EFFECT OF FERTILIZER, MANURE AND IRRIGATION MANAGEMENT ON THE GROWTH, YIELD AND NUTRIENT ACCUMULATION IN T. AMAN RICE

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Dhaka, Bangladesh ***The Author***

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ABSTRACT

The experiment was conducted in the farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from July 2012 to November 2012 to study the effect of various organic manure and inorganic fertilizer with different water management on the growth and yield of T-Aman rice. BRRI dhan 32 was used as the test crop in this experiment. The experiment consists of 2 factors i.e. irrigation and fertilizer plus manure. Two levels of irrigations (I_1= Continuous flooding and I_2= Alternate wetting and drying) were used with 8 levels of fertilizer plus manure, as T_0: Control, T_1: 100% $N_{100}P_{15}K_{45}S_{20}Zn_2$ (Recommended dose), T_2: 50% NPKSZn + 5 ton cowdung/ha, T_3: 70% NPKSZn + 3 ton cowdung/ha, T_4: 50% NPKSZn + 5 ton compost/ha, T_5: 70% NPKSZn + 3 ton compost/ha, T_6: 50% NPKSZn + 3.5 ton poultry manure/ha and T_7: 70% NPKSZn + 2.1 ton poultry manure/ha, with 16 treatment combinations and 3 replications. At the harvest, the yield parameters and yields were recorded; the irrigation had no significant single effect on the yield and yield parameters. The yield contributing characters and yield were significantly affected by fertilizer and manure and the highest effective tillers/hill (9.13), plant height (119.79 cm), panicle length (27.96 cm), 1000 grain wt. (21.67 g), grain yield (5.12 t/ha) and straw yield (10.1 t/ha) were found from T_2(50% NPKSZn + 5 ton cowdung/ha), T_3 (70% NPKSZn + 3 ton cowdung/ha), T_5 (70% NPKSZn + 3 ton compost/ha), T_4 (50% NPKSZn + 5 ton compost/ha), T_7 (70% NPKSZn + 2.1 ton poultry manure/ha) and T_1 (100% $N_{100}P_{15}K_{45}S_{20}Zn_2$) treatment respectively and lowest in T_0 treatment. The highest percent (38.3%) grain yield increase was obtained from T_7 treatment. The higher grain yields were found by the application of organic plus inorganic fertilizers compared to the use of chemical fertilizer alone. The yield parameters were significantly influenced by combined application of irrigation and fertilizer and the highest grain yields (5.78 t/ha) were recorded from I_2T_7 (Alternate wetting and drying + 70% NPKSZn + 2.1 ton poultry manure/ha) and lowest (3.42 t/ha) from I_2T_0 (Alternate wetting and drying + control treatment) treatment combination and 69% grain yield increased over control. The T-Aman rice grain and straw nutrient concentrations were significantly affected by the application of fertilizer and manure. The higher N,P,K & S concentrations and uptake were observed in the treatments where fertilizer plus manure were applied. The highest concentrations of grains N (1.295%), P (0.265%), K (0.282%) and S (0.204%) were recorded from T_6, T_3, T_6 and T_7 treatment respectively and lowest from T_0 treatment. Similarly, higher levels of N, P, K and S were uptaken by grain at T_6, T_3, T_6 and T_7 treatment respectively compared to other fertilizer treatment.

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CHAPTER 1

INTRODUCTION

INTRODUCTION

Food is the prime fundamental demand for human beings in the world. Its demand will continue to increase in the days to come. More than two third of the world's population are presently living in the developing countries where agricultural production is not sufficient to meet the need of country. Bangladesh is a densely populated agro-based country where rice (*Oryza sativa* L.) is the most extensively cultivated cereal crop. Bangladesh is the fourth largest rice growing country of the world. Rice is the staple food of Bangladesh. Almost all the people depend on rice and it has tremendous influence on agrarian economy of Bangladesh. Among the Aus, Aman & Boro rice the T-Aman rice contributes to 35.47% of the total rice production in the country (BBS, 2012). Rice is intensively cultivated in Bangladesh covering about 80% of arable land. Rice alone constitutes 95% of the food grain production in Bangladesh. Unfortunately, the yield of rice is low considering the other rice growing countries like South Korea and Japan where the average yield is 7.00 and 6.22 t/ha, respectively (FAO, 1999). On the other hand, the demand for increasing rice production is mounting up to feed the ever-increasing population.

Depleted soil fertility is a major constrain to higher crop production in Bangladesh. The increasing land use intensity has resulted in a great exhaustion of nutrient in soils. The farmers of this country use on an average 102 kg nutrients/ha annually (70 kg N + 24 kg P + 6 kg K + 2 kg S and Zn) while the crop removal is about 200 kg/ha (Islam *et al.*, 1994). In Bangladesh, most of the cultivated soils have less than 1.5% organic matter while a good agricultural soil should contain at least 2% organic matter. Moreover, this important component of soil is declining with time due to intensive cropping and use of higher dose of chemical fertilizers with little or no addition of organic manure in the farmer's field. In addition, rapid mineralization of soil organic matter occurs due to humid tropic climatic conditions of Bangladesh. Cycling of organic matter in soil is a pre–requisite for efficient cycling of nutrients. Unless due attention is paid to the improvement and maintenance of soil organic matter it may not be possible the goal to increase and sustained productivity of crop.

Nambiar (1991) views that integrated use of organic manure and chemical fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining better soil fertility. The long-term research at BARI revealed that the application of cowdung @ 5 t/ha/year improved rice productivity as well as prevented the soil resources from degradation (Bhuiyan, 1994). Poultry manure is another good source of nutrients in soil. Meelu and Singh (1991) showed that 4 t/ha poultry manure along with 60 kg N/ha as urea produce grain yield of crop similar to that with 120 kg N/ha as urea alone. Organic manure can supply a good amount of plant nutrients thus can contribute to crop yields. Thus, it is necessary to use fertilizer and manure in an integrated way in order to obtain sustainable crop yield without affecting soil fertility. Soil organic matter improves the physicochemical properties of the soil and ultimately promotes crop production. Evidences from different AEZ of the country have shown a decrease in the content of organic matter by the range of 15 to 30% over the last 20 years (Miah, 1994). Therefore, it would not be wise to depend only on inherent potentials of soils for higher crop production. More recently, attention is focused on the global environmental problems; utilization of organic wastes, FYM, compost, vermicompost and poultry manures as the most effective measure for the purpose.

The application of different fertilizers and manures influences the physical and chemical properties of soil and enhances the biological activities. It is also positively correlated with soil porosity and enzymatic activity. Organic fertilizer enhances soil porosity by increasing regular and irregular pores and causes a priming effect of native soil organic matter. Applications of both chemical and organic fertilizers need to be applied for the improvement of soil physical properties and supply of essential plant nutrients for higher yield.

Irrigation is one of the most important factor on the growth and yield of T- Aman rice. Yang *et al.* (2004) reported that application of chemical fertilizers with farmyard manure or wheat straw in alternate wetting and drying condition increased N, P, & K uptake by rice plants & increased 1000 grain weight & grain yield of rice.

Considering above background, the experiment was conducted at Sher-e-Bangla Agricultural University farm under the agro-ecological zone of Madhupur Tract (AEZ-28) with the following objectives:

i. To develop a suitable integrated dose of inorganic fertilizers combined with different manures for T-Aman rice.

ii. To evaluate the effects of combined application of inorganic and organic fertilizer with different water management on the yield, yield components and quality of T-Aman rice.

iii. To investigate the improvement of soil fertility due to the use of organic manure in combination with chemical fertilizers.

CHAPTER 2

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Soil organic manure and inorganic fertilizer is the essential factor for sustainable soil fertility and crop productivity because is the store house of plant nutrients. Sole and combined use of cowdung, poultry manure, compost, and inorganic fertilizer acts as a source of essential plant nutrients. Experimental evidences in the use of cowdung, poultry manure, compost, and nitrogen, phosphorus, potassium and sulphur showed an intimate effect on the yield and yield attributes of rice. Yield and yield contributing characters of rice are considerably influenced by different doses of NPKS fertilizer and cowdung, poultry manure & compost manure and their combined application. Irrigation also an important factor for sustainable soil fertility and crop productivity. Some literature related to the "Effect of level of various organic manure and inorganic fertilizer with different water management on the yield and yield attributes *T-Aman rice* cv. BRRI dhan 32" are reviewed below-

2.1 Effect of chemical fertilizer on the growth and yield of rice

Islam *et al.* (2008) conducted an experiment in 2001-2002, 2002-2003 and 2003-2004 to determine the response and the optimum rate of nutrients (NPK) for Chili- Fallow-T. *Aman* cropping pattern. He found that grain yield influenced significantly due to application of different rates of nutrients and 60-19-36 kg/ha NPK maximized the yield of T. *Aman* rice varieties in respect of yield and economics.

Ndaeyo *et al.* (2008) conducted an experiment in Nigeria with five rice varieties (WAB340- 8-8-2HI, WAB881-10-37-18-8-2-HI, WAB99-1-1, WAB224-8-HB, WAB189-B-B-B-8-HB) and four rates of NPK (15:15:15) fertilizer (0, 200, 400 and 600kg/ha). The results showed that 600kg/ha NPK (15:15:15) fertilizer rate significantly ($P < 0.05$) increased plant height, number of leaves and tillers per plant in both years. The 400kg/ha rate increased the number of panicles per plant, length of central panicle per plant and the overall grain yields, straw yield over other rates by 4-32% and 2-21% in 2005 and 2006, respectively.

Saha *et al.* (2004) conducted an experiment in 2002-2003 to create and compare a suitable fertilizer recommendation model for lowland rice. Five different fertilizer recommendation models were tested and compared with one check plot. Results show that the application of different packages estimated by different fertilizer models significantly influence panicle length, panicle numbers, spikelet number per panicle, total grains panicle^{-1}, number of filled grain and unfilled grain per panicle. The combination of NPK that gives the highest result was 120-13-70-20 kg/ha NPKS.

Amim *et al.* (2004) conducted an experiment to evaluate the effect of increased plant density and fertilizer dose on yield of rice variety IR-6. He found that increased fertilizer dose of NPK increase plant height.

Singh *et al.* (2003 a) also reported that crop growth rate and relative growth rate such as total dry matter production was significantly influenced by NPK. The tiller number and total dry matter production are closely correlated with yield depending on the rice cultivar (Tanaka, 1968) which can be greatly enhanced by applying proper nutrient.

Singh *et al.* (2003 b) reported that crop growth rate, such as plant height, dry mater production averaged across treatments, was highest at 45-60 days after transplanting of rice and significantly influence by NPK fertilizers.

Rashee *et al.* (2003) reported that the effect of different NP levels i.e., 0-0, 25-0, 50-25, 75-50, 100-75 and 125-100 kg ha^{-1} on yield and yield attributes of rice Bas-385. Yield attributes (No. of effective tillers per hill, spikelet per panicle, normal kernels per panicle, 1000-grain weight) were improved linearly with increasing NP levels up to 100-75 kg/ha. The NP level of 100-75 kg/ha resulted in the highest grain yield of 4.53 t $ha^{-1}$with minimum kernel abnormalities (Sterility, abortive kernels and opaque kernels) as against the minimum of 2.356 t/ha in the control (0-0) followed by 25-0 kg NP/ ha with maximum kernel abnormalities.

Haq *et al.* (2002 a) reported that the number of paniclesincreased with increase in the nitrogen rates andthat number of panicles per plant increased with increase in NPK rates.

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

Haq *et al.* (2002 b) conducted an experiment with twelve treatments combination of N, P, K, S, Zn and Diazinon. He found all the treatments significantly increase the grain and straw yield of BRRI dhan 30 rice over control. 90 kg N + 50 kg P_2O_5 + 40 kg K_2O + 10 kg S + 4 kg Zn ha^{-1} + diazinon gave the highest grain and straw yield.

Asif (2000) reported that NPK levels significantly increase the panicle length, number of primary and secondary branches $panicle^{-1}$ when NPK fertilizer applied in 180-90-90 kg ha^{-1} this might be attributed to the adequate supply of NPK.

2.2 Combined effect of chemical fertilizer and manure on the growth and yield of rice

2.2.1 Combined effect of chemical fertilizer and cowdung on the growth and yield of rice

Rahman *et al.* (2009) conducted a field experiment to study the effect of urea N in combination with poultry manure and cowdung in rice and found application of manures and different doses of urea N fertilizer significantly increased the yield components and grain and straw yields.

Tripathy *et al.* (2004) found significantly higher seed yield under the residual effects of the blended cowdung and NPK fertilizer compared to the control.

Saleque *et al.* (2004) conducted a field experiment to determine the effect of different doses of chemical fertilizers alone or in combination with cowdung (CD) and rice husk ash on yield of lowland rice-rice cropping sequence. Cowdung and ash were applied on dry season rice only and found the application of cowdung and ash increased rice yield by about 1 t/ha per year over that obtained with chemical fertilizer alone, the treatments, which showed positive yield trend, also showed positive total P uptake trend and positive yield trends were attributed to the increasing P supplying power of the soil.

M. A. Saleque *et al.* (2004) showed that application of one third of recommended inorganic fertilizers with 5 t cowdung increased the low land rice yield than other treatments and gives yield 8.87t ha^{-1}.

Dao and Cavigelli (2003) reported that animal manure had long been used as an organic source of plant nutrients and organic matter to improve the physical and fertility condition of agricultural lands.

Saitoh *et al.* (2001) conducted an experiment to evaluate the effect of organic fertilizers (cowdung and poultry manure) and pesticides on the growth and yield of rice and revealed that the yield of organic manure treated and pesticide free plots were 10% lower than that of chemical fertilizer and pesticide treated plot due to a decreased in the number of panicle. Yearly application of manure increased the total carbon and nitrogen content in soil.

2.2.2 Combined effect of chemical fertilizer and poultry manure on the growth and yield of rice

Ming-gang Xu *et al.* (2008) observed that application of half inorganic fertilizer and half organic manure (swine manure) increase nutrient absorption, panicle number, yield of rice & also increased soil organic matter.

Miah *et al.* (2006) stated that an application of poultry manure with soil test basis (STB), IPNS and AEZ based fertilizer gave higher grain yield compared to other organic materials.

