sulphur in Bihar, India. Sulphur in Agriculture. Sulphur Institute, Washington D.C. **19** 28.

Sarfraz M, Mehdi SM, Sadiq M, Hassan G 2002: Effect of sulphur on yield and chemical composition of rice. *Sarhad Journal of Agriculture* **18(4)** 411-414.

Sarker RR, Ali MM, Rahman MH, Khan MK 2013: Effect of fertilizers on yield and nutrient uptake by Binadhan-7 rice grown in Old Brahmaputra Floodplain Soils. *Journal of Environmental Science and Natural Resources* **6(2)** 55-59.

Sen P, Roy P, Bhattacharya B 2002: Effect of sulphur application on yield and nutrient uptake in rice-mustard cropping system. *Fertilizer Marketing News* **33(6)** 9-15.

Sengar SS, Wade LJ, Baghel SS, Singh RK, Singh G 2000: Effect of nutrient management on rice in rainfed low land of south Madhya Pradesh. *Indian Journal of Agronomy* **45(2)** 315-322.

Shanmugam PM, Veeraputhran R 2000: Effect of organic manure, biofertilizer, inorganic nitrogen and zinc on growth and yield of rice *(Oryza sativa* L.). *Madras Agricultural Journal* **87(1-3)** 90-93.

Shen W, Zhang G, Ma LM, Gui WG, Szmidt R, Shen WQ, Zhang GP 2003: Uptake of nitrogen, phosphorus and potassium by Mat rash and effects of nitrogen and potassium on plant yield and quality in paddy field soil. *Journal of Plant Nutrients* **26(4)** 457-468.

Shukla ND, Lai J 2002: Economics of sulphur and zinc in balanced fertilization under intensive cropping systems. *Fertilizer News* **47(5)** 51-55.

Singh CS, Singh UN 2002: Effect of nitrogen and sulphur nutrition on growth and yield of rice (*Oryza sativa* L.) cultivars. *Research on Crops* **3(3)** 643-646.

Singh GR, Dixit RS, Dwivedi AP 2006: Effect of nitrogen, phosphorus and potassium levels on growth, yield and quality of hybrid rice (*Oryza sativa* L.). Agronomy ND University Technology India **43(1)** 64-66.

Singh J, Singh CM 2000: Effect of potassium application in rice *(Oryza sativa)* Wheat *(Triticum aestivum)* cropping system. *Indian Journal of Agronomy* **45(1)** 12-20.

Singh J, Sharma HL, Singh CN, Singh J 2000a: Effect of levels of phases of potassium application on growth and yield of rice and wheat. *Journal of Potassium Research* **16(1/4)** 35-40.

Singh MK, Thakur R, Verma UN, Upasni RR,Pal SK 2000b: Effect of planting time and nitrogen on production potential of Basmati rice cultivars in Bihar plateau. *Indian Journal of Agronomy* **45(2)** 300-303.

Singh RN, Singh S, Kumar B 2005: Effect of integrated nutrient management practices in rice in farmer's field. *Journal Research of Birsa Agricultural University* **17(2)** 185-189.

Somado EA, Kuhne RF, Sahrawat KL, Becker M 2007: Application of low phosphorus

containing legume residues reduces extractable phosphorus in a tropical Ultisol. *Journal of Nutrients Soil Science* **170(2)** 205-209.

SRDI, 2009: Saline Soils of Bangladesh by Soil Resources Development Institute, Dhaka, Bangladesh.

Tahir H, Ashraf M, Abbas MA, Ali TI 2000: Comparative effectiveness of two potassium source in rice-wheat cropping pattern. *Pakistan Journal of Agricultural Research* **16(1)** 17-19.

Tang X, Shi YM, Hao X 2011: Phosphorus efficiency in a long term wheat--rice cropping system in China. *Journal of Agricultural Science* **149(3)** 297-304.

Tripathi BN, Dixit VK, Chaubey CN 2001: Influence of various levels of moisture regimes, puddling and phosphorus application in the yield and nutrient uptake by rice. Bhartiya Krishna Anusandhan Patrika **16(1-2)** 45-46.

