EFFECT OF NITROGEN AND SULPHUR ON THE GROWTH AND YIELD OF T. AMAN RICE (BRRI dhan87)

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CERTIFICATE

This is to certify that the thesis entitled "**EFFECT OF NITROGEN AND SULPHUR ON THE GROWTH AND YIELD OF T.AMAN RICE (BRRI dhan-87)**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN SOIL SCIENCE** embodies the result of a piece of genuine *r*esearch work carried out by **MD. BELAL HOSSAIN**, Registration No. **18-09117** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma in any other institutes.

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

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TO

MY BELOVED PARENTS AND DAUGHTER

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ABSTRACT

The experiment was conducted at the Agronomy Field Laboratory, Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207 to study the effect of nitrogen and Sulphur on the growth and yield of T. Aman rice (BRRI Dhan 87) during the period from July, 2019 to December, 2019. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications of each treatment and Plant parameters (growth, yield and yield components) and plant analysis data were subjected to statistical analysis through computer based statistical Program STAR (Statistical Tool for Agricultural Research), developed at IRRI. Means were compared by DMRT at 5% level of probability. The experiment consisted of single factor with six treatments such as T_1: Control (0 kg Nitrogen & 0 kg Sulphur per ha), T_2:$N_{60}S_0$ (60 kg Nitrogen & 0 kg Sulphur per ha), T_3:$N_{90}S_0$ (90 kg Nitrogen & 0 kg Sulphur per ha),T_4:$N_{120}S_0$ (120 kg Nitrogen & 0 kg Sulphur per ha), T_5:N_0S_{12} (0 kg Nitrogen & 12 kg Sulphur per ha), T_6: $N_{60}S_{12}$ (60 kg Nitrogen & 12 kg Sulphur per ha), T_7:$N_{90}S_{12}$ (90 kg Nitrogen & 12 kg Sulphur per ha), T_8:$N_{120}S_{12}$ (120 kg Nitrogen & 12 kg Sulphur per ha), T_9:N_0S_{16} (0 kg Nitrogen & 16 kg Sulphur per ha), T_{10}:$N_{60}S_{16}$ (60 kg Nitrogen & 16 kg Sulphur per ha), T_{11}:$N_{90}S_{16}$ (90 kg Nitrogen & 16 kg Sulphur per ha) and T_{12}:$N_{120}S_{16}$ (120 kg Nitrogen & 16 kg Sulphur per ha). The combination of $N_{120}S_{12}$ (120 kg Nitrogen & 12 kg Sulphur per ha) showed the best result in case of, plant height, leaf length, number of effective tiller per hill, number of effective tillers per hill, panicle length (cm), number of grains per panicle, number of filled grain per panicle, 1000-grain weight (g), grain yield (t ha^{-1}), straw yield (t ha^{-1}), organic matter, Nitrogen and phosphorus content in post harvest soil. So, it can be concluded that the treatment T_8 (120 kg Nitrogen & 12 kg Sulphur per ha) is the best for T. Aman rice (BRRI Dhan87) cultivation during the Aman season.

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LIST OF ACRONYMS

%	=	Percent
^{0}C	=	Degree Centigrade
AEZ	=	Agro-ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
BRRI	=	Bangladesh Rice Research Institute
BCR	=	Benefit Cost Ratio
cm	=	Centimeter
DAS	=	Days after sowing
DAT	=	Days after Transplanting
et al.	=	and others *(at elli)*
FAO	=	Food and Agricultural Organization
g	=	gram (s)
Kg	=	Kilogram
Kg/ha	=	Kilogram/hectare
LER	=	Land Equivalent Ratio
LSD	=	Least Significant Difference
m	=	Meter
MoA	=	Ministry of Agriculture
MoP	=	Muriate of potash
pH	=	Hydrogen ion conc.
RCBD	=	Randomized Complete Block Design
t ha^{-1}	=	ton per hectare
TSP	=	Triple Superphosphate

CHAPTER I

INTRODUCTION

CHAPTER 1
INTRODUCTION

Rice (*Oryza sativa* L.) is the dominant staple food for many countries of the world, especially billions of people of Asia, Africa and Latin America (Dowling et al., 1998, Banik, 1999 and Mobasser et al., 2007). Rice is the major food grain for more than a third of the world population (Zhao et al., 2011). Among the most cultivated cereals in the world, rice ranks as second to wheat (Abodolereza and Racionzer, 2009). Rice is grown in more than 10 countries with a total harvested area of nearly 160 million hectares, producing more than 700 million tones every year (IRRI, 2010). According to the FAO of the UN, 80% of the world rice production comes from 7 countries (UAE/FAO, 2012).

In Bangladesh rice is the staple food which covers about 82% of the total cropped area of Bangladesh. It accounts for 92% of the total food grain production in the country and provides more than 50% of the agricultural value addition employing about 44% of total labour forces (Alam, 2012). Rice alone provides 76% of the calorie intake and 66% of total protein requirement and shares about 95% of the total cereal food supply (Alam, 2012).

The country ranked 4th position in 2014 both in area (11.77 million ha) and production (52.231 million MT) of rice and 39th in the yield per hectare (4.42 t ha-1) among the rice growing countries (FAOSTAT, 2016). This figure indicates production boom of rice in Bangladesh in recent years and it needs to be continued because the population of Bangladesh is growing by two million every year and may increase by another 30 million over the next 20 years. Thus, Bangladesh will require about 27.26 million tons of rice for the year 2020 (BRRI, 2011). During this time total rice area will also shrink to 10.28 million hectares. Rice yield therefore, needs to be increased by 53.3% (Mahamud et al. 2012).

Nitrogen is the essential plant nutrient and key input for increasing rice production in the rice growing countries as well as in Bangladesh, which can augment the production of rice to a great extent (Hossain, 2007). Urea-N application plays a vital role in vegetative growth, development and yield of rice. Yield increase 70- 80% of field rice could be obtained by the application of nitrogen fertilizer (IFDC, 2007). Proper fertilization is an important management practice which can increase the yield of rice. In recent years, rice yield is stagnating even though normal recommended practices have been followed. The lower amount of available nitrogen in soil, low nutrient holding capacity of soil and heavy leaching of nutrients from the soil due to high rainfall of this region have been identified as the limiting factors for getting higher yield of rice.

However, low efficient use of nitrogen fertilizer is one of the main causes of low production of rice. The applied nitrogen is lost due to the leaching, surface runoff, ammonia volatilization and other process, consequently causing reduction of N fertilizer use efficiency.

Farmers usually use prilled urea in rice field because of most available source of nitrogen. But urea is washed out by tidal floodwater. Its application efficiency is only 35 to 40 percent but in case of urea super granules it is increased up to 60 percent. If all the urea could be applied in the granular form, then 1.15 MT urea could be saved then only 0.05 MT urea needs to be imported (Roy, 2010). Therefore, in order to augment and sustain the productivity of tidal floodplain region, granular form of fertilizer application deserves special attention (Miah et al., 2006). To minimize the losses of nitrogen, the slower release of nitrogenous fertilizer has been advocated with deep placement. Placement of USG in the root zone is the most effective method for increasing the nitrogen use efficiency and rice yield (Prasad et al., 1982 and Sharma, 1985).

Besides this, among the soil fertility problems, S has been identified as a major nutritional' problem for rice. Sulphur deficiency has been recognized in most of the soils of Bangladesh (Majid, 1986), which covers not less than four million hectares of cultivable lands (Hussain, 1990). The ri)ajor causes of S deficiency in Bangladesh are due to cropping round the year, use of S free fertilizers, depletion of organic matter with little or no addition of manure, leaching of S in high rainfall areas and particularly leaching loss in light textured soils with flood irrigation. Hague (1997) reported of higher S requirement under wetland rice with phosphate fertilization, which is the major rice cultivation practice in Bangladesh. Gregg and Goh (1982) found that S fertilization resulted in greater release of S from organic matter. Management of crop residues, particularly rice should be considered as a means of reducing S requirement of a cropping system. The turnover of S from crop residues has become increasingly important for maintaining supplies of S to the plant, where other inputs of S to soil-plant system such as fertilizer and atmospheric S decreases.

Therefore, the present study was conducted to meet the following objectives:

a) To observe the effect of N and S on the growth and yield of T. Aman rice.

b) To find out the appropriate dose of N and S for maximum yield of T. Aman rice.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER 2
REVIEW OF LITERATURE

2.1 Effect of nitrogen fertilizer management on T. Aman rice

Nitrogen is the most required plant nutrient which gives higher biomass accumulation through photosynthesis. This gives vigorous plant growth which also takes part in reproductive growth resulting higher yield. Thousands of study was conducted relating this issue. But effect of Nitrogen fertilizer management on local varieties did not studied thoroughly.

However, an experiment was conducted during July-December 2001 at the Agronomy field laboratory, Bangladesh Agricultural University, Mymensingh to study the effect of nitrogen level and plant spacing on the yield and yield contributing character of transplant Aman rice (var. BRRI Dhan31). Five levels of nitrogen (0, 50, 100,150, 200 Kg Nitrogen per ha and three spacing (25cm x 20 cm, 25cm x 15 cm, 25cm x 10cm) were included as treatment variables. A gradual increase in panicle length (24.50 cm), grains per panicle and grain yield (4.91 ton per ha) was observed with the increase in nitrogen levels up to 150 Kg per ha and declined thereafter. 1000 grain weight was not significantly influenced by the application of different levels of nitrogen.