Reddy *et al.* (2005) carried out a field experiment on black clay soils in Gangavati, Karnakata, India, to evaluate the performance of poultry manure (PM) as a substitute for NPK in irrigated rice (cv. IR 64). The application of PM at 5 t/ha recorded a significantly higher grain yield (5.25 t/ha) than the control and FYM application at 7.5 t/ha, significantly improved the soil P and K status, and increased the N content of the soil. Poultry manure at 5 t/ha resulted in higher gross returns (30592 Rupees/ha) over other levels of PM and FYM. However, net returns and benefit cost rations were comparable between 5 and 2 t PM/ha, and between 100 and 75% NPK. The application of 2 t PM/ha and 75% NPK was found economical..

Miah *et al.* (2004) found 5.6-6 t/ha-grain yields with application of 2 t/ha poultry manure plus 120 kg N/ha in T-Aman season.

Umanah *et al.* (2003) find out the effect of different rates of poultry manure on the growth, yield component and yield of upland rice cv. Faro 43 in Nigeria, during the 1997 and 1998 early crop production seasons. The treatments comprised 0, 10, 20 and 30 t/ha poultry manure. There were significant differences in plant height, internode length, tiller number, panicle number per stand, grain number/panicle, and dry grain yield. There was no significant difference among the treatments for 1000-grain weight.

Channabasavanna (2003) conducted a field experiment to evaluate the efficient utilization of poultry manure with inorganic fertilizers in wetland rice and found that the grain yield increased with each increment of poultry manure application and was maximum at 3 t poultry manure/ha. Poultry manure at 2 ton/ha recorded significantly higher values for seed yield and its attributes. The study proved the superiority of poultry manure over farmyard manure (FYM). It was evident from the study that one ton of poultry manure was equivalent to 7 ton FYM which produced at per seed yields. Agronomic efficiency of N (AEN) at 75% NPK (112.5:56.3:56.3 kg NPK/ha) was equivalent to 2 t poultry manure/ha. The results showed that an increase in poultry manure and fertilizer increased rice seed yield. The AEN decreased with an increase in the application of poultry manure and NPK fertilizer.

Vanju and Raju (2002) conducted a field experiment on integrated nutrient management practice in rice crop. Different combinations of chemical fertilizer with poultry manure (PM) 2 t/ ha gave highest grain and straw yield.

Channbasavana and Biradar (2001) reported that the application of poultry manure @ 3 t/ha gave 26% and 19% higher grain yield than that of the control 1998 and 1999, respectively.

Eneji *et al.* (2001) observed that average across the soils, the level of extractable Fe increased by 5% in chicken manure and 71% in cattle manure; Mn by 61% in chicken manure and 172% in swine manure and Cu by 327% in chicken manure and 978% in swine manure. Mixing these manures before application reduce the level of extractable trace elements.

2.2.3 Combined effect of chemical fertilizer and compost on the growth and yield of rice

Ali *et al.* (2009 a) field experiment was conducted to evaluate the suitability of different sources of organic materials for integrated use with chemical fertilizers for the Boro-Fallow-T- Aman rice cropping pattern. Eight-treatments, formulated from organic manure and chemical fertilizers have been imposed. Organic manure or crop residue was applied to T. Aman rice and their residual effects were observed in the following Boro rice. Application of 70% NPKS + PM produced the highest grain yield of T. Aman rice, which was identical to that obtained with 100% NPKS with no manure. In Boro season application of 100% NPKS produced the highest grain yield of 6.87 t/ha, which was identical with the application of 70% NPKS + PM (6.57 t/ha). The total grain yield in the cropping pattern ranged from 5.14 t/ha in T_1 (control) treatment to 12.29 t/ha in the 100% NPKS. The application of 3 t/ha PM with 70% NPKS (T_8) produced the total yield of 12.09 t/ha followed by 11.59 t/ha in the treatment containing 10 t/ha MBR plus 70% NPKS (T_6). It appears that the application of 3 t/ha PM once in a year with 70% NPKS can reduce the use of 30% NPKS as fertilizers. There were negative balances for N and K with the highest mining.

Nayak *et al.* (2007) reported that application of compost and inorganic fertilizer increased microbial growth in soil, vegetative growth and maximum tillering of rice.

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

Aga *et al.* (2004) assessed the effect of compost on the growth and yield of rice. Plant growth characters such as plant height were highest with application of 15 t compost/ha. Grain yield increased significantly with the graded levels of compost application @ 10 t/ha but the response decreased with the increase of compost from 10 to 15 t/ha.

Keeling *et al.* (2003) determined the green waste compost and provided with additional fertilizers and showed consistently that the response of rice rape to compost and fertilizer applied together than the response to the individual additives, but only very stable compost was used (> 10 months processing). Experiments with 15 N-labeled fertilizer showed that rice was able to utilize the applied N-more efficiently when cultivated with the stable compost.

Elsharaeay *et al.* (2003) found the effect of compost of the some plant residues i.e. rice straw and cotton stalk on some physical and chemical properties of the sandy soil. Application of cotton stalks or rice straw composts significantly improved the physical properties of the tasted soil, i.e., bulk density, hydraulic conductivity and moisture content namely field capacity, wilting point and available water, concerning the effect of compost application on the availability of N, P and K in the cultivated soil, rice straw was better than cotton stalks.

Tamaki *et al.* (2002) observed that the correlation between growth and yield and duration of organic farming (compost mixed with straw) in comparison with conventional farming. In inorganic farming plant height of rice was shorter and short number/hill was lesser than in conventional farming, but both of these values increased as the duration of organic farming increased. The maximum tiller number was smaller and panicle number was also smaller than in inorganic farming. However, both the panicle number and panicle length increased as the duration organic farming increased. The grain- straw ratio was higher in organic farming than the conventional farming. These results suggest that the growth and yield of rice increased with continuous organic farming and the yield increased with increase in panicle number/hill and grain number/panicle.

Composts from organic wastes, such as segregated waste, green botanical waste and food processing waste are becoming available in increasing quantities. These supply a complex mixture of nutrients in organic and mineral forms and are also used as soil condition to maintain and improve soil structure (HDRA, 1999).

Application of 50 kg N with green leaf manure increased the grain and straw yield in two seasons (Chittra and Janaki, 1999).

Farid *et al.* (1998) stated that the incorporation of compost or rice straw increased subsequent decomposition and maintained organic matter level at 2.5% that was higher than that in traditionally managed rice soil (<2%).

2.3 Effect of irrigation on growth and yield of rice

Ebrahim *et al.* (2011) conducted experiment with four water management (I_1: submerge irrigation, I_2: 5 day interval, I_3: 8 day interval, I_4: 11 day interval) and showed highest grain yield was found from submerge irrigation (I_1) and also 90 kg/ha nitrogen fertilizer consumption.

Thakur *et al.* (2011) observed that system of rice intensification practices with alternate wet and drying improve rice plants morphology and it benefits physiological processes that results in higher grain yield.

Zhao *et al.* (2011) found that total water use efficiency and irrigation water use efficiency was increased with system of rice intensification (SRI) by 54.2 and 90% respectively. Thus, SRI offered significantly greater water saving while at the same time producing more grain yield of rice in these trials 11.5% more compared to traditional flooding.

Lin *et al.* (2011) reported that intermittent water application with SRI management, grain yield increased by 10.5 and 11.3%, compared to standard irrigation practice (continuous flooding). They also reported that intermittent irrigation with organic material application improved the function of rhizosohere and increased yield of rice.

Qinghua *et al.* (2002) carried out an experiment in rainproof containers to study the response of different varieties (Sanyou 10 and 923 and Zhensan 97B) of rice to three water treatments (flooded, intermittent and dry condition) and observed that grain yields in the dry cultivation treatment amounted to 6.3, 6 and 3.7 t/ha for the varieties Sanyou 10 and 923 and Zhensan 97B respectively. Under intermittent irrigation, yields of Sanyou 10 and 923 were 8% and 10% higher, 9.5 and 8.8 t/ha, respectively than under flooded condition. The highest yield of Zhensan 97B (5.3 t/ha) was obtained under flooded condition.

Gani *et al.* (2002) reported that intermittent (alternate wet and drying) irrigation consistently performed better than continuously flooded irrigation, that is it produced more effective tillers, leaf area, and biomass.

Uphoff and Randriamiharisoa (2002) observed that continuous flood irrigation constrain root growth of rice and contribute to root degeneration and it also limit soil microbial life to anaerobic populations. Keeping paddy fields flooded also restricts biological nitrogen fixation to anaerobic processes and affect plant growth.

Hugh *et al.* (2002) observed highest yield of rice grain was obtained in case of alternate wet and drying system (6.7 t/ha) than no flooded (5.9 t/ha) and continuously flooded irrigation (5.9 t/ha). This result suggest that by combining alternate wet and drying irrigation with system of rice intensification practices, farmers can increase grain yields while reducing irrigation water demand.

CHAPTER 3

MATERIALS AND METHODS

MATERIALS AND METHODS

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from July 2012 to November 2012 to study the effect of various organic manure and inorganic fertilizer with different water management on the growth and yield of T-Aman rice. This chapter includes materials and methods that were used in conducting the experiment. The details are presented below under the following headings -

3.1 Experimental site and soil

The experiment was conducted in typical rice growing silt loam soil at the Sher-e-Bangla Agricultural University Farm, Dhaka during the T-Aman season of 2012. The morphological, physical and chemical characteristics of the soil are shown in the Table 3.1 and 3.2.

3.2 Climate

The climate of the experimental area is characterized by scanty rainfall associated with moderately low temperature during the *kharif*-2 season. The weather information regarding temperature, rainfall, relative humidity and sunshine hours prevailed at the experimental site during the cropping season July 2012 to November 2012 have been presented in Appendix II.

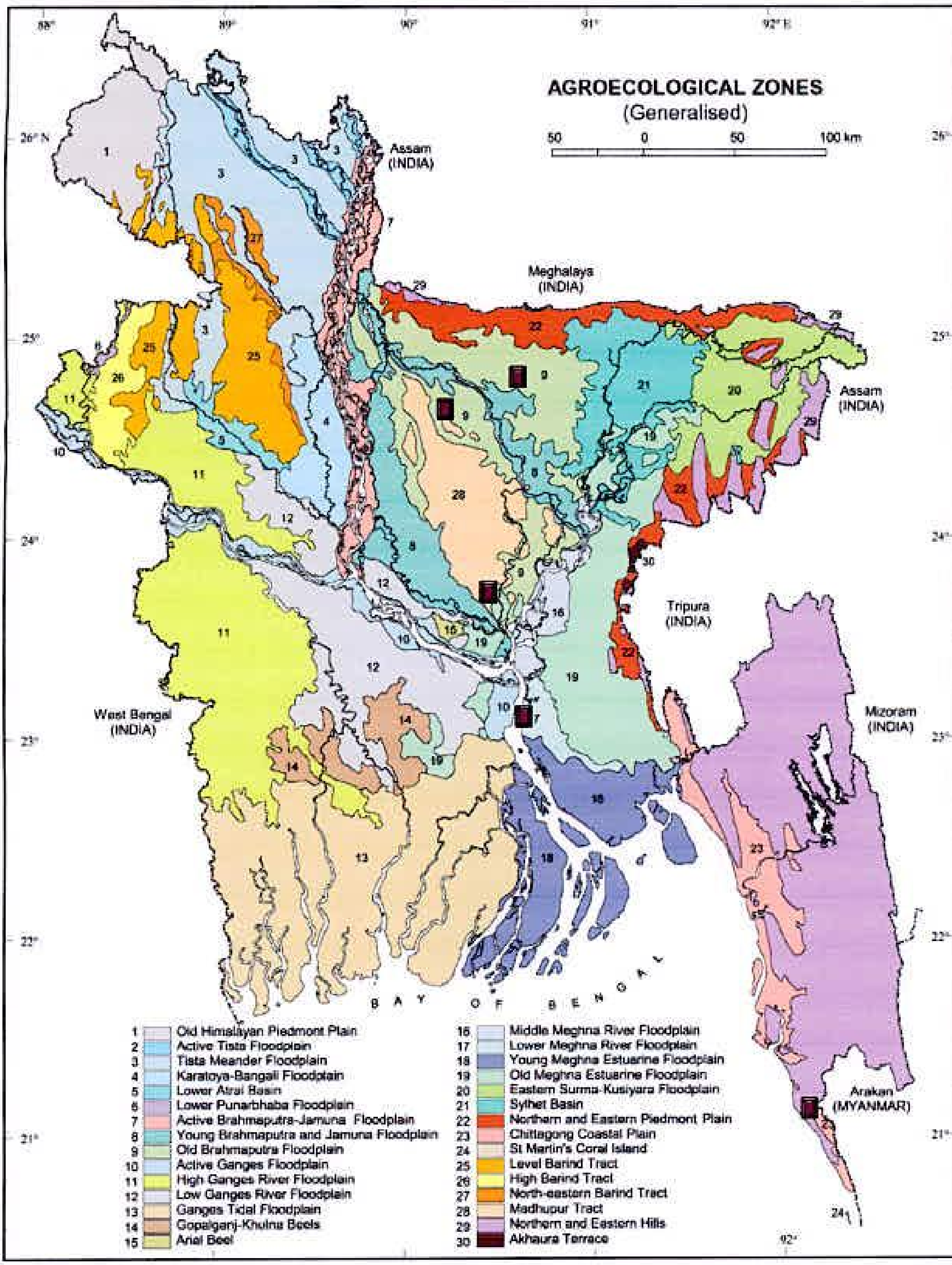

Fig. 3.1: Agroecological zones of Bangladesh

Table 3.1. Morphological characteristics of the experimental field

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

(FAO and UNDP, 1988)

Table 3.2. Initial physical and chemical characteristics of the soil

Characteristics	**Value**
Mechanical fractions: % Sand (2.0-0.02 mm) % Silt (0.02-0.002 mm) % Clay (<0.002 mm)	 22.26 56.72 20.75
Textural class	Silt Loam
pH (1: 2.5 soil- water)	5.9
Organic Matter (%)	1.09
Total N (%)	0.028
Available K (ppm)	15.625
Available P (ppm)	7.988
Available S (ppm)	2.066

3.3 Planting material

BRRI dhan 32 was used as the test crop in this experiment. This variety was developed at the Bangladesh Rice Research Institute. It is recommended for T-Aman season. Average plant height of the variety is 115-120 cm at the ripening stage. The grains are medium fine and white. It requires about 120-130 days completing its life cycle with an average grain yield of 5.0-5.5 t/ha (BRRI, 2004).