Vaiyapuri V, Sriramachandrasekharan MV 2001: Integrated use of green manure and sulphur on nutrient uptake and rice yield. *Journal of Ecobiology* **13(3)** 223-227.

Vipin K, Prasad B 2003: Efficiency of applied nutrients in soil under rice-wheat cropping system. *Journal Research of Birsa Agricultural University* **15(2)** 179-185.

Walkley A, Black IA 1934: An examination of degtiareff method for determining soils organic matter and a proposed modification of the chronic acid titration method. *Soil Science* **37** 29-38.

Wan TY, Shao M, Jiang H, Zhou QM 2010: Effect of fertilizer application on rice yield, potassium uptake in plants, and potassium balance in double rice cropping system. *Journal of Environmental Science* **84(3)** 203-213.

Wang CH 2004: Response of rice yield to deep placement of fertilizer and nitrogen top-dressing during panicle initiation stage and its dignosis of fertilizer application. *Taiwanese Journal of Agricultural Chemistry and Food Science* **42(5)** 383-395.

Yao Y, Yao YL, Wang YU, Yosida T, Miyazaki A, Nitta Y, Caijian Z, Wang YL, Cai JZ 2000: Macro element absorption at maturity in relation to grain yield in high yielding rice cultivars. *Soil Science Plant Nutrition* **40(4)** 815-824.

Zhang QC, Wang GH 2002: Optimum nitrogen application for direct seeding early rice. *Chinese Journal of Rice Science* **16(4)** 346-350.

Appendices

Appendix 1. Effect of fertilizers on the yield contributing characters of Binadhan-10 in saline soil at Satkhira

Source of variation	df	Plant height (cm)	Panicle length (cm)	Effective tillers hill^{-1} (no.)	Filled grains panicle^{-1} (no.)	1000 grain wt. (g)
Replication	2	3.720	0.549	0.552	5.287	1.583
Treatments	5	59.487**	2.441**	2.463**	322.827**	4.382**
Error	10	11.869	0.480	0.256	7.713	0.688

Appendix 2. Effect of fertilizers on grain, straw and biological yields of Binadhan-10 in saline soil at Satkhira

Source of variation	df	Grain yield	Straw yield	Biological yield
Replication	2	0.185	0.087	0.305
Treatments	5	4.119**	5.001**	17.971**
Error	10	0.088	0.194	0.298

Appendix 3. Effect of fertilizers on N, P, K and S contents in grain and straw of Binadhan-10 in saline soil at Satkhira

Source of	df	%N		%P		%K		%S	
variation		Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Replication	2	0.00001	0.065	0.01056	0.00167	0.00212	0.39389	0.00376	0.00062
Treatments	5	0.00047**	0.43567**	0.09289**	0.04533**	0.25925**	2.57022**	0.04717**	0.01116**
Error	10	0.00002	0.06567	0.00456	0.0030	0.01472	0.21989	0.00476	0.00102

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Appendix 4. Effect of fertilizers on N and P uptake (kg ha^{-1}) by Binadhan-10 in saline soil at Satkhira

Source of variation	df	N uptake			P uptake		
		Grain	Straw	Total	Grain	Straw	Total
Replication	2	6.280	2.113	5.778	0.730	0.080	0.964
Treatments	5	1111.189**	156.283**	2089.577**	13.481**	7.156**	38.091**
Error	10	8.946	3.104	14.460	0.103	0.194	0.281

Appendix 5. Effect of fertilizers on K and S uptake (kg ha^{-1}) by Binadhan-10 in saline soil at Satkhira

Source of variation	df	K uptake			S uptake		
		Grain	Straw	Total	Grain	Straw	Total
Replication	2	1.126	0.632	3.429	0.076	0.029	0.112
Treatments	5	70.721**	1086.79**	1670.21**	6.88**	3.62**	20.20**
Error	10	0.326	5.993	8.401	0.049	0.078	0.155