Reddy *et al.* (1988) found that with the increase in nitrogen fertilizer, there was increase in plant height, number of tillers, dry matter production and grain yield. The loss of dry matter was less in crops given nitrogen fertilizer than in those not given nitrogen fertilizer. The varieties capable of producing higher grain yield in response to nitrogen fertilizer under semi-deep water did not improve their grain yield under intermediate deep water (15-50cm). With the increase in application of nitrogen fertilizer from 0-40 kg per ha the nitrogen concentration in grain increased.

2.1.1 Effect of prilled urea on growth and yield of rice

In a field experiment on clay loam soil at Haryana, Singh and Om (1993) observed that the highest rice grain yield of 5.71 t ha^{-1} was obtained from applying 120 kg N ha^{-1} in three splits at 50% at puddling + 25% at 21-day after transplanting (DAT) + 25% at 42 DAT at maximum tillering and primordial initiation and flowering respectively, produced the highest grain yield.

BINA (1996) observed that the highest number of productive tiller per hill was obtained from the highest level of nitrogen (120 kg ha^{-1}).

Wopereis *et al.* (2002) stated that rice yields increased significantly as a result of N application on two N dressing (applied at the onset of tillering and at panicle initiation) with a total of approximately 120 kg N ha^{-1} in farmer's fields.

Singh and Shivay (2003) evaluated that the effective tillers $hill^{-1}$ was significantly affected by the level of nitrogen and increasing levels of nitrogen significantly increased the number of effective tillers per hill.

Dongarwar *et al.* (2003) conducted a field experiment in Shandara, Maharashtra, India to investigate the response of the rice (KJTRH-1), Jaya and Sawarna to 4 fertilizer rates i.e. 75, 100, 125 and 150 kg N ha^{-1}. There was a significant increase in grain yield with successive increase in fertilizer rate. The highest grain yield (53.05 q ha^{-1}) was obtained with 150 kg N ha^{-1} and KJSTRH-1 produced a significant higher yield than Jaya (39.64 q ha^{-1}) and Sawarna (46.06 q ha^{-1}).

Salam *et al.* (2004) conducted an experiment to determine the level of nitrogen (0, 40, 80 and 120 kg ha^{-1}) and the highest grain yield was recorded from the application of 80 kg N ha^{-1}.

Sidhu *et al.* (2004) reported that nitrogen fertilizers substantially increased the mean grain yield of Basmati up to 40 kg N ha^{-1} in the fallow Basmati-wheat sequence while 60 kg N ha^{-1} reduced Basmati yield. Compared to the treatment No, the mean grain yield of Basmati was increased by 0.31, 0.40 t ha^{-1} at doses of 20 and 40 kg N ha^{-1}, respectively.

Mashkar and Thorat (2005) conducted a field experiment during the 1994 kharif season in Konkan, Maharashtra, India, to study the effects of different nitrogen levels (0, 40, 80 and 120 kg N ha^{-1}) on the N, P and K uptake and grain yield of scented rice cultivars (Pula Basmati 1, Kasturi, Indrayani and Sugandha). The different levels of N had significant effect in augmenting the uptake of N, P and K nutrients and grains as well as straw yield of rice. Application of 120 kg N ha^{-1} recorded significantly higher N, P and K uptake in rice compared to the rest of the N levels. Every increment of 40 kg N ha^{-1} from 0 to 120 kg N ha^{-1} increased the total N uptake by 49.55, 34.30 and 27.17% total P uptake by 40.33, 27.06 and 20.32% and total K-uptake by 32.43, 20.70 and 17.25%, respectively.

Rahman *et al.* (2009) determined the nitrogen level and found that the grain yield of rice was increased with increasing nitrogen levels and the highest yield (4.19 t ha^{-1}) was attained with 150 kg N ha^{-1} while further increase in nitrogen level decreased the grain yield. It was estimated that the grain yield with 150 kg N ha^{-1} was 35.8, 18.9, 5.0 and 6.0% higher than those obtained with 0, 50, 100 and 200 kg N ha^{-1}, respectively.

Dwivedi *et al.* (2006) conducted a field experiments to evaluate the effects of nitrogen levels on growth and yield of hybrid rice. They found 184.07 kg N ha^{-1} was the optimum rate for highest yield.

Ahammed (2008) observed that leaf area increased with increasing level of nitrogen application from 40 kg N ha^{-1} up to 120 kg N ha^{-1}.

Mizan (2010) reported that the highest plant height 983.32cm) was obtained from 160 kg N ha^{-1} followed by 120 kg N ha^{-1}.

Razib (2010) observed that the highest plant height (100.2 cm) when 120 kg N ha^{-1} was applied. Das (2011) found the highest grain yield (4.28 t ha^{-1}) in treatment U4 (240 kg PU ha^{-1}) and the lowest grain yield (3.06 t ha^{-1}) in treatment U1 (no nitrogen application).

2.1.2 Effect of USG on growth and yield of rice

Kumar and Singh (1983) carried out an experiment with rice cv. Hindhum grown by applying 29-116 kg N ha^{-1} under flooded condition and stated that 87 kg N ha^{-1} in the form of USG gave the highest yield which was 14.4% higher compared to split application of urea.

Ali (1985) carried out field trials with rice cv. BR3 growing on grey floodplain and red brown terrace soils applying N as PU, USG or SCU, immediately before or after transplanting or in 2-3 splits. He stated that deep point placement of USG was superior to 2 or 3 applications of PU on both soils and USG was superior at all N rates; 62 kg N ha^{-1} gave the highest grain production kg^{-1} N applied on both the soils. Generally grain yield were increased with increasing N application up to 124 or 155 kg N ha^{-1} regardless of management.

Manickam and Ramaswami (1985) stated that the highest grain yields, varying from 3.4 to 4.6 t ha^{-1}, were obtained with USG, followed by PPDU and PU.

Rajagopalan and Palaniasamy (1985) carried out an experiment with rice cv. TK 43 giving 50 or 75 kg N ha^{-1} as neem-cake coated urea, coal coated urea and USG in the Kharif season. They found that highest grain and straw yields and plant height (83 cm), number of panicles $hill^{-1}$ (10), panicle length (21 cm) and number of filled grains $panicle^{-1}$ (85) were obtained with 75 kg N ha^{-1} as USG.

Sen *et al.* (1985) evidenced that the average yields were increased by 20% (in 1983) and 46% (in 1982) over urea alone in three splits dressing due to placementof USG.

Singh and Singh (1986) reported that deep placement of USG resulted in thehighest plant height than PU.

Raja *et al.* (1987) conducted an experiment with rice cv. Pravath and six different forms of nitrogen and mentioned that nitrogen as USG gave the highest average yield of 5.44 t ha^{-1} compared with 4.64-4.92 t ha^{-1} for nitrogen in five other forms and the USG at 75 kg N ha^{-1} gave the highest yield of 7.21 t ha^{-1}.

Jee and Mahapatra (1989) observed that number of panicles m^{-2} were significantly higher @ 90 kg ha^{-1} as deep placed USG than split application of PU.

Krishnappa *et al.* (1986) found slow release fertilizer performed better than PU at all N levels and yield with SCU or USG at 38 kg or 75 kg ha^{-1} was similar to yield with PU at 113 kg N ha^{-1}, but yield declined with SCU or USG at 150 kg N ha^{-1}.

Chakravorti *et al.* (1989) reported that application of N as USG @ 37.5, 75.0 and 112.5 kg N ha^{-1} gave rice yield of 3.85, 5.22 and 5.48 t ha^{-1}, respectively compared with 3.10, 4.29 and 4.97 t ha^{-1} respectively, with N as PU and 1.95 t ha^{-1} without N.

Sen and Pandey (1990) carried out a field trial to study the effect of placement of USG (5, 10 or 15 cm deep) and broadcast PU on rice yields of tall long duration Mashuri and dwarf short duration Madhuri. They found all depths of USG placement resulted in significantly higher yield characters except panicle length than broadcast PU.

Kamal *et al.* (1991) conducted a field experiment with different levels of nitrogen @ 29, 58, 87 kg ha^{-1} as USG. Among the three doses of N, total tillers was highest when 87 kg ha^{-1} was applied, productive tillers also followed a similar trend.

Narayanan and Thangamuthu (1991) carried out field experiments on rice cv.TKM9 and IR20 at Coimbatore, Tamil Nadu in 1984-85, N was applied at 30, 60 or 90 kg ha^{-1} using USG placed at a depth of 10 cm in the main plot. They notedthat maximum yields of grain and straw were obtained from 90 kg N ha^{-1}, while the lowest was under the control treatment.

Reddy *et al.* (1991) carried out a field experiment in 1984 to study the effects of different N sources on rice cv. Jaya and Mangala. They found that the highest grain yield of 5863 kg ha^{-1} was found from cv. Jaya treated with 112 kg ha^{-1} of USG placed in the root zone.

Singh *et al.* (1993) revealed that grain yield and N uptake increased with increased rates of N application and was highest with deep placement of USG.