3.4 Land preparation

The land was first opened on July, 2012 by a tractor and prepared thoroughly by ploughing and cross ploughing with a power tiller followed by country plough. Laddering helped breaking the clods and leveling the land followed every ploughing. Before transplanting each unit plot was cleaned by removing the weeds, stubbles and crop residues. Finally each plot was prepared by puddling.

3.5 Experimental design and layout

The experiment was laid out in a split plot design (SPD) with three replications. The layout was made distributing two irrigations (continuous flooding and alternate wetting and drying) to the main plots and fertilizer plus manure treatments to the sub plots. The total number of plots was 48, measuring 2.5 m × 2.0 m and ails separated plots from each other. The distance maintained between two main plots and two sub plots were 1.0 m and 0.5 m, respectively.

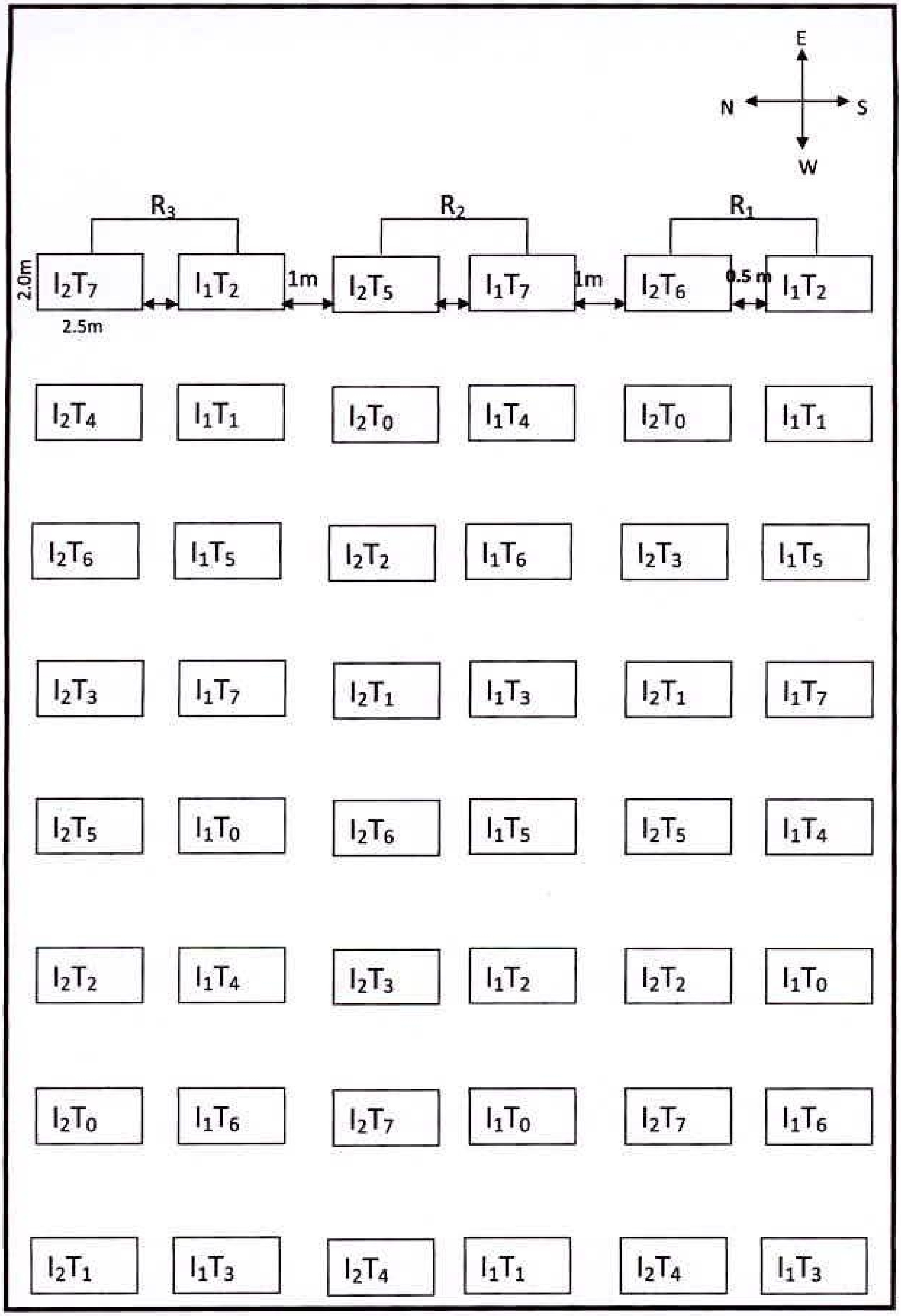

Fig.3.2: Layout of the experimental plot of T-Aman rice

3.6 Initial soil sampling

Before land preparation, initial soil samples at 0-15 cm depth were collected from different spots of the experimental field. The composite soil sample were air-dried, crushed and passed through a 2 mm (8 meshes) sieve. After sieving, the soil samples were kept in a plastic container for physical and chemical analysis of the soil.

3.7 Treatments

The experiment consists of 2 factors i.e. irrigation and fertilizer plus manure. Details of factors and their combinations are presented below:

Factor A: Irrigation

I_1= Continuous flooding

I_2= Alternate wetting and drying

Factor B: Fertilizer plus manure

T_0: Control

T_1: 100% $N_{100}P_{15}K_{45}S_{20}Zn_2$ (Recommended dose)

T_2: 50% NPKSZn + 5 ton cowdung/ha

T_3: 70% NPKSZn + 3 ton cowdung/ha

T_4: 50% NPKSZn + 5 ton compost/ha

T_5: 70% NPKSZn + 3 ton compost/ha

T_6: 50% NPKSZn + 3.5 ton poultry manure/ha

T_7: 70% NPKSZn + 2.1 ton poultry manure/ha

Treatment combination

I_1T_0 = (Continuous flooding + Control)

I_1T_1 = {(Continuous flooding + 100% $N_{100}P_{15}K_{45}S_{20}Zn_2$ (Recommended dose)}

I_1T_2 = (Continuous flooding + 50% NPKSZn + 5 ton cowdung/ha)

I_1T_3 = (Continuous flooding + 70% NPKSZn + 3 ton cowdung/ha)

I_1T_4 = (Continuous flooding + 50% NPKSZn + 5 ton compost/ha)

I_1T_5 = (Continuous flooding + 70% NPKSZn + 3 ton compost/ha)

I_1T_6 = (Continuous flooding + 50% NPKSZn + 3.5 ton poultry manure/ha)

I_1T_7 = (Continuous flooding + 70% NPKSZn + 2.1 ton poultry manure/ha)

I_2T_0 = (Alternate wetting and drying + Control)

I_2T_1 = [Alternate wetting and drying + 100% $N_{100}P_{15}K_{45}S_{20}Zn_2$ (Recommended dose)]

I_2T_2 = (Alternate wetting and drying + 50% NPKSZn + 5 ton cowdung/ha)

I_2T_3 = (Alternate wetting and drying + 70% NPKSZn + 3 ton cowdung/ha)

I_2T_4 = (Alternate wetting and drying + 50% NPKSZn +5 ton compost/ha)

I_2T_5 = (Alternate wetting and drying + 70% NPKSZn + 3 ton compost/ha)

I_2T_6 = (Alternate wetting and drying + 50% NPKSZn +3.5 ton poultry manure/ha)

I_2T_7 = (Alternate wetting and drying + 70% NPKSZn + 2.1 ton poultry manure/ha)

3.8 Fertilizer application

The amounts of N, P, K, S and Zn fertilizers required per plot were calculated as per the treatments. Full amounts of TSP, MP, gypsum and Zinc sulphate were applied as basal dose before transplanting of rice seedlings. Urea were applied in 3 equal splits: one third was applied at basal before transplanting, one third at active tillering stage (30 DAT) and the remaining one third was applied at 5 days before panicle initiation stage (55 DAT).

3.9 Organic manure incorporation

Three different types of organic manure viz. cowdung, poultry manure and compost were used. The rates of manure were 3 & 5, 2.1 & 3.5, and 3 & 5 ton/ha for cow dung, poultry manure and compost per plot were calculated as per the treatments, respectively. Cowdung, poultry manures and compost were applied before four days of final land preparation. Chemical compositions of the manures used have been presented in Table 3.3

Table 3.3. Chemical compositions of the cowdung, poultry manure and Compost (oven dry basis)

Sources of organic manure	Nutrient content			
	N (%)	P (%)	K (%)	S (%)
Cowdung	1.46	0.29	0.74	0.24
Poultry manure	2.2	1.99	0.82	0.29
Compost	2.89	0.28	1.60	0.32

3.10 Raising of seedlings

The seedlings of rice were raised wet-bed methods. Seeds (95% germination) @ 5 kg/ha were soaked and incubated for 48 hour and sown on a well-prepared seedbed. During seedling growing, no fertilizers were used. Proper water and pest management practices were followed whenever required.

3.11 Transplanting

Forty days old seedlings of BRRI dhan-32 were carefully uprooted from the seedling nursery and transplanted onAugust, 2012 in well puddle plot. Two seedlings per hill were used following a spacing of 20 cm × 20 cm. After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings whenever required.

3.12 Intercultural operations

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

3.12.1 Irrigation

T-Aman is cultivated in rainfed condition. So it is very difficult to maintain irrigation treatments in the main plots. When supplemented irrigation was applied, treatment wise irrigation levels were maintained. Necessary irrigations were provided to the plot as and when required during the growing period of rice crop. Irrigationtreatment ofalternate wetting and drying was not properly maintained due to rainy season.

3.12.2 Weeding

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

3.12.3 Insect and pest control

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

3.13 Crop harvest

The crop was harvested at full maturity when 80-90% of the grains were turned into straw colored on 26 November, 2012. The crop was cut at the ground level and plot wise crop was bundled separately and brought to the threshing floor. Eight hills of rice plant were selected randomly from the plants for measuring yield contributing characters.

3.14 Yield components

3.14.1 Total no. of effective tiller/hill

The total number of effective tiller $hill^{-1}$ was counted as the number of panicle bearing hill/plant. Data on effective tiller/hill were counted from 8 selected hills and average value was recorded.

3.14.2 Total no. of non effective tiller/hill

The total number of non-effective tiller/hill was counted as the number of non-panicle bearing plant/hill. Data on non effective tiller/hill were counted from 8 randomly selected hills and average value was recorded.

3.14.3 Plant height (cm)

The height of plant was recorded in centimeter (cm) at harvesting stage. Data were recorded as the average of 8 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the panicle.

3.14.4 Length of panicle (cm)

The length of panicle was measured with a meter scale from 8 selected plants and the average value was recorded as per plant.

3.14.5 No. of unfilled and filled grain per panicle

The total numbers of unfilled grains were calculated from selected 8 plants of a plot on the basis of no grain in the spikelet and then average numbers of unfilled grain per panicle was recorded. Similarly filled grains panicle^{-1} were counted

3.14.6 Weight of 1000 seeds (g)

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

3.14.7 Straw yield (kg)

Straw obtained from each unit plot were sun-dried and weighed carefully. The dry weight of straw of the respective unit plot was converted to ton/ha.

3.14.8 Grain yield (kg)

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of the respective unit plot was converted to ton/ ha.

3.15 Chemical analysis of plant samples

3.15.1 Collection and preparation of plant samples

Grain and straw samples were collected after threshing for N, P, K and S analysis. The plant samples were dried in an oven at 70 ^{0}C for 72 hours and then ground by a grinding machine (wiley-mill) to pass through a 20-mesh sieve. The samples were stored in plastic vial for analysis of N, P, K and S. The grain and straw samples were analyzed for determination of N, P, K and S concentrations. The methods were as follows:

3.15.2 Digestion of plant samples with sulphuric acid for N

For the determination of nitrogen an amount of 0.5 g oven dry, ground sample were taken in a micro kjeldahl flask. 1.1 g catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se in the ratio of 100: 10: 1), and 7 ml conc. H_2SO_4 were added. The flasks were heated at 160^{0}C and added 2 ml 30% H_2O_2 then heating was continued at 360 ^{0}C until the digests become clear and colorless. After cooling, the content was taken into a 50 ml volumetric flask and the volume was made up to the mark with de-ionized water. A reagent blank was prepared in a similar manner. Nitrogen in the digest was estimated by distilling the digest with 10 N NaOH followed by titration of the distillate trapped in H_3BO_3 indicator solution with 0.01N H_2SO_4.

The amount of N was calculated using the following formula:

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

Where,

T = Sample titration (ml) value of standard H_2SO_4

B = Blank titration (ml) value of standard H_2SO_4

N = Strength of H_2SO_4

S = Sample weight in gram.

3.15.3 Digestion of plant samples with nitric-perchloric acid for P, K and S

A sub sample weighing 0.5 g was transferred into a dry, clean 100 ml digestion vessel. Ten ml of di-acid (HNO_3: $HClO_4$ in the ratio 2:1) mixture was added to the flask. After leaving for a while, the flasks were heated at a temperature slowly raised to 200^0C. Heating were stopped when the dense white fumes of $HClO_4$ occurred. The content of the flask were boiled until they were became clean and colorless. After cooling, the content was taken into a 50 ml volumetric flask and the volume was made up to the mark with de-ionized water. P, K and S were determined from this digest by using different standard methods.

3.15.4 Determination of P, K and S from plant samples

3.15.4.1 Phosphorus

Plant samples (grain and straw) were digested by diacid (Nitric acid and Perchloric acid) mixture and P content in the digest was measured by blue color development (Olsen *et al.*, 1954). Phosphorus in the digest was determined by using 1 ml for grain sample and 2 ml for straw sample from 50 ml digest by developing blue color with reduction of phosphomolybdate complex and the color intensity were measured colorimetrically at 660 nm wavelength and readings were calibrated with the standard P curve (Page *et al.*, 1982).

3.15.4.2 Potassium

Five milli-liters of digest sample for the grain and 10 ml for the straw were taken and diluted 50 ml volume to make desired concentration so that the flame photometer reading of samples were measured within the range of standard solutions. The concentrations were measured by using standard curves.

3.15.4.3 Sulphur

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

3.16 Nutrient Uptake

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

Nutrient uptake (kg/plot) = { Nutrient content (%)/100 × Yield (kg/plot) }

CHAPTER 4

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

The results of different yield attributes, yield and nutrient concentration in the plant and grains and consumption of nutrients by plants and grains of rice are presented this chapter.

4.1 Effective tiller

4.1.1 Effect of irrigation on the effective tillers/hill of T-Aman rice

The effects of irrigation on the effective tillers/hill of T-Aman rice are presented in Table 4.1. Insignificant variation was observed on the effective tillers/hill of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_1 (Continuous flooding) showed the highest number of effective tillers/hill (8.27) and I_2 (Alternate wetting and drying) irrigation showed lowest number of effective tillers/hill (8.20).

Table 4.1 Effect of irrigation on effective tillers/hill and non-effective tillers/hill of rice

Treatments (irrigation)	No. of effective tillers/hill	No. of non-effective tillers/hill
I_1	8.27	1.15
I_2	8.20	1.34
SE (±)	NS	NS

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

I_1= Continuous flooding

I_2= Alternate wetting and drying

4.1.2 Effects of different doses of fertilizer and manure on the effective tillers/hill of T-Aman rice

Different doses of fertilizers showed significant variations in respect of effective tillers/hill of T-Aman rice (Table 4.2). Among the different doses of fertilizers, T_2:(50% NPKSZn + 5 ton cowdung/ha) showed the highest number of effective tillers/hill (9.13) which was followed (8.99) by T_7: (70% NPKSZn +2.1 poultry manure/ha) treatment. The highest number of effective tillers/hill was statistically comparable with all other treatment except T_0 (control). The same amount of fertilizer was added by different sources and produced almost similar number of effective tillers/hill. On the contrary, thelowest number of effective tillers/hill (7.58) was observed with T_0 where no fertilizer was applied. Nayak *et* *al.* (2007) reported a significant increase in effective tillers/hill due to application of chemical fertilizer with organic manure. Similar results also found by Rahman *et al.* (2009) and Reddy *et al.* (2004).

Table 4.2 Effects of different doses of fertilizer and manure on effective tillers/hill and non-effective tillers/hill of rice

Treatments	No. of effective tiller	No. of non-effective tiller
T_0	7.58 b	0.83
T_1	8.00 ab	1.33
T_2	9.13 a	0.92
T_3	8.08 ab	1.42
T_4	8.46 ab	1.42
T_5	7.75 ab	1.25
T_6	7.88 ab	1.42
T_7	8.99 a	1.38
SE (±)	0.38	NS

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

T_0: Control

T_1: 100% $N_{100}P_{15}K_{45}S_{20}Zn_2$ (Recommended Dose)

T_2: 50% NPKSZn + 5 ton cowdung/ha

T_3: 70% NPKSZn + 3 ton cowdung/ha

T_4: 50% NPKSZn + 5 ton compost/ha

T_5: 70% NPKSZn + 3 ton compost/ha

T_6: 50% NPKSZn +3.5 ton poultry manure/ha

T_7: 70% NPKSZn +2.1 poultry manure/ha

4.1.3 Effects of combined use of fertilizer, manure and irrigation on the number of effective tillers/hill T-Aman rice

The combined effect of different doses of fertilizer and irrigation on the number of effective tillers/hill of rice was insignificant (Table 4.3). The highest number of effective tillers/hill of rice (9.50) was recorded with the treatment combination I_1T_2 (Continuous flooding in combination with 50% NPKSZn + 5 ton cowdung/ha). On the other hand, the lowest number of effective tillers/hill (7.25) was found in I_2T_0 (Alternate wetting and where no fertilizer was applied).

Table 4.3 Interaction effect of fertilizer and irrigation on effective tillers/hill and non-effective tillers/hill of rice

Treatments	No. of effective tillers/hill	No. of non-effective tillers/hill
I_1T_0	7.92	0.67
I_1T_1	8.08	1.50
I_1T_2	9.50	1.00
I_1T_3	8.17	1.25
I_1T_4	8.42	1.17
I_1T_5	7.92	0.83
I_1T_6	7.67	1.75
I_1T_7	8.50	1.00
I_2T_0	7.25	1.00
I_2T_1	7.92	1.17
I_2T_2	8.75	0.83
I_2T_3	8.00	1.58
I_2T_4	8.50	1.67
I_2T_5	7.58	1.67
I_2T_6	8.08	1.08
I_2T_7	9.48	1.75
SE (±)	NS	NS

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

4.2 Non-effective tiller

4.2.1 Effect of irrigation on the non-effective tillers/hill of T-Aman rice

The effects of irrigation on the non-effective tillers/hill ofT-Aman rice are presented in Table 4.1. Insignificant variation was observed on the non-effective tillers/hill of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_1 (Continuous flooding) showed the lowest number of non-effective tillers/hill (1.15) and I_2 (Alternate wetting and drying) irrigation showed highest number of non-effective tillers/hill (1.34).

4.2.2 Effects of fertilizer and manure on the non-effective tillers/hill of T-Aman rice

Different doses of fertilizers and manure showed insignificant variations in respect of non-effective tillers/hill of T-Aman rice (Table 4.2). Among the different doses of fertilizers, T_0 (where no fertilizer was applied) showed the lowest number of non-effective tillers/hill (0.83). On the contrary, the highest number of non-effective tillers/hill (1.42) was observed with T_3 (70% NPKSZn + 3 ton cowdung/ha), T_4 (50% NPKSZn + 5 ton compost/ha) & T_6 (50% NPKSZn +3.5 ton poultry manure/ha) treatment.

4.2.3 Interaction effect of fertilizer, manure and irrigation on the number of non-effective tillers/hill of T-Aman rice

The combined effect of different doses of fertilizer and irrigation on the number of non-effective tillers/hill of rice was insignificant (Table 4.3). The highest number of non-effective tillers/hill of rice (1.75) was recorded with the treatment combination I_1T_6 (continuous flooding in combination with 50% NPKSZn +3.5 ton poultry manure/ha) & I_2T_7 (Alternate wetting and drying in combination with 70% NPKSZn +2.1 poultry manure/ha) . On the other hand, the lowest number of non-effective tillers/hill (0.67) was found in I_1T_0 treatment where no fertilizer was applied.

4.3 Plant height

4.3.1 Effect of irrigation on the plant height of T-Aman rice

The effects of irrigation on the plant height of rice are presented in Table 4.4. Insignificant variation was observed on the plant height of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_1 (Continuous flooding) showed the highest plant height (116.54 cm) and I_2 (Alternate wetting and drying) irrigation showed lowest plant height (116.38 cm).

Table 4.4 Effect of irrigation on the plant height and panicle length of T-Aman rice

Treatments (irrigation)	Plant height (cm)	Panicle length (cm)
I_1	116.54	24.04
I_2	116.38	24.91
SE (±)	NS	NS

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

4.3.2 Effect of fertilizer and manure on the plant height of T-Aman rice

Rice plants showed significant variation in respect of plant height when fertilizers of different doses were applied (Table 4.5 & Figure 4.2). Among the different fertilizer doses, T_3 (70% NPKSZn + 3 ton cowdung/ha) showed the highest plant height (119.79 cm), which was closely followed by (119.45 cm) T_7 (: 70% NPKSZn + 2.1 poultry manure/ha). On the other hand lowest plant height (105.43 cm) was observed in the T_0 treatment where no fertilizer was applied. Almost similar plant heights were obtained where 100% recommended dose of fertilizer, 50% organic plus inorganic and 30% organic plus 70% inorganic fertilizer were applied. Plant height was significantly influenced by the application of organic manure and chemical fertilizers reported by Naya *et al.* (2007). Similar results also reported by Aga *et al.* (2004), Reddy *et al.* (2004).

Table 4.5 Effect of fertilizer and manure on the plant height and panicle length of rice

Treatments	Plant height (cm)	Panicle length (cm)
T_0	105.43 b	23.05
T_1	117.15 a	24.96
T_2	118.17 a	23.47
T_3	119.79 a	23.86
T_4	117.67 a	24.30
T_5	116.75 a	27.96
T_6	117.27 a	24.03
T_7	119.45 a	24.18
SE (±)	2.113	NS

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

4.3.3 Interaction effects of fertilizer, manure and irrigation on the plant height of T-Aman rice

Combined application of different doses of fertilizer, manure and irrigation had insignificant variation on the plant height of T-Aman rice (Table 4.6). The lowest plant height (103.96 cm) was observed in the treatment combination of I_2T_0 (Alternate wetting and drying + No fertilizer). On the other hand, the highest plant height (121.24 cm) was recorded with I_1T_1 (Continuous flooding + 100% $N_{100}P_{15}K_{45}S_{20}Zn_2$ -Recommended) treatment.

Table 4.6 Interaction effect of fertilizer and irrigation on the plant height and panicle length of T-Aman rice

Treatments	Plant height (cm)	Panicle length (cm)
I_1T_0	106.89	23.10
I_1T_1	121.24	25.80
I_1T_2	118.06	23.45
I_1T_3	120.80	23.28
I_1T_4	114.47	24.57
I_1T_5	112.56	23.44
I_1T_6	120.15	24.14
I_1T_7	118.14	24.54
I_2T_0	103.96	23.01
I_2T_1	113.07	24.13
I_2T_2	118.28	23.48
I_2T_3	118.28	24.43
I_2T_4	120.88	24.03
I_2T_5	120.94	32.48
I_2T_6	114.38	23.92
I_2T_7	120.75	23.82
SE (±)	NS	NS

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

4.4 Panicle length

4.4.1 Effect of irrigation on the panicle length of T-Aman rice

The effects of irrigation on the panicle length ofT-Aman rice are presented in Table 4.4. Insignificant variation was observed on the panicle length of rice when the field was irrigated with two different irrigations. Between this two irrigations, I_2 (alternate wetting and drying) showed the highest panicle length (24.91 cm) and I_1 (continuous flooding) irrigation showed lowest panicle length (24.04 cm).

4.4.2 Effects of different doses of fertilizer and manure on the panicle length of T-Aman rice

Rice plants showed insignificant variation in respect of panicle length when different doses of fertilizer and manures were applied (Table 4.5). Among the different fertilizer doses, T_5 (70% chemical fertilizer + 5 ton cowdung) showed the highest panicle length (27.96 cm), on the other hand, lowest panicle length (23.05 cm) was observed in the T_0 treatment where no fertilizer was applied. Rahman *et al.* (2009) noted a significant increase in panicle length due to the application of organic manure and chemical fertilizers. Babu*et al.* (2001), Reddy *et al.* (2005) also reported similar results.

4.4.3 Interaction effects of fertilizer, manure and irrigation on the panicle length of T-Aman rice

Combined application of different doses of fertilizer, manure and irrigation had insignificant variation on the panicle length of rice (Table 4.6). The lowest panicle length (23.01 cm) was observed in the treatment combination of I_2T_0 (Alternate wetting and drying + No fertilizer). On the other hand, the highest panicle length (32.48 cm) was recorded with I_2T_5 (Alternate wetting and drying with 70% NPKSZn + 3 ton compost/ha) treatment.

4.5 Number of filled grain per panicle

4.5.1 Effect of irrigation on the number of filled grain per panicle of T-Amanrice The effects of irrigation on the number of filled grain per panicle of rice are presented in Table 4.7. Insignificant variation was observed on the number of filled grain per panicle of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_1 (Continuous flooding)) showed the highest number of filled grain per panicle (88.91) and I_2 (Alternate wetting and drying irrigation) showed lowest number of filled grain per panicle (85.11).

4.7 Effect of irrigation on the no. of filled grains/panicle and 1000 grain wt. of rice

Treatments	No. of filled grain/panicle	1000 grain wt. (g)
I_1	88.91	20.81
I_2	85.11	20.92
SE (±)	NS	NS

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

4.5.2 Effect of fertilizer and manure on the number of filled grain per panicle of T-Aman rice

Significant variation was observed in number of filled grain per panicle of T-Aman rice when different doses of fertilizer and manure were applied (Table 4.8). Higher number of filled grains/panicle was found in organic plus inorganic treatments compared to inorganic fertilizer alone. The highest number of filled grain per panicle (97.21) was recorded in T_3 (70% NPKSZn + 3 ton cowdung t/ha) treatment which was statistically similar to T_6 (50% NPKSZn + 3.5 ton poultry manure/ha), T_7 (70% NPKSZn + 2.1 ton poultry manure/ha), T_4 (50% NPKSZn + 5 ton compost/ha) treatments. The lowest number of filled grain per panicle (71.86) was recorded in T_0 (control treatment). Similar result was found by Rahman *et al.* (2009).

Table 4.8 Effect of fertilizer on the no. of filled grains/panicle and 1000 grain wt. of T-Aman rice

Treatments	No. of filled grain/panicle	1000 grain wt. (g)
T_0	71.86 b	19.58 c
T_1	83.12 ab	20.17 bc
T_2	84.41 ab	21.17 ab
T_3	97.21 a	21.08 ab
T_4	93.41 a	21.67 a
T_5	84.61 ab	20.67 abc
T_6	93.27 a	21.25 ab
T_7	88.20 ab	21.33 ab
SE (±)	4.980	0.388

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

4.5.3 Interaction effects of fertilizer, manure and irrigation on the number of filled grain per panicle of T-Aman rice

The combined effect of different doses of fertilizer, manure and irrigation on the number of filled grain per panicle was insignificant (Table 4.9). The highest number of filled grain per panicle of rice (101.77) was recorded with the treatment combination I_1T_4 (continuous flooding with 50% NPKSZn + 5 ton compost/ha) treatment. On the other hand, the lowest number of filled grain (71.15) was found in I_2T_0 (Alternate wetting and drying with no fertilizer) treatment combination.