Bhardwaj and Singh (1993) observed that placement of 84 kg N as USG produced a grain yield of 6.8 t ha^{-1} which was similar to placement of 112 kg USG. The highest mean grain yields of 6.68 and 6.59 t ha^{-1} were obtained with split application of 80 kg N ha^{-1} as PU + dicyandiamide and by basal application of 80 kg N ha^{-1} as USG, respectively (Tomar and Verma, 1993).

Das and Singh (1994) reported that grain yield and N use efficiency by rice were greater for deep placed USG than for USG broadcast and incorporated or three split application of PU.

Bhuiyan *et al.* (1998) concluded that economic benefit due to USG relative to PU was very high during the boro season than the transplant Aman season and the benefit was higher in a lower rate of USG application in both seasons.

Mishra *et al.* (1999) observed that application of nitrogen increased plant height, panicle length, number of tillers $hill^{-1}$, N uptake and consequently the grain and straw yields of lowland rice and they also observed that 76 kg N ha^{-1} as USG produced the best results.

Wani *et al.* (1999) conducted a field experiment on the efficiency of some slowrelease or modified sources of urea at different N levels and found that USG @ 120 kg N ha^{-1} was the best in producing the yield and yield attributes of rice.

Akhter (1999) observed that the placement of USG @ 2 granules per 4 hills significantly influence the plant height.

Ahmed *et al.* (2000) revealed that USG was more efficient than PU at all levels of nitrogen in producing all yield components and in turn, grain and straw yields. Placement of USG @ 160 kg N ha^{-1} produced the highest grain yield (4.32 t ha^{-1}) which was statistically identical to that obtained from 120 kg N ha^{-1} as USG and significantly superior to that obtained from any other level and source of nitrogen. Alom (2002) observed that 1000 grain weight was not influenced by level of USG.

Rahman (2003) found that two USG per 4 hills produced the higher grain and straw yields (5.22 and 6.09 t ha^{-1} respectively).

Jena *et al.* (2003) reported that deep placement of USG significantly improved grain and straw yields and nitrogen use efficiency of rice and reduced volatilization loss of ammonia relative to the application of PU.

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

Bowen *et al.* (2005) conducted 531 on-farm trials during boro and Aman seasons in 7 districts of Bangladesh from 2003-2004. The results showed that UDP (Deep placement of USG) increased grain yields by 1120 kg ha^{-1} and 890 kg ha^{-1} during boro and Aman season, respectively.

Mazumder *et al.* (2005) reported that different levels of nitrogen influenced grain yield and straw yield with the application of 100% RD of N (99.82 kg N ha^{-1}) which was statistically followed by other treatments in descending order. The highest grain yield (4.86 t ha^{-1}) was obtained with 100% RD of N the lowest one (3.801 ha^{-1}) from no application of nitrogen.

Hasan (2007) conducted an experiment during the Aman season of 2006 and recorded the increased number of tillers per hill with increased nitrogen level as USG. He showed that different levels of USG did not have any significant effect on 1000- grain weight of three Aman rice cultivars.

Dhyani *et al.* (2007) conducted an experiment to see the economics, yield potential and soil health of rice (Oryza sativa)-wheat (Triticum aestivum) cropping system under long-term fertilizer experimentation. Results showed that balancing of plant nutrients improved the nitrogen use efficiency and the highest cost: benefit ratio was obtained with the application of 100% N only.

Das (2011) observed that the highest number of total tillers hill^{-1} (13.14) was produced in treatment U3 (1.8 g USG 4hill^{-1}) and the lowest number of total tillers hill^{-1}(8.57) was produced in treatment U1 (no application of nitrogenous fertilizer).

Tahura (2011) found the highest grain yield (3.38 t ha^{-1}) in U3 (1.8 g USG 4 hill^{-1}) and the lowest grain yield (1.99 t ha^{-1}) in U1 (control).

Jun *et al.* (2011) conducted an experiment in a rice field with different crop rotation systems and nitrogen application rates, surface water nitrogen content, nitrogen loss via runoff, soil fertility and rice yield were determined. Based on the experiment, chemical nitrogen fertilizer application during rice season in alfalfa rice or rye-rice rotation systems can be reduced, and not in wheat-rice rotation system in Yixing, Jiangsu Province. Alfalfa-rice and rye-rice rotation systems enhanced soil nitrogen content, promoted rice nitrogen absorption and significantly improved rice yield.

2.2 Effect of Sulphur on growth and yield of rice

Haque and Chowdhury (2004) carried out an experiment abouteffects of rice straw and sulphur on the growth and yield of rice and reported that dry matter yield of rice plants significantly increased at both maximum tillering and panicle initiation stage in treatment with rice straw and S applied together. There were significant increases in all yield contributing attributes of the crop except, 1000-grain weight in both rice straw and S treatments over control. Grain and straw yields of rice significantly increased due to application of rice straw and S together over the control treatment. Grain yield increases were 11.90, 19.76 and 25.95% in rice straw, S and rice straw and S (together) treatments respectively over the control treatment.

Ali*et al.* 2004 conducted an experiment titled by interaction effects of sulphur and phosphorus on wetland riceand observed that the dry matter yield of rice plant at maximum tillering stage, grain and straw yields were significantly increased due to combined application of S and P ($S_{40}P_{35}$). This combination increased 20% higher dry matter, 61.1% higher grain yield and 65.1% higher straw yield than the control plot (S_0P_0). Nutrient concentrations and uptake by rice plants also increased with the treatment combination of $S_{40}P_{35}$.

Jahan *et al.* 2012 found that the different rates of sulphur had significant effects on the yield and yield components of transplanted Amanrice by their experiment named effect of level of sulphur on the performance of thevarieties of transplanted aman rice (*Oiyza sativa*) All the yield and yield attributes of transplanted Amon rice were also influenced by variety. The results also showed that there were significant interaction effects of sulphur and variety. On the performance of transplanted Amanrice, The highest grain yield (5.85 t ha^{-1}) and biological yield (16.08 t ha^{-1}) were produced by the variety BRRI dhan 52 x 5 kg sulphur ha4 and the lowest grain yield (2.75 t ha^{-1}) was obtained from the variety Pajamx 20 kg sulphur ha^{-1}.

CHAPTER III

MATERIALS AND METHODS

CHAPTER 3
MATERIALS AND METHODS

The experiment was conducted at the Agronomy Field Laboratory, Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagor, Dhaka during the period from July, 2019 to December, 2019 to study the effect of nitrogen and Sulphur on the growth and yield of T. Aman rice (BRRI Dhan 87). This chapter presents a brief description about experimental site, agro-ecological region, climatic condition, treatments, experimental design and layout along with plant material and raising of seedlings, crop growing procedures, data recording and their statistical analysis are also stated precisely.

3.1 Description of the Experimental site

3.1.1 Location

The geographical location of the experimental field between 22.26^{0}N latitude and 90.22^{0}E longitude at an elevation of 1.5 m above the sea level.

3.1.2 Experimental period

The experiment was carried out during the period from July, 2019 to December, 2019.

3.1.3 Soil type

The experimental field was medium high land with clay loam soil belonging to the Madhupur Tract (AEZ 28) of Bangladesh. Before the experiment started, soil test was done. The soil samples were collected randomly up to 0-15 cm depth from various plots in the experimental field and mixed properly for analyzing physiochemical properties.

3.1.4 Climate and weather

The experimental field characterized by subtropical climate. Moderately high temperature and heavy rainfall during the *kharif* season (April-September) and low rainfall with moderately low temperature during the *rabi* season (October-March). The monthly total precipitation, daily average, maximum, and minimum temperature and humidity during the study period have been presented in Appendix III.

3.2 Experimental Treatment

Total twelve treatment of nitrogen and sulphur fertilizer management was applied. These are-

i. T_1: Control (0 kg Nitrogen & 0 kg Sulphur per ha)
ii. T_2:$N_{60}S_0$(60 kg Nitrogen & 0 kg Sulphur per ha)
iii. T_3:$N_{90}S_0$(90 kg Nitrogen & 0 kg Sulphur per ha)
iv. T_4:$N_{120}S_0$(120 kg Nitrogen & 0 kg Sulphur per ha)
v. T_5:N_0S_{12}(0 kg Nitrogen & 12 kg Sulphur per ha)
vi. T_6: $N_{60}S_{12}$(60 kg Nitrogen & 12 kg Sulphur per ha)
vii. T_7:$N_{90}S_{12}$(90 kg Nitrogen & 12 kg Sulphur per ha)
viii. T_8:$N_{120}S_{12}$(120 kg Nitrogen & 12 kg Sulphur per ha)
ix. T_9:N_0S_{16}(0 kg Nitrogen & 16 kg Sulphur per ha)
x. T_{10}:$N_{60}S_{16}$(60 kg Nitrogen & 16 kg Sulphur per ha)
xi. T_{11}:$N_{90}S_{16}$(90 kg Nitrogen & 16 kg Sulphur per ha)
xii. T_{12}:$N_{120}S_{16}$(120 kg Nitrogen & 16 kg Sulphur per ha)

Commonly used

15 kg Phosphorus, 60 kg Potassium and 1.6 kg Zinc ha^{-1}

3.3 Rice Cultivar

T. Aman cultivar 'BRRI Dhan87' was used as test crop. Seeds of this cultivar were collected from Bangladesh Rice Research Institute.