Table 4.9 Interaction effects of fertilizer and irrigation on the no. of filled grain/panicle and 1000 grain wt. of T-Aman rice

Treatments	No. of filled grain/panicle	1000 grain wt. (g)
I_1T_0	72.56	19.83
I_1T_1	82.24	20.50
I_1T_2	87.04	21.83
I_1T_3	99.58	20.50
I_1T_4	101.77	20.83
I_1T_5	80.31	20.83
I_1T_6	96.18	21.17
I_1T_7	91.61	21.00
I_2T_0	71.15	19.33
I_2T_1	83.99	19.83
I_2T_2	81.77	20.50
I_2T_3	94.84	21.67
I_2T_4	85.04	22.50
I_2T_5	88.92	20.50
I_2T_6	90.36	21.33
I_2T_7	84.78	21.67
SE (±)	NS	NS

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

4.6 1000 grain wt. of T-Aman rice

4.6.1 Effect of irrigation on the 1000 grain wt. of T-Aman rice

The effects of irrigation on the 1000 grain wt. of rice are presented in Table 4.7. Insignificant variation was observed on the 1000 grain wt. of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_2 (alternate wetting and drying) showed the highest 1000 grain wt. (20.92 g) and I_1 (continuous flooding) irrigation showed lowest 1000 grain wt. (20.81 g).

4.6.2 Effect of fertilizer and manure on the 1000 grain wt. ofT-Aman rice

Rice plants showed significant variation in respect of 1000 grain wt. of rice when fertilizers of different doses were applied (Table 4.8). Among the different fertilizer doses, T_4 (50% NPKSZn + 5 ton compost/ha) showed the highest 1000 grain wt. (21.67 g) which was statistically comparable to other treatments of T_3 (70% NPKSZn + 3 ton cowdung/ha), T_6 (50% NPKSZn + 3.5 ton poultry manure/ha) and T_7 (70% NPKSZn + 2.1 ton poultry manure/ha) treatments. On the other hand, the lowest 1000 grain wt. (19.58 g) was observed in the T_0 treatment where no fertilizer was applied. Yang *et al.* (2004) also recorded that 1000-grain weight were increased by the application of chemical fertilizer with organic manure. Statistically similar thousand- grain weight was observed in maximum treatments.

4.6.3 Interaction effects of fertilizer, manure and irrigation on the 1000 grain wt. of T-Aman rice

The combined effect of different doses of fertilizer, manure and irrigation on the 1000 grain wt. of T-Aman rice was insignificant (Table 4.9). The highest 1000 grain wt. of rice (22.50 g) was recorded with the treatment combination I_2T_4 (Alternate wetting and drying +50% NPKSZn + 5 ton compost/ha). On the other hand, the lowest 1000 grain wt. (19.33) was found in I_2T_0 (Alternate wetting and drying + control) treatment combination.

4.7 Grain yield

4.7.1 Effect of irrigation on the grain yield ofT-Aman rice

The effects of irrigation on the grain yield of T-Aman rice are presented in Table 4.10. Insignificant variation was observed on the grain yield of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_1 (Continuous flooding) showed the highest grain yield (2.36 kg/plot) (4.72 t/ha) and I_2 (Alternate wetting and drying) irrigation showed lowest grain yield (2.35 kg/plot) (4.70 t/ha).

Table 4.10 Effect of irrigation on the grain and straw yield/plot of rice

Treatments	Grain yield (ton/ha)	Straw yield (ton/ha)
I_1	4.72	9.36
I_2	4.70	9.42
SE (±)	NS	NS

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

4.7.2 Effects of different doses of fertilizer and manure on the grain yield of T-Aman rice

Different doses of fertilizers showed significant variations in respect of grain yield/plot (Table 4.11). The application of fertilizers and manure had a positive effect on the grain yield of T-Aman rice. The yield increase varied from 11.4% to 38.3% and lowest yield increase was observed in T_1 (recommended chemical fertilizer) treatment. The higher levels of % grain yield increase were observed in the integrated use of fertilizer and manure compared to chemical fertilizer alone. Among the different doses of fertilizers, T_7 (70% NPKSZn + 2.1 ton poultry manure/ha) showed the highest grain yield/plot (2.56 kg/plot) (5.12 t/ha) which was statistically similar with all other treatments except control treatment. On the contrary, the lowest grain yield/plot (1.85 kg/plot) (3.70 t/ha) was observed with T_0 where no fertilizer was applied. The higher grain yield was found in the treatments where organic plus inorganic fertilizers were used. The yield decreased in order to T_7 (70% NPKSZn + 2.1 ton poultry manure/ha) › T_6 (50% NPKSZn + 3.5 ton poultry manure/ha) › T_3 (70% NPKSZn + 3 ton cowdung/ha). Rahman *et al.* (2009) reported the grain yield was significantly increased due to application of organic manure and chemical fertilizers. This is also in agreement with the findings of Miah*et al.* (2006), Xu *et al.* (2008) and Miah *et al.* (2004).

Table 4.11 Effect of fertilizer on the straw and grain yield of T-Aman rice

Treatments	Grain yield (ton/ha)	Straw yield (ton/ha)
T_0	3.70 b	7.40 c
T_1	4.12 ab	10.10 a
T_2	4.90 a	9.86 ab
T_3	5.10 a	9.54 ab
T_4	4.86 a	9.40 ab
T_5	4.78 a	9.80 ab
T_6	5.10 a	9.06 b
T_7	5.12 a	9.92 ab
SE (±)	0.142	0.123

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

4.7.3 Interaction effect of fertilizer and irrigation on the grain yield of T-Aman rice

The combined effect of different doses of fertilizer and irrigation on the grain yield of T-Aman rice was insignificant (Table 4.12). The highest grain yield of rice (5.78 t/ha) was recorded with the treatment combination I_2T_7 (Alternate wetting and drying +70% NPKSZn + 2.1 ton poultry manure/ha). On the other hand, the lowest grain yield (1.71 kg/plot) (3.42 t/ha) was found in I_2T_0 (Alternate wetting and drying + control treatment) treatment combination. Lin *et al.* (29011) reported that irrigation with organic material application increased yield of rice.

Table 4.12 Interaction effects of fertilizer and irrigation on the grain and straw yield/ha of T-Aman rice

Treatments	Grain yield (ton/ha)	Straw yield (ton/ha)
I_1T_0	3.98	7.96
I_1T_1	4.56	9.12
I_1T_2	5.14	10.28
I_1T_3	5.36	10.72
I_1T_4	4.42	8.84
I_1T_5	4.72	9.44
I_1T_6	5.16	10.32
I_1T_7	4.46	8.92
I_2T_0	3.42	6.84
I_2T_1	3.7	7.4
I_2T_2	4.66	9.32
I_2T_3	4.82	9.64
I_2T_4	5.3	10.6
I_2T_5	4.92	9.84
I_2T_6	5.04	10.08
I_2T_7	5.78	11.56
SE (±)	NS	NS

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

4.8 Straw yield

4.8.1 Effect of irrigation on the straw yield of T-Aman rice

The effects of irrigation on the straw yield of T-Aman rice are presented in Table 4.10. Insignificant variation was observed on the straw yield of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_2 (Alternate wetting and drying irrigation) showed the highest straw yield (9.43 t/ha) and I_1 (Continuous flooding) showed lowest straw yield (4.68 kg/plot) (9.35 t/ha).

4.8.2 Effects of different doses of fertilizer and manure on the straw yield of T-Aman rice

Significant variation was observed on the straw yield of rice when different doses of fertilizer were applied (Table 4.11). The highest yield of straw/plot (5.05 kg/plot) (10 t/ha) was recorded in T_1 (100% $N_{100}P_{15}K_{45}S_{20}Zn_2$)(Recommended dose of fertilizer) treatment which was statistically similar to T_2 (50% NPKSZn + 5 ton cowdung/ha), T_3 (70% NPKSZn + 3 ton cowdung/ha) and T_4(50% NPKSZn + 5 ton compost/ha) treatment. The lowest straw yield/plot (3.70 kg/plot) (7.40 t/ha) was recorded in the T_0 treatment where no fertilizer was applied. The straw yield increase varied from 11.4% to 38.3% and the highest level of straw yield increase was found in the T_1 (100% $N_{100}P_{15}K_{45}S_{20}Zn_2$) treatment where highest level of chemical fertilizer was used. Rahman *et al.* (2009) reported that the application of organic manure and chemical fertilizers increased the straw yields of rice. These findings are corroborated with the work of Mannan *et al.* (2000). It is clear that organic manure in combination with inorganic fertilizers increased vegetative growth of plants and thereby increased straw yield of rice.

4.8.3 Interaction effect of fertilizer and irrigation on the straw yield of T-Aman rice

The combined effect of different doses of fertilizer and irrigation on the straw yield of T-Aman rice was insignificant (Table 4.12). The highest straw yield of rice (5.13 kg) (10.27 t/ha) was recorded with the treatment combination I_1T_1 (Continuous flooding +100% $N_{100}P_{15}K_{45}S_{20}Zn_2$ (Recommended). On the other hand, the lowest straw yield (6.80 t/ha) was found in I_2T_0 (Alternate wetting and drying + control) treatment combination.

4.9 NPKS concentration in T-Aman rice grain

4.9.1 Effect of irrigation on N concentration in T-Aman rice grain

The effects of irrigation on N concentration in grain of rice are presented in Table 4.13. Insignificant variation was observed on N concentration in grain of rice when the field was irrigated with two different irrigations. Between these two irrigationsI_2(Alternate wetting and drying) irrigation showed the highest N concentration in grain (1.224%)and I_1 (Continuous flooding) showed the lowest N concentration in grain (1.142%).

Table 4.13 Effect of irrigation on NPKS concentration in T-Aman rice grain

Treatments	Concentration (%) in grain			
	N	P	K	S
I_1	1.142	0.238	0.266	0.163
I_2	1.224	0.217	0.247	0.176
SE (±)	NS	NS	NS	NS

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

4.9.2 Effect of different doses of fertilizer and manure on N concentration in T-Aman rice grain

Nitrogen concentrations in grain of rice showed statistically significant variation due to the application of different doses of fertilizers are presented in Table 4.14. The nitrogen concentration in T-Aman rice grain significantly increased due to application of fertilizers and manure. The higher levels of grain N concentrations were recorded in the combined application of fertilizer and manure compare to the chemical fertilizer alone. The highest N concentration in grain (1.295%) was recorded from T_6 (50% NPKSZn + 3.5 ton poultry manure/ha) compared to (1.225%) by T_1 as 100% NPKSZn. On the other hand, the lowest N concentration in grain (1.073%) was found from T_0 as control treatment which was closely followed (1.085%) by T_4 as 50% NPKSZn + 5 ton compost/ha. A significant increase in N content in rice grain due to the application of organic manure and fertilizers have been reported by investigators (Azim, 1999 and Hoque, 1999).

Table 4.14 Effect of fertilizer and manure on NPKS concentration of T Aman rice grain

Treatment	Concentration (%) in grain			
	N	P	K	S
T_0	1.073 c	0.175 f	0.207 b	0.096 b
T_1	1.225 a	0.240 b	0.250 ab	0.196 a
T_2	1.190 ab	0.230 c	0.282 a	0.167 a
T_3	1.190 ab	0.265 a	0.250 ab	0.171 a
T_4	1.085 bc	0.232 c	0.282 a	0.167 a
T_5	1.190 ab	0.225 d	0.218 b	0.181 a
T_6	1.295 a	0.240 b	0.282 a	0.173 a
T_7	1.213 a	0.217 e	0.282 a	0.204 a
SE (±)	0.0321	0.0070	0.0127	0.0172

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

4.9.3 Interaction effect of fertilizer and irrigation on N concentration of T-Aman rice grain

The combined effect of different doses of fertilizer and irrigation on N concentration of T-Aman rice was significant (Table 4.15). The highest N concentration in grain of rice (1.40%) was recorded with the treatment combination I_2T_1 (Alternate wetting and drying +100% NPKSZn) and I_2T_6 (Alternate wetting and drying +50% NPKSZn + 3.5ton poultry manure/ha) which was statistically similar to I_2T_7 (Alternate wetting and drying + 70% NPKSZn + 2.1 ton poultry manure/ha) and I_1T_2 (Continuous flooding + 50% NPKSZn + 5 ton cowdung/ha). On the other hand, the lowest N concentration in grain of rice (0.980%) was found in I_1T_0 (Continuous flooding + control) treatment combination.

Table 4.15 Combined effects of fertilizer and irrigation on the NPKS concentration of T-Aman rice grain

Treatments	Concentration (%) in grain			
	N	P	K	S
I_1T_0	0.980 d	0.173 k	0.218	0.088
I_1T_1	1.050 cd	0.270 b	0.282	0.196
I_1T_2	1.260 ab	0.243 cd	0.282	0.175
I_1T_3	1.120 bcd	0.290 a	0.282	0.150
I_1T_4	1.120 bcd	0.240 de	0.282	0.138
I_1T_5	1.260 ab	0.237 ef	0.218	0.167
I_1T_6	1.190 bc	0.247 c	0.282	0.183
I_1T_7	1.153 bc	0.207 j	0.282	0.208
I_2T_0	1.167 bc	0.177 k	0.197	0.104
I_2T_1	1.400 a	0.210 ij	0.218	0.196
I_2T_2	1.120 bcd	0.217 h	0.282	0.158
I_2T_3	1.260 ab	0.240 de	0.218	0.192
I_2T_4	1.050 cd	0.223 g	0.282	0.196
I_2T_5	1.120 bcd	0.213 hi	0.218	0.196
I_2T_6	1.400 a	0.233 f	0.282	0.163
I_2T_7	1.273 ab	0.227 g	0.282	0.200
SE (±)	0.045	0.010	0.013	0.024

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

4.9.4 Effect of irrigation on P concentration in T-Aman rice grain

The effects of irrigation on P concentration in grain of T-Aman rice are presented in Table 4.13. Insignificant variation was observed on P concentration in grain of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_1

(Continuous flooding) showed the highest (0.238%) P concentration in grain and I_2 (Alternate wetting and drying) irrigation showed the lowest (0.217%) P concentration in grain.

4.9.5 Effects of different doses of fertilizer and manure on P concentration of T-Aman rice grain

Phosphorous concentrations in grain of rice showed statistically significant variation due to the application of different doses of fertilizers and manure are presented in Table 4.14. The highest P concentration in grain (0.265%) was recorded from T_3 (70% NPKSZn + 3 ton cowdung/ha). On the other hand, the lowest P concentration in grain (0.175%) was found from T_0 as control treatment. A significant increase in P content in rice grain due to the application of organic manure and fertilizers has been reported by investigators (Azim, 1999 and Hoque, 1999).

4.9.6 Interaction effect of fertilizer and irrigation on P concentration of T-Aman rice grain

The combined effect of different doses of fertilizer and irrigation on P concentration in grain of rice was significant (Table 4.15). The highest P concentration in grain of rice (0.290%) was recorded with the treatment combination I_1T_3 (Continuous flooding +70% NPKSZn + 3 ton cowdung/ha). On the other hand, the lowest P concentration in grain of rice (0.173%) was found in I_1T_0 (Continuous flooding + control treatment) .

4.9.7 Effect of irrigation on K concentration in T-Aman rice grain

The effects of irrigation on K concentration in T-Aman rice grain are presented in Table 4.13. Insignificant variation was observed on K concentration in grain of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_1 (continuous flooding) showed the highest K concentration (0.266%) in grain and I_2 (alternate wetting and drying) irrigation showed the lowest K concentration (0.247%) in grain.

4.9.8 Effect of fertilizer and manure on K concentration in T-Aman rice grain

Potassium concentrations in grain of rice showed statistically significant variation due to the application of different doses of fertilizers are presented in Table 4.14. The highest K concentration in grain (0.282%) was recorded from T_2 (50% NPKSZn +5 ton cowdung), T_4 (50% NPKSZn + 5 ton compost/ha), T_6 (50% NPKSZn + 3.5 ton poultry manure/ha) and in T_7 (70% NPKSZn + 2.1 ton poultry manure/ha) treatments. The combined application of fertilizer and manure increased the K accumulation in rice grain. On the other hand, the lowest K concentration in grain (0.207%) was found from T_0 as control treatment. Singh *et al.* (2001) revealed that potassium content in grains were increased due to combined application of organic manure and chemical fertilizers.

4.9.9 Interaction effect of fertilizer and irrigation on K concentration in T-Aman rice grain

The combined effect of different doses of fertilizer and irrigation on K concentration in T-Aman rice grain was insignificant (Table 4.15). The highest K concentration in grain of rice (0.282%) was recorded with the treatment combination I_1T_1(Continuous flooding + 100% $N_{100}P_{15}K_{45}S_{20}Zn_2$ (Recommended dose), I_1T_2(Continuous flooding + 50% NPKSZn + 5 ton cowdung/ha), I_1T_3 (Continuous flooding + 70% NPKSZn + 3 ton cowdung/ha), I_1T_4 (Continuous flooding + 50% NPKSZn + 5 ton compost/ha), I_1T_6 (Continuous flooding + 50% NPKSZn + 3.5 ton poultry manure/ha), I_1T_7 (Continuous flooding + 70% NPKSZn +2.1 ton poultry manure/ha), I_2T_2 (Alternate wetting and drying + 50% NPKSZn + 5 ton cowdung/ha), I_2T_4 (Alternate wetting and drying + 50% NPKSZn + 5 ton compost/ha), I_2T_6 (Alternate wetting and drying + 50% NPKSZn + 3.5 ton poultry manure/ha), I_2T_7 (Alternate wetting and drying +70% NPKSZn +2.1 ton poultry manure/ha) On the other hand, the lowest K concentration in grain of rice (0.197%) was found in I_2T_0 (alternate wetting and drying + control treatment) treatment combination.

4.9.10 Effect of irrigation on S concentration of T-Aman rice grain

The effects of irrigation on S concentration in grain ofT-Aman rice are presented in Table 4.13. Insignificant variation was observed on S concentration in grain of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_1 (Continuous flooding) showed the lowest S concentration in grain (0.163%) and I_2 (Alternate wetting and drying) irrigation showed the highest S concentration in grain (0.176%).

4.9.11 Effects of different doses of fertilizer and manure on S concentration in T-Aman rice grain

Sulphur concentrations in grain of T-Aman rice showed statistically significant variation due to the application of different doses of fertilizers are presented in Table 4.14. The highest S concentration in grain (0.204%) was recorded from T_7 (70% NPKSZn + 2.1 ton poultry manure/ha) which was closely followed by (0.196%) at T_1 (100% NPKSZn). On the other hand, the lowest S concentration in grain (0.096%) was found from T_0 as control treatment.

4.9.12 Interaction effect of fertilizer and irrigation on S concentration in T-Aman rice grain

The combined effect of different doses of fertilizer and irrigation on S concentration of grain was insignificant (Table 4.15). The highest S concentration in grain of rice (0.208%) was recorded with the treatment combination I_1T_7 (Continuous flooding +70% NPKSZn + 2.1 ton poultry manure/ha). On the other hand, the lowest S concentration in grain of rice

(0.088%) was found in I_1T_0 (Continuous flooding + control treatment) treatment combination.

4.10 NPKS concentration in T-Aman rice straw

4.10.1 Effect of irrigation on N concentration in T-Aman rice straw

The effects of irrigation on N concentration in straw of T-Amanrice are presented in Table 4.16. Insignificant variation was observed on N concentration in straw of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_1 (Continuous flooding) showed the lowest N concentration in straw (0.54%) and I_2 (Alternate wetting and drying) irrigation showed the highest N concentration in straw (0.60%).

Table 4.16 Effect of irrigation on NPKS concentration in T-Aman rice straw

Treatments	Concentration (%) in straw			
	N	P	K	S
I_1	0.544 b	0.138	1.354	0.110
I_2	0.600 a	0.122	1.442	0.120
SE (±)	0.0093	NS	NS	NS

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

4.10.2 Effect of fertilizer on N concentration in T-Aman rice straw

Nitrogen concentrations in straw of T-Aman rice showed statistically significant variation due to the application of different doses of fertilizers are presented in Table 4.17. The N concentration of T-Aman rice straw significantly increased due to the application of fertilizer and manure. The higher levels of N concentrations were found in the treatments where fertilizer and manure were combinedly applied. The highest N concentration in straw (0.630%) was recorded from T_1 (100% NPKSZn) which was statistically similar (0.630%) by T_2 (50% NPKSZn + 5 ton cowdung/ha), T_6 (50% NPKSZn + 3.5 ton poultry manure/ha), T_7 (70% NPKSZn + 2.1 ton poultry manure/ha) and T_3 (70% NPKSZn + 3 ton cowdung/ha) treatments. On the other hand, the lowest N concentration in straw (0.477%) was found from T_0 as control treatment.

Table 4.17 Effect of fertilizer on NPKS concentration in T-Aman rice straw

Treatments	Concentration (%) in straw			
	N	P	K	S
T_0	0.477 c	0.113 e	1.282 c	0.066 d
T_1	0.630 a	0.129 c	1.346 bc	0.096 bcd
T_2	0.630 a	0.140 a	1.378 bc	0.133 abc
T_3	0.560 abc	0.136 b	1.314 c	0.128 abc
T_4	0.525 bc	0.132 bc	1.506 ab	0.090 cd
T_5	0.560 abc	0.134 b	1.314 c	0.138 ab
T_6	0.595 ab	0.124 d	1.378 bc	0.106 bcd
T_7	0.598 ab	0.132 bc	1.667 a	0.163 a
SE (±)	0.028	0.004	0.052	0.012

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

4.10.3 Interaction effect of fertilizer and irrigation on N,P,K,S concentration in T-Aman rice straw

The combined effect of different doses of fertilizer and irrigation on N concentration of T-Aman rice straw was significant (Table 4.18). The highest N concentration in T-Aman rice straw (0.700%) was recorded with the treatment combination I_1T_2 (Continuous flooding +50% NPKSZn + 5 ton cowdung/ha) and I_2T_6 (Alternate wetting and drying +50% NPKSZn + 3.5 ton poultry manure/ha). On the other hand, the lowest N concentration in straw of rice (0.457%) was found in I_1T_0 (Continuous flooding + control treatment) treatment combination.

Table 4.18 Combined effects of fertilizer and irrigation on the NPKS concentration in T-Aman rice straw

Treatments	Concentration (%) in straw			
	N	P	K	S
I_1T_0	0.457	0.104 h	1.090 d	0.063 d
I_1T_1	0.630	0.144 b	1.282bcd	0.067 d
I_1T_2	0.700	0.156 a	1.410 bc	0.106 abcd
I_1T_3	0.490	0.134 c	1.410 bc	0.121 abcd
I_1T_4	0.490	0.145 b	1.474 bc	0.081 cd
I_1T_5	0.560	0.147 b	1.346 bcd	0.138 abc
I_1T_6	0.490	0.128 d	1.346 bcd	0.144 abc
I_1T_7	0.537	0.146 b	1.474 bc	0.161 ab
I_2T_0	0.497	0.122 def	1.474 bc	0.069 d
I_2T_1	0.630	0.114 g	1.410 bc	0.125 abcd
I_2T_2	0.560	0.124 de	1.346 bcd	0.161 ab
I_2T_3	0.630	0.137 c	1.218 cd	0.136 abc
I_2T_4	0.560	0.119 efg	1.538 b	0.098 bcd
I_2T_5	0.560	0.122 def	1.282 bcd	0.138 abc
I_2T_6	0.700	0.121 ef	1.410 bc	0.067 d
I_2T_7	0.660	0.117 fg	1.859 a	0.165 a
SE (±)	0.0402	0.0055	0.0736	0.0172

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

4.10.4 Effect of irrigation on P concentration in T-Aman rice straw

The effects of irrigation on P concentration in straw of rice are presented in Table 4.16. Insignificant variation was observed on P concentration in straw of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_1 (Continuous flooding) showed the P concentration in straw (0.138%) and I_2 (Alternate wetting and drying) irrigation showed the P concentration in straw (0.122%).

4.10.5 Effect of different doses of fertilizer and manure on P concentration in straw

The application of different levels of fertilizer and manure increased the P concentration of T-Aman rice. Phosphorous concentrations in straw of rice showed statistically significant variation due to the application of different doses of fertilizers are presented in Table 4.17. The highest P concentration in straw (0.140%) was recorded from T_2 (50% NPKSZn + 5 ton cowdung/ha). On the other hand, the lowest P concentration in straw (0.113%) was found from T_0 as control treatment.

4.10.6 Interaction effect of fertilizer and irrigation on P concentration in straw of T-Aman rice

The combined effect of different doses of fertilizer and irrigation on P concentration in straw of rice was significant (Table 4.18). The highest P concentration in straw of rice (0.156%) was recorded with the treatment combination I_1T_2 (Continuous flooding and 50% NPKSZn + 5 ton cowdung/ha) followed (0.147) by I_1T_5 (Continuous flooding +70% NPKSZn + 3 ton compost/ha) and I_1T_7 (Continuous flooding +70% NPKSZn + 2.1 ton poultry manure/ha). Higher P was accumulated in rice straw by the application of organic plus inorganic fertilizer with continuous flooded condition, due to higher availability of P in water logged condition. On the other hand, the lowest P concentration in straw of rice (0.104%) was found in I_1T_0 (Continuous flooding + control treatment) which was followed (0.114%) by I_2T_1 (Alternate wetting and drying +100% NPKSZn).

4.10.7 Effect of irrigation on K concentration in straw

The effects of irrigation on K concentration in straw of rice are presented in Table 4.16. Insignificant variation was observed on K concentration in straw of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_1 (Continuous flooding) showed the lowest K concentration in straw (1.354%) and I_2 (Alternate wetting and drying) irrigation showed the highest K concentration in straw (1.442%).

4.10.8 Effects different doses of fertilizer and manure on K concentration in T-Aman rice straw

Potassium concentrations in straw of rice showed statistically significant variation due to the application of different doses of fertilizers are presented in Table 4.17. The highest K concentration in straw (1.667%) was recorded from T_7 (70% NPKSZn + 2.1 ton poultry manure/ha) which was statistically similar to (1.506%) at T_4 as 50% NPKSZn + 5 ton compost/ha. Higher level of K was accumulated in combined application of organic plus inorganic fertilizer. Among the organic plus inorganic treatments, higher level of K was accumulated where compost and poultry manure were used in combination with inorganic fertilizer. On the other hand, the lowest K concentration in straw (1.282%) was found from T_0 as control treatment. Singh *et al.* (2001) revealed that Potassium content in grain was increased due to combined application of organic manure and chemical fertilizers.

4.10.9 Interaction effect of fertilizer and irrigation on K concentration in straw of T-Aman rice

The combined effect of different doses of fertilizer and irrigation on K concentration in straw of rice was significant (Table 4.18). The highest K concentration in straw of rice (1.859%) was recorded with the treatment combination I_2T_7 (Alternate wetting and drying +70% NPKSZn + 2.1 ton poultry manure/ha) and the second highest level of K concentration (1.538) found in I_2T_4 (Alternate wetting and drying +50% NPKSZn + 5 ton compost/ha). On the other hand, the lowest K concentration in straw of rice (1.090%) was found in I_1T_0 (Continuous flooding + control treatment) treatment combination.

4.10.10 Effect of irrigation on S concentration in straw of T-Aman rice

The effects of irrigation on S concentration in straw of rice are presented in Table 4.16. Insignificant variation was observed on S concentration in straw of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_1 (Continuous flooding) showed the lowest S concentration in straw (0.110%) and I_2 (Alternate wetting and drying) irrigation showed the highest S concentration in straw (0.120%) which were almost simile ar.

4.10.11 Effect of fertilizer and manure on S concentration in straw of T-Aman rice

Sulphur concentrations in straw of rice showed statistically significant variation due to the application of different doses of fertilizers are presented in Table 4.17. The S concentration in T-Aman rice straw significantly increased due to application of fertilizer and manure. The highest S concentration in straw (0.163%) was recorded from T_7 (70% NPKSZn + 2.1 ton poultry manure/ha) which was statistically identical (0.138%) with T_5as 70% NPKSZn + 3 ton compost/ha. On the other hand, the lowest S concentration in straw (0.066%) was found from T_0 as control treatment. Azim (1999) and Hoque (1999) reported that application of sulphur from manure and fertilizers increased S content both in grain and straw.