Size of the land: 30m×12m (360m^2)
Size of plot: 3m×2m (6m^2)
Treatment: 12
Replication: 3
Total no of plot: 36
Plot to plot distance: 0.5m
Replication to replication distance: 1m

Layout:

Figure-1: Layout of the experimental plot.

3.4 Fertilizer used in this experiment

3.4.1 Nitrogen

Prilled urea was used as nitrogen fertilizer. It is the most common form of urea available in Bangladesh. It contains about 46%N.

3.4.2 Sulphur

Gypsum was used as source sulphur fertilizer. It is the most common form of sulphur available in Bangladeshi. It contains about 17%S.

3.5 Experimental design and layout

The experiment was laid out in randomize complete block design (RCBD). Where, the nitrogen and Sulphur fertilizer doses were assigned in main plot treatment. The treatments were randomly assigned in each replication. There were 36 unit plots in the experiment. The size of each plot was 3 m × 2 m. Each unit plot and block was separated from each other by 50 cm and 1m, respectively.

3.6 Raising seedlings

Seedlings were raised in well prepared nursery bed at Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagor, Dhaka-1207. Before sowing in the nursery, the seeds were soaked in water for 24 hours and kept in gunny bags under dark condition for 48 hours. After sprouting, the seeds were sown in the wet nursery bed on 06 July 2019.

3.7 Land preparation and transplanting

The land was first opened on 26 July, 2019 with a tractor driven rotator then puddle, cleaned and leveled thoroughly, later on 31 July, 2019. Immediately after final land preparation, the seedlings were uprooted from the seedbed early in the morning with due care to avoid injury. The uprooted seedlings were transplanted in the main field on 01 August, 2019 at 3 seedlings per hill with 25cm× 15cm spacing.

3.8 Application of fertilizers

3.8.1 Basal dose

The whole amount of Triple Super Phosphate (TSP), Muriate of potash (MoP) were broadcast and incorporated into the soil @ 80 kg and 90 kg ha^{-1} respectively. Urea and Gypsum fertilizer were applied according to the experimental specification.

3.8.2 Spilt application of prilled urea

Prilled urea was applied according to the experimental specification. In the first recommended dose was applied during final land preparation. In the second recommended dose was applied in two splits. Half of the dose prilled urea was top dressed on the plots as first split at 20 DAT and the rest half dose was top dressed on the plots as second split at 35 DAT.

3.9 Intercultural operations

To ensure and maintain the normal growth and development of the crop, intercultural operations were done at proper time. The following intercultural operations were done.

3.10 Irrigation and drainage

Flood irrigation was given to maintain a constant level of standing water up to 3 cm in the early stages to enhance tillering and 4-5cm in the later stage to discourage late tillering. The field was finally dried out at 15 days before harvesting.

3.11 Weeding

Crops were infested with different weeds during the growth period of the crop. To keep the plots weeds free, weeds were uprooted by hand as and when they emerged in the plots. Weeding was done three times. The first weeding was done at 20 after transplanting (DAT). Second weeding was done at 35 DAT and the third weeding was done at 50 DAT.

3.12 Plant protection measures

The crop was infested by rice stem borer and green leaf hopper, which was successfully, controlled by applying Furadan 5G @ 12 kg ha^{-1} and Malathion 100 scw @ 1 liter ha^{-1}.

3.13 Sampling, Harvesting and Processing of Samples

Harvesting was done depending upon the full maturity of crop. Maturity of crop was determined when 90% of the grain became golden yellow color. Five hills from each plot excluding border hills were selected at random prior to harvesting and taken out for studying yield attributes. The crop of individual plots was harvested on 18November 2019, when 90% of the grain was matured. These plants were taken out with respective tag levels. An area of central 3 m^2 (2.5 m X 1.2 m) in each plot excluding the crop sampling zone was harvested for measurement of grain and straw yields. The harvested crop of each plot was separately bundled, properly tagged and then brought to the threshing floor. The crop was threshed by pedal thresher. Grain was sun dried and cleaned. Straw was also sun dried properly. Finally, grain was adjusted at 14% moisture and converted to ton per hectare.

3.14 Data Collection

3.14.1 Yield and yield components

- **I.** Plant height (cm)
- **II.** Leaf length (cm)
- **III.** Number of tillers per hill
- **IV.** Number of effective tillers per hill
- **V.** Number of non-effective tillers per hill
- **VI.** Panicle length (cm)
- **VII.** Number of grains per panicle
- **VIII.** Number of filled grain per panicle
- **IX.** Number of unfilled grain per panicle
- **X.** 1000-grain weight (g)

XI. Grain yield (t ha^{-1})

XII. Straw yield (t ha^{-1})

XIII. Post Harvest soil Analysis

3.14.2 Procedure of Recording Data

A brief outline of procedure for recording data is given below:

i) Plant height (cm)

Plant height was recorded at harvesting stage of crop in cm with the help of meter scale. For this observation five hills were tagged randomly in each plot for measuring the height. The height of plant measured from the ground level up to the auricle of fully open leaf till the emergence of panicle and up to the neck of panicle after emergence of panicle.

ii) Leaf length (cm)

Leaf length was recorded at harvesting stage of crop in cm with the help of meter scale. For this observation five hills were tagged randomly in each plot for measuring the leaf length. The length of leaf measured from the end of the leaf sheath up to the tip portion of the leaf.

iii) Number of effective tillers per hill

The tillers having panicle with at least one grain considered as effective tillers.

iv) Number of non-effective tillers per hill

The panicle that had no grain was recorded as non-effective tillers.

v) Total tiller per hill

By the summation of the number of effective tiller and number of non-effective tiller the total tiller per hill were recorded.

vi) Length of panicle (cm)

Length of panicle was recorded by measuring all sampled panicle from base of panicle up to the end of terminal rachillae and average was calculated to get the mean length of panicle.

vii) Number of grains per panicle

The grain received from the sampled panicle was counted separately and their average number was recorded.

viii) Number of filled grains per panicle

The total number of filled grains per panicle was separately counted from the sample, which was earlier used for recording the number of grains per panicle and average for statistical analysis.

ix) Number of unfilled grains per panicle

Spikelet that lacked any food materials inside was considered as sterile spikelet and such spikelet present on each panicle were counted.

x) 1000-grain weight

Thousand grains were taken from each plot and the weights of grains were measured after sun draying (14% moisture) with an electrical balance.

xi) Grain Yield (t ha^{-1})

Grains obtained from five square meter central area of each plot were sun dried and weighed carefully. The grains were weighed and converted to ton per hectare

xii) Straw yield (t ha^{-1})

Straws obtained from the harvested area of each unit plot were sun dried and weighed. Straw yield was then converted to ton per hectare.

3.15 Post Harvest soil Analysis

3.15.1 Collection and processing of soil samples

Plant growing topsoil samples were also collected from each plot by means of auger. All the samples were carried to the laboratory for necessary chemical analysis. The properly labeled soil samples were dried and removed all kinds of dirts, trash and plant parts. Then it was grind and sieved carefully. After that the soil samples were dried in oven and it was kept carefully for further chemical analyses.

3.15.2 Determination of pH

pH of the samples was determined with the help of a glass electrode pH meter (Microprocessor pH Meter-211, Hanna) as described by Jackson (1962).

3.15.3 Determination of Organic Carbon

The percent of organic carbon of the soil sample were determined by wet oxidation method developed by walkley and Black (Black 1965). In this method wet oxidation of organic carbon was done with potassium dichromate and concentrated sulphuric acid. Then,the sample was titrated with ferrous sulphate by using diphenylamine indicator. The organic matter content in each individual soil sample can be determined by multiplying the content of organic carbon by Van Bemmelen factor 1.73 (Page, 1982).

3.15.4 Determination of total nitrogen (N)

Total nitrogen content was determined by macro Kjeldahl method. It was done in three steps- digestion, distillation and titration. About 0.2g samples were taken in an 100 ml kjeldhal flask and then 15 ml conc. H_2SO_4 and 0.2 g catalyst mixture was added to it and the digestion was started. The colorless contents and volatile dense white fumes indicated the completion of digestion. After cooling the digestion flask was placed under the distillation set. 25 ml 4% boric acid was taken in a 500 ml Erlenmeyer flask and 5 drops of indicator was added to it. After collection of distillate, distillation was over. Then the distillate was titrated against 0.05N H_2SO_4. At the end point green color changed to pink. A blank titration was conducted simultaneously (Jackson, 1973).