4.10.12 Interaction effect of fertilizer and irrigation on S concentration in straw of T-Aman rice

The combined effect of different doses of fertilizer and irrigation on S concentration in straw of rice was significant (Table 4.18). Higher S was accumulated in rice straw when alternate wetting and drying was maintained and fertilizer was applied in combination with poultry manure.The highest S concentration in straw of rice (0.165%) was recorded with the treatment combination I_2T_7 (Alternate wetting and drying +70% NPKSZn + 2.1 ton poultry manure/ha) which was statistically identical with I_1T_7,(Continuous flooding +

2.1 ton poultry manure/ha) and I_2T_2(Alternate wetting and drying +50% NPKSZn + 5 ton cowdung/ha). On the other hand, the lowest S concentration in straw of rice (0.063%) was found in I_1T_0 (Continuous flooding + control treatment) treatment combination which was statistically identical (0.067%) with I_1T_1 (Continuous flooding and 100% NPKSZn) and I_2T_6 (Alternate wetting and drying +70% NPKSZn + 2.1 ton poultry manure/ha).

4.11 NPKS uptake by T-Aman rice grain

4.11.1 Effect of irrigation on N uptake by T-Aman rice grain

The effects of irrigation on N uptake by grain of rice are presented in Table 4.19. Insignificant variation was observed on N uptake by grain of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_1 (Continuous flooding) showed the grain N uptake of 0.027 kg/plot and I_2 (Alternate wetting and drying) irrigation showed the grain N uptake of 0.028 kg/plot which were almost similar.

Table 4.19 Effect of irrigation on NPKS uptake by T-Aman rice grain

Treatments	Uptake by grain (kg/plot)			
	N	P	K	S
I_1	0.027	0.005	0.15	0.004
I_2	0.028	0.005	0.15	0.004
SE (±)	NS	NS	NS	NS

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

4.11.2 Effect of fertilizer and manure on N uptake by grain of T-Aman rice

Nitrogen uptake by grain of rice showed statistically significant variation due to the application of different doses of fertilizers is presented in Table 4.20. The highest N uptake by grain (0.033 kg/plot) was recorded from T_6 (50% NPKSZn + 3.5 ton poultry manure/ha) which was closely followed (0.030 kg/plot) by T_3 as 70% NPKSZn + 3 ton cowdung /ha. On the other hand, the lowest N uptake by grain (0.021 kg/plot) was found from T_0 as control treatment. Sengar *et al.* (2000) reported that the N uptake by rice grain and straw increased significantly with the combined application of organic manure and chemical fertilizers. Rahman (2001); Duhan and Singh (2002) also reported similar results.

Table 4.20 Effect of fertilizer and manure on NPKS uptake by grain of T-Aman rice

Treatments	Uptake by grain (kg/plot)			
	N	P	K	S
T_0	0.021 c	0.003 c	O.012	0.002
T_1	0.026 b	0.005 ab	0.015	0.004
T_2	0.029 ab	0.006 ab	0.016	0.004
T_3	0.030 ab	0.007 a	0.015	0.004
T_4	0.026 b	0.005 ab	0.015	0.004
T_5	0.029 ab	0.005 ab	0.015	0.004
T_6	0.033 a	0.006 ab	0.016	0.005
T_7	0.028 b	0.005 b	0.015	0.005
SE (±)	0.0016	0.004	NS	NS

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

4.11.3 Interaction effect of fertilizer and irrigation on N uptake by T-Aman rice grain

The combined effect of different doses of fertilizer and irrigation on N uptake by T-Aman rice grain was insignificant (Table 4.21). The highest N uptake by grain (0.035 kg/plot) was recorded with the treatment combination I_2T_6 (Alternate wetting and drying +50% NPKSZn + 3.5 ton poultry manure/ha). On the other hand, the lowest N uptake by grain of rice (0.021 kg/plot) was found in I_1T_0 (Continuous flooding + control treatment) treatment combination.

Table 4.21 Combined effects of fertilizer and irrigation on the NPKS uptake by grain of T-Aman rice

Treatments	Uptake by grain (kg/plot)			
	N	P	K	S
I_1T_0	0.021	0.003 e	0.014	0.002
I_1T_1	0.023	0.006 ab	0.016	0.005
I_1T_2	0.032	0.006 ab	0.017	0.005
I_1T_3	0.030	0.007 a	0.014	0.004
I_1T_4	0.025	0.005 abcde	0.013	0.003
I_1T_5	0.030	0.006 abc	0.016	0.003
I_1T_6	0.031	0.005 abcd	0.016	0.005
I_1T_7	0.026	0.004 cde	0.014	0.005
I_2T_0	0.022	0.003 de	0.010	0.002
I_2T_1	0.029	0.005 bcde	0.014	0.004
I_2T_2	0.026	0.005 bcde	0.015	0.004
I_2T_3	0.030	0.006 ab	0.015	0.005
I_2T_4	0.028	0.005 bcde	0.017	0.005
I_2T_5	0.028	0.005 bcde	0.014	0.005
I_2T_6	0.035	0.006 ab	0.016	0.004
I_2T_7	0.031	0.006 ab	0.016	0.006
SE (±)	NS	0.0005	NS	NS

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

4.11.4 Effect of irrigation on P uptake by grain of T-Aman rice

The effects of irrigation on P uptake by grain of rice are presented in Table 4.19. Insignificant variation was observed on P uptake by grain of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_1 (Continuous flooding) showed the P uptake by grain (0.005 kg/plot) and I_2 (Alternate wetting and drying) irrigation showed the same P uptake by T-Aman rice grain (0.005 kg/plot).

4.11.5 Effect of fertilizer and manure on P uptake by grain of T-Aman rice

Phosphorous uptake by grain of rice showed statistically significant variation due to the application of different doses of fertilizers is presented in Table 4.20. The highest P uptake by grain (0.007 kg/plot) was recorded from T_3 (70% NPKSZn + 3 ton cowdung/ha) which was closely (0.006 kg/plot) followed by T_2 as 50% NPKSZn + 5 ton cowdung/ha and T_6

(50% NPKSZn + 3.5 ton poultry manure/ha). On the other hand, the lowest P uptake by grain (0.003 kg/plot) was found from T_0 as control treatment. Sengar*et al.* (2000) observed that the highest P uptake by rice grain was recorded with the combined application of organic manure and phosphatic fertilizers.

4.11.6 Interaction effect of fertilizer and irrigation on P uptake by grain of T-Aman rice

The combined effect of different doses of fertilizer and irrigation on P uptake by grain was significant (Table 4.21). The highest P uptake by grain (0.007 kg/plot) was recorded with the treatment combination I_1T_3 (Continuous flooding +70% NPKSZn + 3 ton cowdung /ha). On the other hand, the lowest P uptake by grain of rice (0.003 kg/plot) was found in I_1T_0 (Continuous flooding + control treatment) treatment combination.

4.11.7 Effect of irrigation on K uptake by grain of T-Aman rice

The effects of irrigation on K uptake by grain of rice are presented in Table 4.19. Insignificant variation was observed on K uptake by grain of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_1 (Continuous flooding) showed the K uptake of grain (0.15 kg/plot) and I_2 (Alternate wetting and drying) irrigation also showed the same amount of K uptake of grain (0.15 kg/plot).

4.11.8 Effect of fertilizer on K uptake by grain of T-Aman rice

Potassium uptake by grain of rice showed statistically insignificant variation due to the application of different doses of fertilizers is presented in Table 4.20. The highest K uptake by grain (0.016 kg/plot) was recorded from T_2 (50% NPKSZn + 5 ton cowdung/ha) and T_6 (50% NPKSZn + 3.5 ton poultry manure/ha). On the other hand, the lowest K uptake by grain (0.012 kg/plot) was found from T_0 as control treatment. Sengar *et al.* (2000) reported that application of chemical fertilizer and organic manure significantly increased the K uptake by rice.

4.11.9 Interaction effect of fertilizer and irrigation on K uptake by grain of T-Aman rice

The combined effect of different doses of fertilizer and irrigation on K uptake by grain was insignificant (Table 4.21). The highest K uptake by grain (0.017 kg/plot) was recorded with the treatment combination I_1T_2 (Continuous flooding +50% NPKSZn + 5 ton cowdung/ha) and at I_2T_4 (Alternate wetting and drying +5 ton compost/ha). On the other hand, the lowest K uptake by grain of rice (0.010 kg/plot) was found in I_2T_0 (Alternate wetting and drying + control) treatment.

4.11.10 Effect of irrigation on S uptake by grain of T-Aman rice

The effects of irrigation on S uptake by grain of rice are presented in Table 4.19. Insignificant variation was observed in S uptake by grain of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_1 (Continuous flooding) showed the S uptake of grain (0.004 kg/plot) and I_2 (Alternate wetting and drying) irrigation showed the same amount of S uptake of T-Aman rice grain (0.004 kg/plot).

4.11.11 Effect of fertilizer and manure on S uptake by grain of T-Aman rice

Sulphur uptake by grain of rice showed statistically insignificant variation due to the application of different doses of fertilizers is presented in Table 4.20. The highest S uptake by grain (0.005 kg/plot) was recorded from T_6 (50% NPKSZn + 3.5 ton poultry manure/ha) and T_7 (70% NPKSZn + 2.1 ton poultry manure/ha). On the other hand, the lowest S uptake by grain (0.002 kg/plot) was found from T_0 as control treatment. Sengar *et al.* (2000) recorded the higher uptake of S with the application of manure and fertilizers either alone or in combinations. Similar results were also reported by Rahman (2001).

4.11.12 Interaction effect of fertilizer and irrigation on S uptake by grain of T-Aman rice

The combined effect of different doses of fertilizer and irrigation on S uptake by grain was insignificant (Table 4.21). The highest S uptake by grain (0.006 kg/plot) was recorded with the treatment combination I_2T_7 (Alternate wetting and drying +70% NPKSZn + 2.1 ton poultry manure/ha). On the other hand, the lowest S uptake by grain of rice (0.002 kg/plot) was found in I_1T_0 (Continuous flooding + control treatment) and I_2T_0 (Alternate wetting and drying + control) treatment.

4.12 NPKS uptake by straw

4.12.1 Effect of irrigation on N uptake by T-Aman rice straw

The effects of irrigation on N uptake by straw of rice are presented in Table 4.22. Insignificant variation was observed on N uptake by straw of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_1 (Continuous flooding) showed the lowest N uptake of straw (0.025 kg/plot) and I_2 (Alternate wetting and drying) irrigation showed the highest N uptake of straw (0.029 kg/plot).

Table 4.22 Effect of irrigation on NPKS uptake by straw

Treatments	Uptake by straw (kg/plot)			
	N	P	K	S
I_1	0.025	0.006	0.063	0.005
I_2	0.029	0.006	0.094	0.006
SE (±)	NS	NS	NS	NS

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

4.12.2 Effect of fertilizer and manure on N uptake by straw of T-Aman rice

Nitrogen uptake by straw of rice showed statistically significant variation due to the application of different doses of fertilizers is presented in Table 4.23. The higher N uptake was observed in the combined application of fertilizer and manure compared to the application of chemical fertilizer alone. The highest N uptake by straw (0.031 kg/plot) was recorded from T_2 (50% NPKSZn + 5 ton cowdung/ha). On the other hand, the lowest N uptake by straw (0.022 kg/plot) was found from T_0 as control treatment.

Table 4.23 Effect of fertilizer and manure on NPKS uptake by T-Aman rice straw

Treatments	Uptake by straw (kg/plot)			
	N	P	K	S
T_0	0.022 e	0.004 b	0.047	0.002
T_1	0.030 b	0.006 a	0.174	0.005
T_2	0.031 a	0.007 a	0.068	0.006
T_3	0.027 c	0.006 a	0.062	0.006
T_4	0.025 d	0.006 a	0.071	0.004
T_5	0.027 c	0.007 a	0.064	0.007
T_6	0.027 c	0.006 a	0.062	0.005
T_7	0.027 c	0.006 a	0.083	0.008
SE (±)	0.0017	0.0002	NS	NS

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

4.12.3 Interaction effect of fertilizer and irrigation on N uptake by T-Aman rice straw

The combined effect of different doses of fertilizer and irrigation on N uptake by straw was significant (Table 4.24). The highest N uptake by straw (0.034 kg/plot) was recorded with the treatment combination I_1T_2 (Continuous flooding +50% NPKSZn + 5 ton cowdung/ha). On the other hand, the lowest N uptake by straw of rice (0.022 kg/plot) was found in I_2T_0 (Alternate wetting and drying + control treatment), I_1T_4 (Continuous flooding + 50% NPKSZn + 5 ton compost/ha), I_1T_6 (Continuous flooding + 50% NPKSZn +3.5 ton poultry manure/ha) treatment combination.

Table 4.24 Combined effects of fertilizer and irrigation on the NPKS uptake by T-Aman rice straw

Treatments	Uptake by straw (kg/plot)			
	N	P	K	S
I_1T_0	0.023 fg	0.004 bc	0.043	0.002
I_1T_1	0.028 e	0.007 a	0.066	0.003
I_1T_2	0.034 a	0.008 a	0.069	0.005
I_1T_3	0.023 fg	0.006 a	0.066	0.006
I_1T_4	0.022 g	0.007 a	0.067	0.004
I_1T_5	0.027 e	0.007 a	0.065	0.007
I_1T_6	0.022 g	0.006 abc	0.060	0.006
I_1T_7	0.025 f	0.007 a	0.072	0. 008
I_2T_0	0.022 g	0.004 c	0.050	0.003
I_2T_1	0.031 bc	0.006 abc	0.281	0.006
I_2T_2	0.028 de	0.006 ab	0.067	0.008
I_2T_3	0.031 bc	0.007 a	0.059	0.006
I_2T_4	0.027 e	0.006 abc	0.075	0.005
I_2T_5	0.028 e	0.006 abc	0.064	0.007
I_2T_6	0.032 ab	0.006 abc	0.065	0.003
I_2T_7	0.030 cd	0.006 ab	0.094	0.008
SE (±)	0.0024	0.0003	NS	NS

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

4.12.4 Effect of irrigation on P uptake by T-Aman rice straw

The effects of irrigation on P uptake by straw of T-Aman rice are presented in Table 4.22. Insignificant variation was observed on P uptake by straw of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_1 (Continuous flooding) showed the P uptake of straw (0.006 kg/plot) and I_2 (Alternate wetting and drying) irrigation showed the same P uptake of straw (0.006 kg/plot).