3.15.5 Determination of Available Phosphorus

Phosphorus (P) was determined using ascorbic acid as a reductant for color development and reading was recorded with the help of spectrophotometer (T60UV). For the preparation of 50 ppm primary standard phosphorus solution, exactly 0.2195 g KH_2PO_4 (AR grade) was taken in 1000 ml volumetric flask and filled up to the mark with distilled water. Then 4 ml of 50 ppm solution was taken in a 100 volumetric flask and made up to the marks with distilled water. This solution contained 2 ppm P solution and was used as working standard stock solution. 35 ml of concentrated sulphuric acid (H_2SO_4) was diluted to 250 mL solution with distilled water for preparing 5N sulphuric acids. 4% ammonium molybdate solution was prepared by dissolving 20g of ammonium molybdatetetrahydrate ($(NH_4)6Mo7O_2.4H_2O$) into 500 ml volumetric flask and made up to the marks with distilled water. 1.76 g of ascorbic acid was dissolved into a 100 ml flask and volume up to the mark with distilled water. Antimonytartarate solution was prepared by dissolving 0.27 g of antimony tartarate in 100 ml distilled water. Finally for the preparation of mixed reagent, 50 ml of 5N H_2SO_4, 15 ml of 4% ammonium molybdate solution, 5 ml of antimony solution and 30 ml ascorbic acid solution were mixed after the addition of each reagent. This mixed reagent cannot be preserved for longer time.

0.1, 0.2, 0.3, 0.4 and 0.5 ppm standard P working solutions were prepared by pipe ting 5, 10, 15, 20 and 25 ml of 2 ppm standard P stock solution into 100 ml volumetric flasks as well as 8 ml mixed reagent solution was added and then made volume up to the volumetric flasks with distilled water. In the same way, color was developed in sample solution taking 8 ml mixed reagent and made up to the 100 ml volumetric flasks instead of secondary standard solution. In case of very concentrated sample, it was required to dilute several times.

The absorbance was read after 15 minutes in spectrophotometer at 660 nm wavelength (T60 UV). Finally a standard curve was prepared by plotting the absorbance of light from spectrophotometer against the P concentrations and amount of P calculated from the soil and plant sample by using this standard curve.

3.15.6 Determination of available sulphur

Sulphur (S) was determined by turbidimetric method (Tandon, 1995) with the help of spectrophotometer (T60UV). 100 ppm of sulphur standard solution was prepared by dissolving exactly 0.769 g of Epsom salt in 1000 ml volumetric flask containing about 300- 400 ml distilled water. It was shaken thoroughly. The volume was made up to the mark with distilled water. This solution contained 100 ppm S. Then a series of sulphur standard solution was prepared containing 0, 5, 10, 15, 20, 25 and 30 ppm S in seven test tube by pipe ting 0, 1, 2, 3, 4, 5 and 6 ml of 100 ppm of S solution and adding 20, 19, 18, 17, 16, 15 and 14 ml of distilled water from a burette respectively. Acid seed solution was prepared by pouring about 50 ml H_20 into 100 ml volumetric flask, then adding 6.5 ml concentrated HNO_3 (69%), 25 ml of glacial acetic acid, 20 ml of 100 ppm S stock solution and made the volume up to mark with distilled water. After reagent preparation 5 ml of each soil sample was taken in a 25 ml conical flask. Then 1 ml of acid seed solution and 0.30 g barium chloride was added to each standard series and unknown test solutions. After mixing when barium chloride dissolved completely the absorbance reading was taken at 420 nm wavelengths with spectrophotometer.

3.15 Statistical Analysis

Data were compiled and tabulated in proper form for statistical analysis. The recorded data on various plant characters were statistical analysis through computer based statistical Program STAR (Statistical Tool for Agricultural Research), developed at IRRI.

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER 4
RESULTS AND DISCUSSION

Performance of T.Aman rice variety (BRRI Dhan87) due to the effect nitrogen and Sulphur fertilizer management was studied in the present experiment. The data observed on plant height, leaf length, number of effective tillers hill^{-1}, number of non- effective tillers hill^{-1},number of total tillers hill^{-1}, panicle length (cm), number of filled grains panicle^{-1}, number of unfilled grains panicle^{-1}, total grains panicle^{-1},1000-grain weight (g), grain yields (ton ha^{-1}) and straw yields (ton ha^{-1}) have been presented in tables and graphically in this chapter. For the convenience of easy understanding the results have been presented and discussed under following sub-headings.

4.1 Effect of nitrogen and Sulphur on the growth of T. Aman rice (BRRI Dhan87)

4.1.1 Plant height

Nitrogen and Sulphur fertilizer management significantly affected plant height at harvest stages of rice plant (Figure 2 & Appendix III). At harvest stage significantly tallest plants (131.78 cm) were recorded from T_8 treatment ($N_{120}S_{12}$) and the shortest plant at harvest stage (105.94 and 102.33 cm) was recorded from T_5(N_0S_{12}) and T_1(Control) treatment, respectively. These findings corroborated with the results reported by Surekha *et al.* (1999) and Singh *et al.* (1996). They found that the higher plant height due to higher application of N.

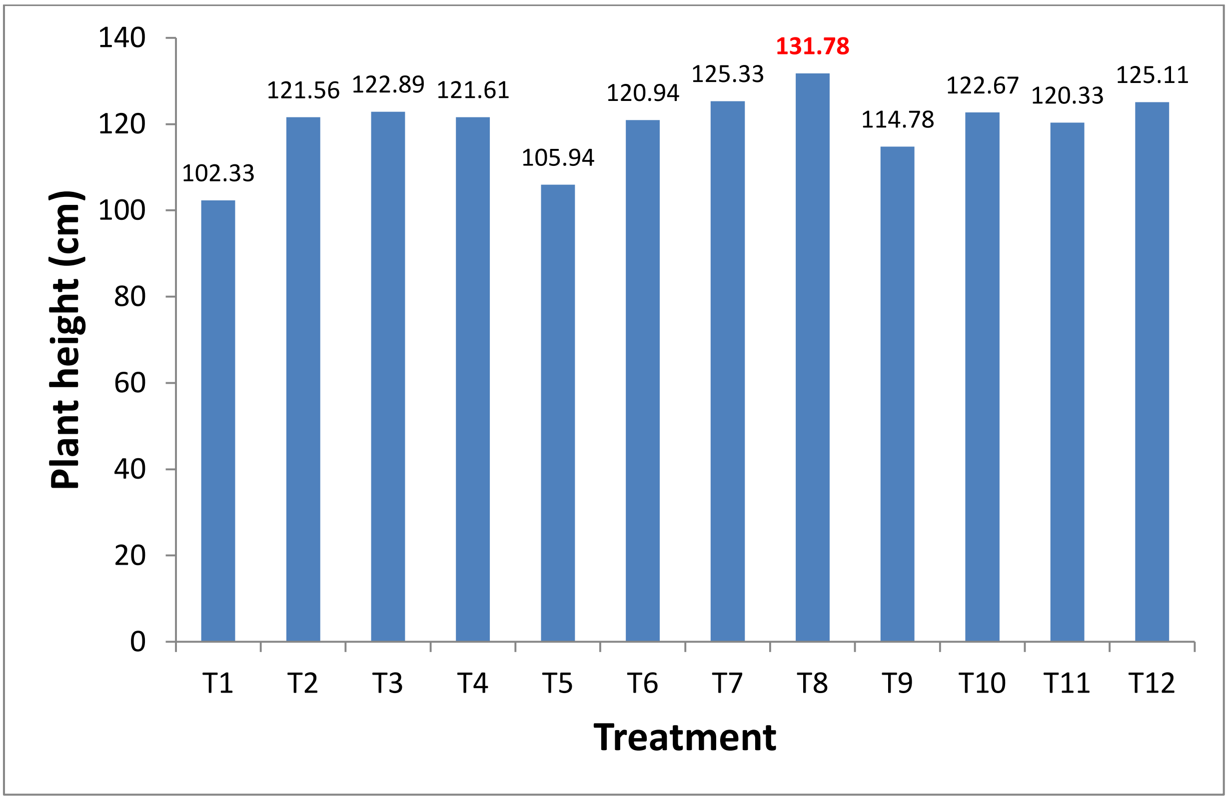

Figure 2: Effect of nitrogen and sulphur on plant height of T. Amon rice (BRRI Dhan87)

Here, vertical bar represent standard error

T_1: Control, T_2:$N_{60}S_0$, T_3:$N_{90}S_0$, T_4:$N_{120}S_0$, T_5:N_0S_{12}, T_6: $N_{60}S_{12}$, T_7:$N_{90}S_{12}$, T_8:$N_{120}S_{12}$, T_9:N_0S_{16}, T_{10}:$N_{60}S_{16}$, T_{11}:$N_{90}S_{16}$, T_{12}:$N_{120}S_{16}$

4.1.2 Leaf length

In case of leaf length of rice significant difference was observed due to the effect of nitrogen and Sulphur fertilizer management at the harvest stage of rice (Figure 3 & Appendix III). The highest leaf length at the harvest stage (34.94 cm) was recorded from treatment $T_8(N_{120}S_{12})$ followed by treatment T_{12} $(N_{120}S_{16})$, T_3 $(N_{90}S_0)$, T_{11} $(N_{90}S_{16})$, T_4 $(N_{120}S_0)$, T_{10} $(N_{60}S_{16})$ and T_{17} $(N_{90}S_{12})$ where the lowest leaf length (23.06 cm) was recorded from treatment T_1 (control).

It was observed that the higher dose of nitrogen increase the leaf length.

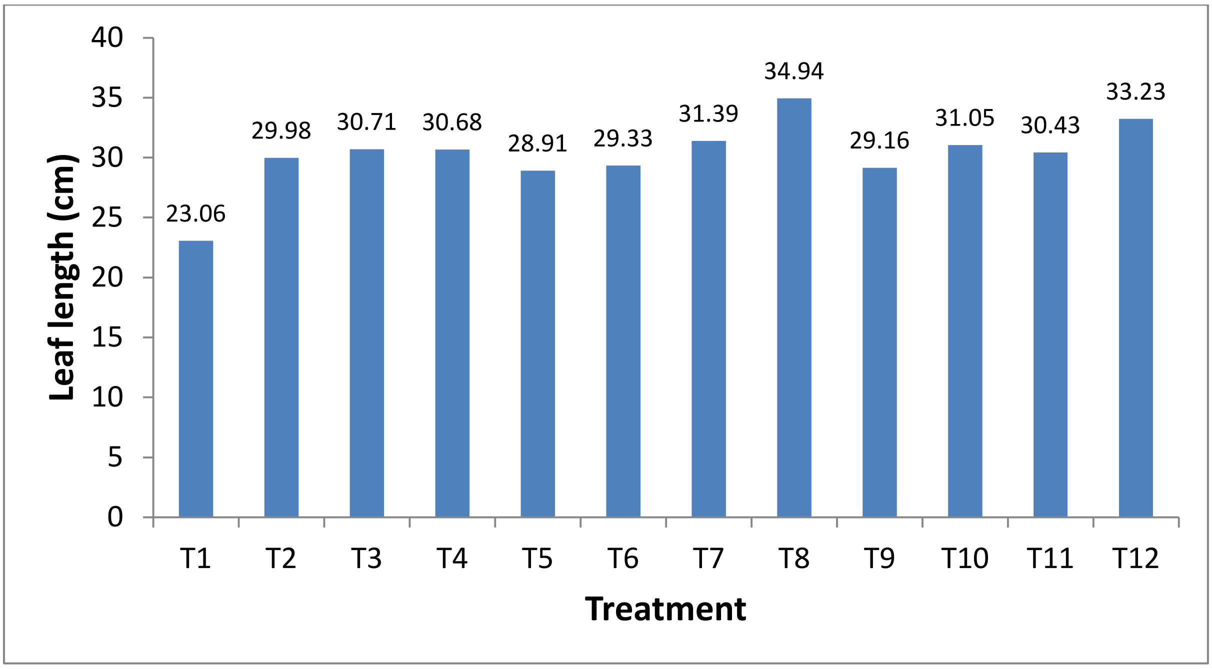

Figure 3: Effect of nitrogen and sulphur on leaf length of T. Amon rice (BRRI Dhan87)

Here, vertical bar represent standard error

T_1: Control, T_2:$N_{60}S_0$, T_3:$N_{90}S_0$, T_4:$N_{120}S_0$, T_5:N_0S_{12}, T_6: $N_{60}S_{12}$, T_7:$N_{90}S_{12}$, T_8:$N_{120}S_{12}$, T_9:N_0S_{16}, T_{10}:$N_{60}S_{16}$, T_{11}:$N_{90}S_{16}$, T_{12}:$N_{120}S_{16}$

4.1.3 Effective tillers hill^{-1}

Nitrogen and Sulphur fertilizer management significantly affect the no of effective tillers per hill (Table 1). The highest number of effective tillers per hill (15.33) was recorded from treatment $T_8(N_{120}S_{12})$ followed by treatment $T_{12}(N_{120}S_{16})$ and the lowest number of effective tillers per hill (10.00) was recorded from treatment T_1 (control) followed by $T_5(N_0S_{12})$, $T_2(N_{60}S_0)$ and $T_{11}(N_{90}S_{16})$.

Present experiment showed that higher doses of nitrogen produce maximum number of effective tillers per hill. BINA (1996) also observed that the highest number of productive tillers per hill was obtained from the highest level of nitrogen (120 kg ha^{-1}).

4.1.4 Non-effective tillers hill^{-1}

No significant difference was found in case of non-effective tiller per hill of rice due to effect of nitrogen and Sulphur fertilizer management.

4.1.5 Total tillers hill^{-1}

Significant difference was observed in case of total tillers per hill due to effect of nitrogen and sulphur fertilizer management (Table 01). The highest number of total tillers per hill (16.34) was recorded from treatment $T_8(N_{120}S_{12})$ followed by treatment $T_{12}(N_{120}S_{16})$, $T_4(N_{120}S_0)$ and $T_7(N_{90}S_{12})$ where the lowest number of total tiller per hill(10.99) was recorded from treatment T_1 (control) followed by $T_5(N_0S_{12})$.

Singh and Shivay (2003) reported that the effective tillers hill^{-1} was significantly affected by the level of nitrogen and increasing levels of nitrogen significantly increased the number of effective tillers per hill.

Table 1: **Effect of Nitrogen and Sulphur on plant height of T. Amon rice (BRRI Dhan87)**

Treatment	**Effective tillers hill^{-1} (no.)**	**Non-effective tillers hill^{-1} (no.)**	**Total tillers hill^{-1} (no.)**
T_1: Control	10.00 e	0.99	10.99 e
T_2:$N_{60}S_0$	11.11 de	1.333	12.44 cde
T_3:$N_{90}S_0$	12.00 cde	0.777	12.78 cde
T_4:$N_{120}S_0$	14.11 abc	1.110	15.22 ab
T_5:N_0S_{12}	11.33 de	0.877	12.21 de
T_6: $N_{60}S_{12}$	12.78 bcd	1.78	14.56 abc
T_7:$N_{90}S_{12}$	13.33 abcd	2.110	15.44 ab
T_8:$N_{120}S_{12}$	15.33 a	1.003	16.3 4a
T_9:N_0S_{16}	12.00 ade	1.000	13.00 cde
T_{10}:$N_{60}S_{16}$	12.55 bcd	0.847	13.40 bcd
T_{11}:$N_{90}S_{16}$	11.44 de	1.000	12.44 cde
T_{12}:$N_{120}S_{16}$	14.45 ab	0.887	15.33 ab
CV (%)	**9.93**	**7.06**	**8.66**
Level of sig.	*	**NS**	*
SE (±)	**1.02**	**0.439**	**0.967**

Means followed by same letter in a column are not significantly different at 5 % level by DMRT. SE (±) = Standard error of means, CV= Coefficient of variation, **= Significant at 1% level, *= Significant at 5% level.

T_1: Control, T_2:$N_{60}S_0$, T_3:$N_{90}S_0$, T_4:$N_{120}S_0$, T_5:N_0S_{12}, T_6: $N_{60}S_{12}$, T_7:$N_{90}S_{12}$, T_8:$N_{120}S_{12}$, T_9:N_0S_{16}, T_{10}:$N_{60}S_{16}$, T_{11}:$N_{90}S_{16}$, T_{12}:$N_{120}S_{16}$

4.1.6 Panicle length (cm)

Nitrogen and Sulphur fertilizer management significantly affect the panicle length of rice (Figure 04 & Appendix III). The highest panicle length (27.52 and 25.40 cm) was recorded from treatment $T_8(N_{120}S_{12})$ and $T_{12}(N_{120}S_{16})$, respectively followed by treatment $T_6(N_{60}S_{12})$, $T_4(N_{120}S_0)$, $T_{10}(N_{60}S_{16})$ and $T_7(N_{90}S_{12})$ where the lowest panicle length (19.44 cm) was recorded from T_1 (control) followed by treatment $T_5(N_0S_{12})$ and $T_9(N_0S_{16})$. It was observed that the highest panicle length was recorded from those treatments which contain higher doses of nitrogen.

Mishra *et al.* (1999) observed that application of nitrogen increased panicle length of lowland rice.