4.12.5 Effect of fertilizer and manure on P uptake by T-Aman rice straw

Phosphorous uptake by straw of rice showed statistically significant variation due to the application of different doses of fertilizers is presented in Table 4.23. The highest P uptake by straw (0.007 kg/plot) was recorded from T_5 (70% NPKSZn + 3 ton compost/ha) which was statistically identical (0.007 kg/plot) with T_2 as 50% NPKSZn + 5 ton cowdung/ha. On the other hand, the lowest P uptake by straw (0.004 kg/plot) was found from T_0 as control treatment.

4.12.6 Interaction effect of fertilizer and irrigation on P uptake by straw of T-Aman rice

The combined effect of different doses of fertilizer and irrigation on P uptake by straw was significant (Table 4.24). The highest P uptake by straw (0.007 kg/plot) was recorded with the treatment combination I_1T_7 (Continuous flooding +70% NPKSZn + 2.1 ton poultry manure/ha) which was statistically identical (0.007 kg/plot) with I_2T_3 (Alternate wetting and drying + 70% NPKSZn + 3 ton cow dung/ha). On the other hand, the lowest P uptake by straw of rice (0.004 kg/plot) was found in I_1T_0 (Continuous flooding + control treatment) and I_2T_0 (Alternate wetting and drying + control treatment) treatment combination.

4.12.7 Effect of irrigation on K uptake by T-Aman rice straw

The effects of irrigation on K uptake by straw of rice are presented in Table 4.22. Insignificant variation was observed on K uptake by straw of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_1 (Continuous flooding) showed the lowest K uptake of straw (0.063 kg/plot) and I_2 (Alternate wetting and drying) irrigation showed the highest K uptake of straw (0.094 kg/plot).

4.12.8 Effect of fertilizer and manure on K uptake by straw

Potassium uptake by straw of rice showed statistically insignificant variation due to the application of different doses of fertilizers is presented in Table 4.23. The highest K uptake by straw (0.174 kg/plot) was recorded from T_1 (100% NPKSZn). On the other hand, the lowest K uptake by straw (0.047 kg/plot) was found from T_0 as control treatment.

4.12.9 Interaction effect of fertilizer and irrigation on K uptake by T-Aman rice straw

The combined effect of different doses of fertilizer and irrigation on K uptake by straw was insignificant (Table 4.24). The highest K uptake by straw (0.281 kg/plot) was recorded with the treatment combination I_2T_1 (Alternate wetting and drying + 100% NPKSZn). On the other hand, the lowest K uptake by straw of rice was (0.043 kg/plot) with I_1T_0 (Continuous flooding + control) treatment combination.

4.12.10 Effect of irrigation on S uptake by T-Aman rice straw

The effects of irrigation on S uptake by straw of rice are presented in Table 4.22. Insignificant variation was observed on S uptake by straw of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_1 (Continuous flooding) showed the lowest S uptake in straw (0.005 kg/plot) and I_2 (Alternate wetting and drying) irrigation showed the highest S uptake in straw (0.006 kg/plot).

4.12.11 Effect of fertilizer and manure on S uptake by T-Aman rice straw

Sulphur uptake by straw of rice showed statistically insignificant variation due to the application of different doses of fertilizers is presented in Table 4.23. The highest S uptake by straw (0.008 kg/plot) was recorded from T_7 (70% NPKSZn + 2.1 ton poultry manure/ha). On the other hand, the lowest S uptake by straw (0.002 kg/plot) was found from T_0 as control treatment.

4.12.12 Interaction effect of fertilizer and irrigation on S uptake by T-Aman rice straw

The combined effect of different doses of fertilizer and irrigation on S uptake by straw was insignificant (Table 4.24). The highest S uptake by straw (0.008 kg/plot) was recorded with the treatment combination I_1T_7 (Continuous flooding +70% NPKSZn + 2.1 ton poultry manure/ha), I_2T_2 (Alternate wetting and drying +50% NPKSZn + 5 ton cowdung/ha) and I_2T_7 (Alternate wetting and drying +70% NPKSZn + 2.1 ton poultry manure/ha). On the other hand, the lowest S uptake by straw of rice (0.002 kg/plot) was found in I_1T_0 (Continuous flooding + control) treatment combination.

CHAPTER 5

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from July 2012 to November 2012 to study the effect of various organic manure and inorganic fertilizer with different water management on the growth and yield of T-Aman rice. BRRI dhan 32 was used as the test crop in this experiment. The experiment consists of 2 factors i.e. irrigation and fertilizer plus manure. Two levels of irrigations (I_1 = Continuous flooding and I_2 = Alternate wetting and drying) were used with 8 levels of fertilizer plus manure, as T_0: Control, T_1: 100% $N_{100}P_{15}K_{45}S_{20}Zn_2$ (Recommended dose), T_2: 50% NPKSZn + 5 ton cowdung/ha, T_3: 70% NPKSZn + 3 ton cowdung/ha, T_4: 50% NPKSZn + 5 ton compost/ha, T_5: 70% NPKSZn + 3 ton compost/ha, T_6: 50% NPKSZn + 3.5 ton poultry manure/ha and T_7: 70% NPKSZn + 2.1 ton poultry manure/ha, with 16 treatment combination as I_1T_0 = (Continuous flooding + Control), I_1T_1 = (Continuous flooding + 100% $N_{100}P_{15}K_{45}S_{20}Zn_2$ (Recommended dose), I_1T_2 = (Continuous flooding + 50% NPKSZn + 5 ton cowdung/ha), I_1T_3 = (Continuous flooding + 70% NPKSZn + 3 ton cowdung/ha), I_1T_4 =(Continuous flooding + 50% NPKSZn + 5 ton compost/ha), I_1T_5 = (Continuous flooding + 70% NPKSZn + 3 ton compost/ha), I_1T_6 = (Continuous flooding + 50% NPKSZn + 3.5 ton poultry manure/ha), I_1T_7 = (Continuous flooding + 70% NPKSZn +2.1 ton poultry manure/ha), I_2T_0 = (Alternate wetting and drying + Control), I_2T_1 = (Alternate wetting and drying + 100% $N_{100}P_{15}K_{45}S_{20}Zn_2$(Recommended dose), I_2T_2 = (Alternate wetting and drying + 50% NPKSZn + 5 ton cowdung/ha), I_2T_3 = (Alternate wetting and drying + 70% NPKSZn + 3 ton cowdung/ha), I_2T_4 = (Alternate wetting and drying + 50% NPKSZn + 5 ton compost/ha), I_2T_5 = (Alternate wetting and drying + 70% NPKSZn + 3 ton compost/ha), I_2T_6 = (Alternate wetting and drying + 50% NPKSZn + 3.5 ton poultry manure/ha), I_2T_7 = (Alternate wetting and drying +70% NPKSZn +2.1 ton poultry manure/ha), and 3 replications. The total number effective tillers/hill, plant height, panicle length, number of filled grain/panicle, 1000 grain weight, grain yield and straw yield were not significantly affected by single effect of irrigation. The highest plant height, number of effective tillers/hill, number of filled grain and grain yield were observed from I_1 (Continuous flooding) treatment and the higher panicle length, 1000 grain weight and straw yield were observed from I_2 (Alternate wetting and drying) treatment.

Yield contributing characters and yields were significantly affected by fertilizer and manure. The highest effective tillers/hill (9.13), plant height (119.79 cm), panicle length (27.96 cm), 1000 grain weight (21.67 g), grain yield (5.12 t/ha) and straw yield (10.1 t/ha) were found from T_2(50% NPKSZn + 5 ton cowdung/ha), T_3 (70% NPKSZn + 3 ton cowdung/ha), T_5 (70% NPKSZn + 3 ton compost/ha), T_4 (50% NPKSZn + 5 ton compost/ha), T_7 (70% NPKSZn + 2.1 ton poultry manure/ha) and T_1 (100% $N_{100}P_{15}K_{45}S_{20}Zn_2$) treatment respectively and lowest in T_0 treatment. The grain yield of different fertilizer treatments followed the order of T_7> $T_{6,}$ T_3> T_2> T_4> T_5 > T_1 >$T_{0.}$ Number of non effective tillers/hill and grain yield were insignificantly influenced by combinedapplication of irrigation and fertilizer. The highest values of effective tillers/hill (9.50), grain yield (2.89 kg/plot) (5.78 t/ha) and straw yield (5.13 kg/plot) (10.26 t/ha) were recorded from I_1T_2 (Continuous flooding + 50% NPKSZn + 5 ton cowdung/ha), I_2T_7 (Alternate wetting and drying +70% NPKSZn +2.1 ton poultry manure/ha) and I_1T_1 (Continuous flooding + 100% $N_{100}P_{15}K_{45}S_{20}Zn_2$[Recommended dose]) treatments combination respectively. The lowest values of effective tillers/hill (7.25), plant height (103.96 cm), panicle length (23.01cm), 1000 grain weight (19.33 g) grain yield (1.71 kg/plot)(3.42 t/ha) and straw yield (3.40 kg/plot)(6.80 t/ha) were observed from I_2T_0 (Alternate wetting and drying + Control) treatment combination.

The nutrient concentration in T-Aman rice plant was significantly affected by application of irrigation. The higher levels of grain N, S concentrations were recorded from I_2 (Alternate wetting and drying), and P, K concentrations were recorded from I_1 (Continuous flooding) treatment. The highest concentrations of grain N (1.295%), P (0.265%), K (0.282%), S (0.204%) were recorded from T_6 (50% NPKSZn + 3.5 ton poultry manure/ha), T_3 (70% NPKSZn + 3 ton cowdung/ha), T_6 (50% NPKSZn + 3.5 ton poultry manure/ha) and T_7 (70% NPKSZn + 2.1 ton poultry manure/ha) treatments combinations respectively and in all cases lowest value was observed in T_0 (control) treatment. The highest concentrations of straw N (0.630%), P (0.140%), were recorded from T_2 (50% NPKSZn + 5 ton cowdung/ha) treatment and K (1.667%), S (0.163%) were recorded from T_7 (70% NPKSZn + 2.1 ton poultry manure/ha) treatment and in all cases lowest value was observed in T_0 (control) treatment. The combined effect of irrigation and fertilizer significantly influenced the grain and straw N,P,K and S concentrations and higher levels grain N concentrations were observed in fertilizer plus alternate wetting and drying treatment combinations and higher levels of grain P and K concentrations were observed in the continuous flooding plus fertilizer treatment combinations. Similarly higher levels of N (0.033 kg/plot), P (0.007 kg/plot), K (0.016 kg/plot), S (0.005 kg/plot) were uptake by grain in the T_6 (50% NPKSZn + 3.5 ton poultry manure/ha), T_3 (70% NPKSZn + 3 ton cowdung/ha), T_2 and T_6 (50% NPKSZn + 3.5 ton poultry manure/ha) and T_6 and T_7 (70% NPKSZn + 2.1 ton poultry manure/ha) treatment respectively and the lowest values of N (0.021 kg/plot), P (0.003 kg/plot), K (0.012 kg/plot), S (0.002 kg/plot) were found in T_0 treatment. The higher levels of N (0.031 kg/plot), P (0.007 kg/plot), K (0.174 kg/plot), S

(0.008 kg/plot) were uptaken by straw in the T_2 (50% NPKSZn + 5 ton cowdung/ha), T_2 (50% NPKSZn + 5 ton cowdung/ha) and T_5 (70% NPKSZn + 3 ton compost/ha), T_1 (100% $N_{100}P_{15}K_{45}S_{20}Zn_2$) and T_7 (70% NPKSZn + 2.1 ton poultry manure/ha) treatments respectively and the lowest values of N (0.022 kg/plot), P (0.004 kg/plot), K (0.047 kg/plot), S (0.002 kg/plot) were found in T_0 (control) treatment.

From the above discussion it can be concluded that irrigation had no significant effect on yield and yield contributing characters and alternate wetting and drying is preferable than flood irrigation. The application of inorganic fertilizer plus manure performed better compared to inorganic fertilizer. The application of70% NPKSZn + 2.1 ton poultry manure/ha and alternate wetting and drying was most favorable for improving yield and yield contributing characters of T-Aman (BRRI dhan 32) rice.

Before recommend findings of the present study, the following recommendations and suggestions may be made:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance.
2. Another combination of NPKS and others organic manures with different water management may be included for further study.

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APPENDICES

Appendix

Appendix-I: Particulars of the Agro-ecological Zone of the Experimental site

Agro-ecological region	: Madhupur Tract (AEZ-28)
Land Type	: Medium high land
General soil type	: Non- Calcareous Dark gray floodplain soil
Soil series	: Tejgaon
Topography	: Up land
Location	: SAU Farm, Dhaka
Field level	: Above flood level
Drainage	: Fairly good
Firmness(consistency)	: Compact to friable when dry.

Appendix-II : Monthly mean weather

AppendixII. Records of meteorological information (monthly) during the period from July, 2012 toNovember, 2012

Name of the Months	Air temperature (^0C)		Relative humidity (%)	Rainfall (mm)
	Maximum	Minimum		
July, 2012	31.4	26.2	83	373.1
August, 2012	31.6	26.3	82	316.5
September, 2012	31.8	25.9	83	300.4
October, 2012	31.6	23.8	78	172.3
November, 2012	29.6	19.2	73	34.4

Source : Bangladesh Meteorological Department(Climate Division) Agargoan, Sher-e-Bangla Nagar, Dhaka-1207.

Appendix-III : SOME COMMONLY USED ABBREVIATIONS AND SYMBOLS

Abbreviations	Full word
%	Percent
@	At the rate
AEZ	Agro-Ecological Zone
Agric.	Agriculture
Agril.	Agricultural
Agron.	Agronomy
ANOVA	Analysis of variance
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BD	Bangladesh
BSMRAU	Bangladesh Sheikh MujiburRahman Agricultural University
CEC	Cation Exchange Capacity
cm	Centi-meter
CV%	Percentage of coefficient of variation
DMRT	Duncan's Multiple Range Test
et al.	and others
etc	et cetera
FAO	Food and Agricultural Organization
g	gram
hr.	Hours
j.	Journal
Kg/ha	kiligrams per hectare
kg	kilogram
LAD	Leaf area diseased
m	Meter

Abbreviations	Full word
MSE	Mean square of the error
No.	Number
ppm	parts per million
RCBD	randomized complete block design
Rep.	replication
Res.	research
SAU	Sher-e-Bangla Agricultural University
Sc.	science
SE	Standard Error
Univ.	University
var.	variety
Wt.	Weight