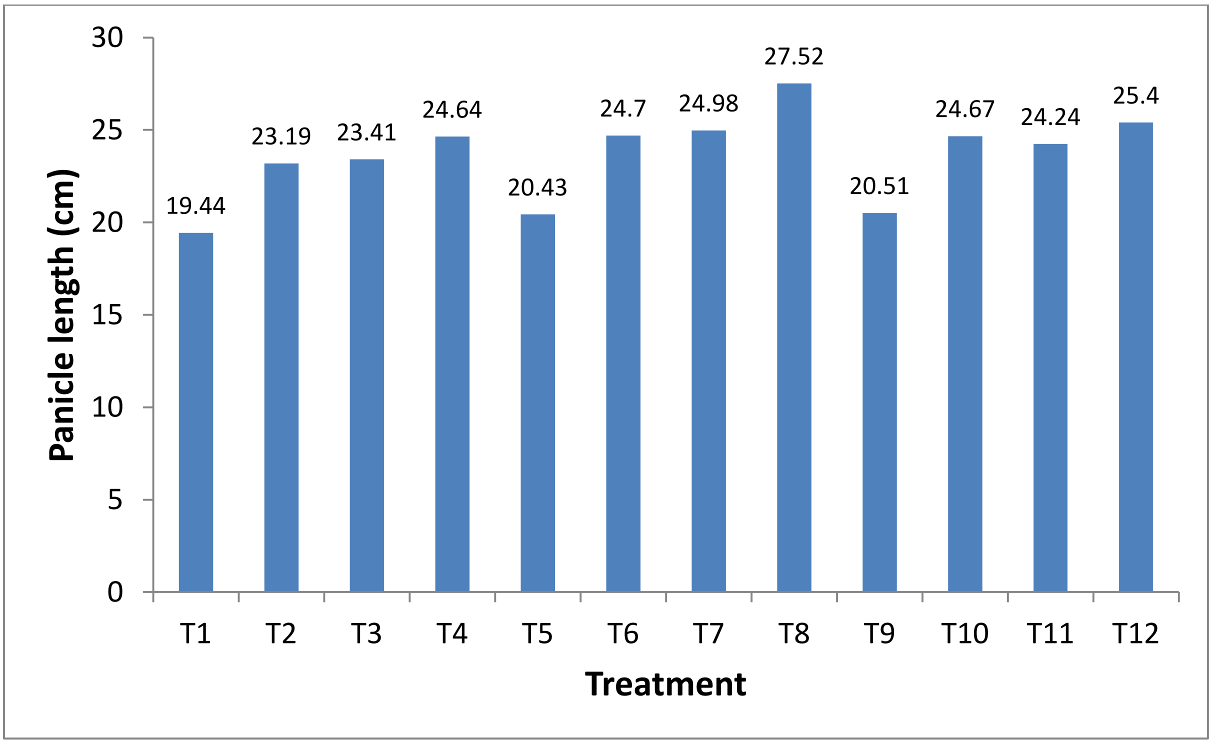

Figure 4: Effect of nitrogen and sulphur on panicle length of T. Amon rice (BRRI Dhan87)

Here, vertical bar represent standard error

T_1: Control, T_2:$N_{60}S_0$, T_3:$N_{90}S_0$, T_4:$N_{120}S_0$, T_5:N_0S_{12}, T_6: $N_{60}S_{12}$, T_7:$N_{90}S_{12}$, T_8:$N_{120}S_{12}$, T_9:N_0S_{16}, T_{10}:$N_{60}S_{16}$, T_{11}:$N_{90}S_{16}$, T_{12}:$N_{120}S_{16}$

4.2 Effect of nitrogen and sulphur on the yield of T. Aman rice (BRRI Dhan87)

4.2.1 Fill Grain panicle^{-1}

Number of filled grain per panicle of T. Aman rice (BRRI Dhan87) showed significant difference due to the effect of nitrogen and sulphur fertilizer management (Table 2). The highest number of filled grain per panicle (140.37) was recorded from treatment $T_8(N_{120}S_{12})$ and the lowest number of filled grain per panicle (68.29) was recorded from treatment T_1 (control).

4.2.2 Unfilled grain panicle^{-1}

In case of unfilled grain per panicle of T. Aman rice (BRRI Dhan87) significant difference was found due to the effect of nitrogen and sulphur fertilizer management (Table 2). The highest number of unfilled grain per panicle (24.15) was recorded from treatment T_1 (control) followed by all other treatment except treatment T_{10} $(N_{60}S_{16})$ and $T_7(N_{90}S_{12})$ where the lowest number of unfilled grain per panicle (19.26) was recorded from treatment $T_{10}(N_{60}S_{16})$ followed by treatment $T_7(N_{90}S_{12})$.

4.2.3 Total grain panicle^{-1}

Total grain per panicle of T. Aman rice (BRRI Dhan87) also showed significant difference due to the effect of nitrogen and sulphur fertilizer management (Table 2). The highest number of total grain per panicle (156.44) was counted from treatment $T_8(N_{120}S_{12})$ where the lowest number of total grain per panicle (92.44) was recorded from treatment T_1 (control).

Table 2: Effect of nitrogen and sulphur on filled grain per panicle, unfilled grain per panicle and total grain per panicle of T.Aman rice (BRRI Dhan87)

Treatment	Filled Grain panicle^{-1} (no)	Unfilled grain panicle^{-1} (no)	Total grain panicle^{-1} (no)
T_1: Control	68.29f	24.15a	92.44g
T_2:$N_{60}S_0$	106.85d	22.18ab	129.03de
T_3:$N_{90}S_0$	115.11c	23.59ab	138.70bc
T_4:$N_{120}S_0$	122.33bc	21.14ab	143.47bc
T_5:N_0S_{12}	98.41e	22.37ab	120.78f
T_6: $N_{60}S_{12}$	104.67de	21.92ab	126.59ef
T_7:$N_{90}S_{12}$	117.63bc	20.52bc	138.15bc
T_8:$N_{120}S_{12}$	140.37a	16.07ab	156.44a
T_9:N_0S_{16}	117.59bc	20.89ab	138.48bc
T_{10}:$N_{60}S_{16}$	116.74bc	19.26c	136.00cd
T_{11}:$N_{90}S_{16}$	123.44b	22.44ab	145.89b
T_{12}:$N_{120}S_{16}$	122.66bc	22.52ab	145.18b
CV (%)	3.75	10.71	3.23
Level of sig.	**	*	**
SE (±)	3.46	1.87	3.54

Means followed by same letter in a column are not significantly different at 5 % level by DMRT. SE (±) = Standard error of means, CV= Coefficient of variation, **= Significant at 1% level, *= Significant at 5% level.

4.2.4 1000 grain weight (g)

1000 grain weight of T.Aman rice (BRRI Dhan87) showed significant difference due to the effect of nitrogen and sulphur fertilizer management (Figure 5 & Appendix IV). The highest 1000 seed weight of T.Aman rice (BRRI Dhan87) (57.00g) was recorded from treatment $T_8(N_{120}S_{12})$ followed by treatment $T_4(N_{120}S_0)$ where the lowest 1000 seed weight of T.Aman rice (BRRI Dhan87) (45.50 g) was recorded from treatment T_1 (control).

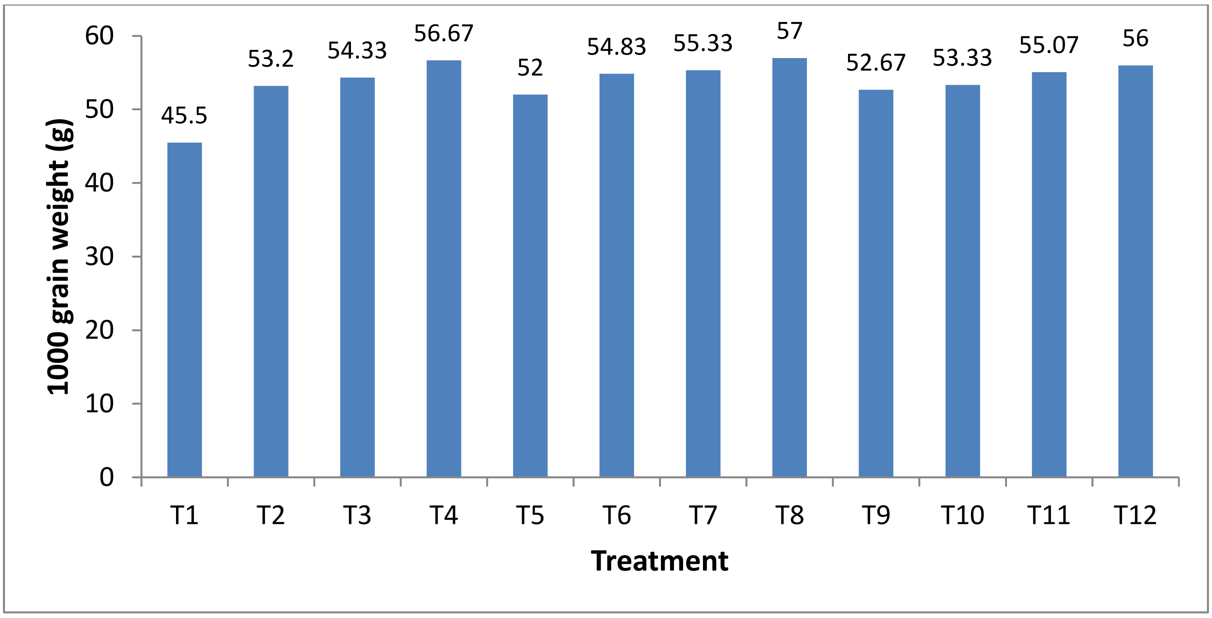

Figure 5: Effect of nitrogen and sulphur on 1000 grain weight of T. Amon rice (BRRI Dhan87)

Here, vertical bar represent standard error

T_1: Control, T_2:$N_{60}S_0$, T_3:$N_{90}S_0$, T_4:$N_{120}S_0$, T_5:N_0S_{12}, T_6: $N_{60}S_{12}$, T_7:$N_{90}S_{12}$, T_8:$N_{120}S_{12}$, T_9:N_0S_{16}, T_{10}:$N_{60}S_{16}$, T_{11}:$N_{90}S_{16}$, T_{12}:$N_{120}S_{16}$

4.2.5 Grain yield tons ha^{-1}

In case of grain yield of T.Aman rice (BRRI Dhan87) significant difference was observed due to the effect of nitrogen and sulphur fertilizer management (Figure 6 & Appendix IV). The highest grain yield (5.67 ton ha^{-1}) was recorded from T_8 ($N_{120}S_{12}$) where the lowest grain yield (2.85 ton ha^{-1}) was recorded from treatment T_1 (control). Wopereis et al. (2002) stated that rice yields increased significantly as a result of N application on two N dressing (applied at the onset of tillering and at panicle initiation) with a total of approximately 120 kg N ha^{-1} in farmer's fields.

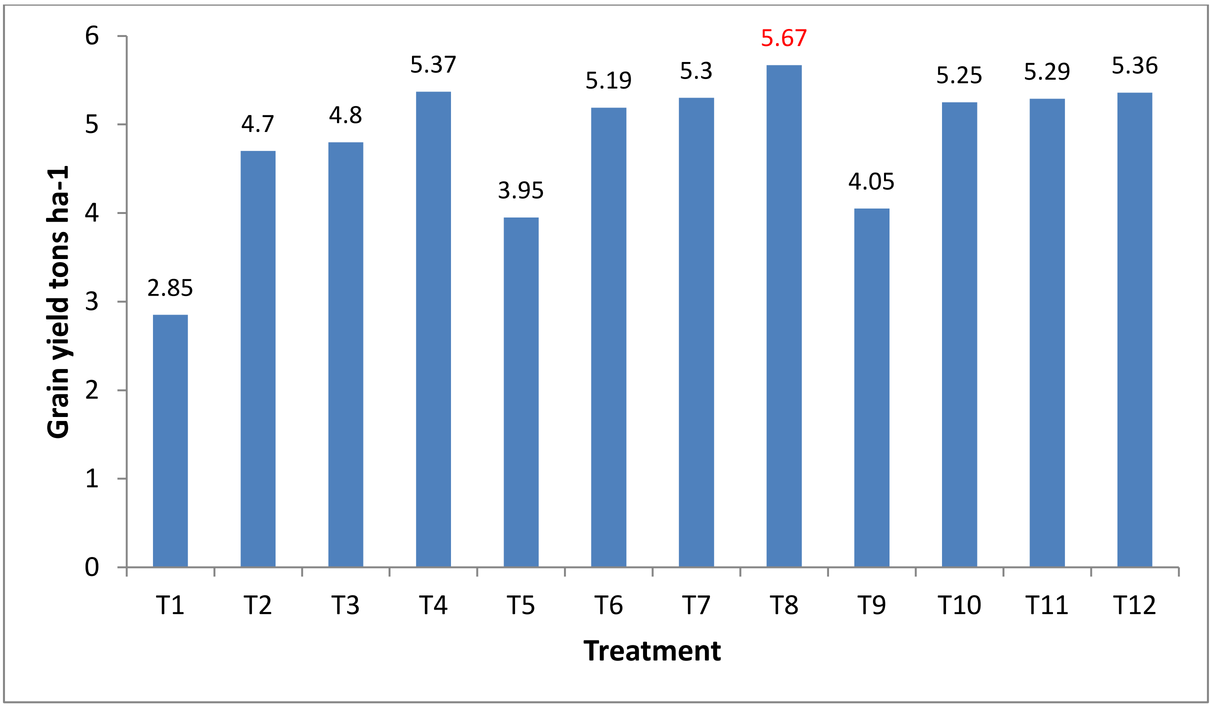

Figure 6: Effect of nitrogen and sulphur on grain yield of T. Amon rice (BRRI Dhan-87)

Here, vertical bar represent standard error

T_1: Control, T_2:$N_{60}S_0$, T_3:$N_{90}S_0$, T_4:$N_{120}S_0$, T_5:N_0S_{12}, T_6: $N_{60}S_{12}$, T_7:$N_{90}S_{12}$, T_8:$N_{120}S_{12}$, T_9:N_0S_{16}, T_{10}:$N_{60}S_{16}$, T_{11}:$N_{90}S_{16}$, T_{12}:$N_{120}S_{16}$

4.2.6 Straw yield tons ha^{-1}

Significant difference also found in case of straw yield of T. Aman rice (BRRI Dhan-87) due to the effect of nitrogen and sulphur fertilizer management (Figure 7& Appendix IV). The highest grain yield (6.88 ton ha^{-1}) was recorded from $T_8(N_{120}S_{12})$ where the lowest grain yield (3.75 ton ha^{-1}) was recorded from treatment T_1 (control). Mishra *et al.* (1999) observed that application of nitrogen increased straw yields of lowland rice.

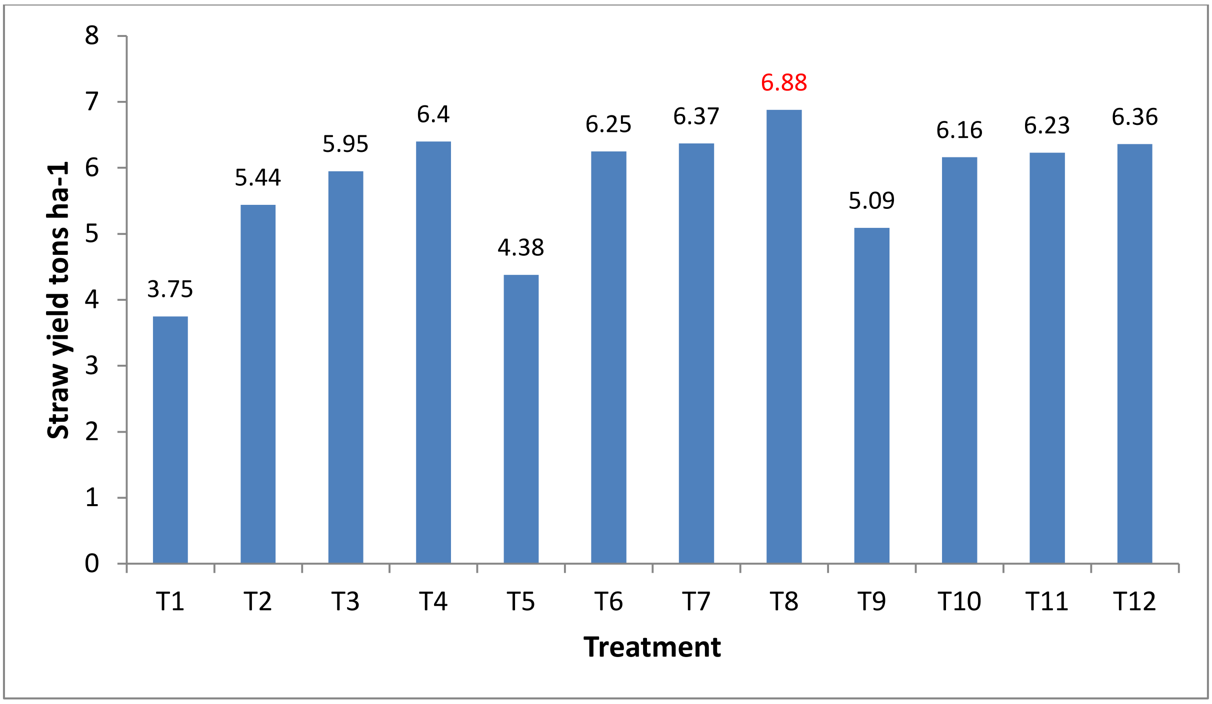

Figure 7: Effect of nitrogen and sulphur on straw yield of T. Amon rice (BRRI Dhan 87)

Here, vertical bar represent standard error

T_1: Control, T_2:$N_{60}S_0$, T_3:$N_{90}S_0$, T_4:$N_{120}S_0$, T_5:N_0S_{12}, T_6: $N_{60}S_{12}$, T_7:$N_{90}S_{12}$, T_8:$N_{120}S_{12}$, T_9:N_0S_{16}, T_{10}:$N_{60}S_{16}$, T_{11}:$N_{90}S_{16}$, T_{12}:$N_{120}S_{16}$

4.3 Effect of nitrogen and sulphur on pH, OM, N (%), P (ppm) and S (ppm) in post-harvest soil of T.Aman rice

4.3.1 Effect of nitrogen and sulphur on the pH of post-harvest soil of T. Aman rice

Non-significant difference was found in case of Effect of nitrogen and sulphur on the pH in post-harvest soil of T. Aman rice (Table 3).

4.3.2 Effect of nitrogen and sulphur on the OM in post-harvest soil of T. Aman rice

Effect of nitrogen and sulphur on the organic matter content in post-harvest soil of T. Aman rice showed significant difference (Table 3). The highest amount of organic matter content of the soil (1.42) was recorded from the plot treated with treatment T_8 ($N_{120}S_{12}$) followed by treatment T_{12} ($N_{120}S_{16}$) where the lowest organic matter content of the soil (0.91) was recorded from the plot treated with treatment T_1 (control).

4.3.3 Effect of nitrogen and sulphur on the total N (%) in post-harvest soil of T. Aman rice

Total N content in the post-harvest soil of T. Aman rice showed significant difference due to the effect of nitrogen and sulphur fertilizer management (Table 3). The highest total N content of the soil (0.066%) was recorded from the plot treated with treatment T_8 ($N_{120}S_{12}$) followed by treatment T_{12} ($N_{120}S_{16}$) where the lowest total N content of the soil (0.046%) was recorded from the plot treated with treatment T_1 (control).

4.3.4 Effect of nitrogen and sulphur on the Available P (ppm) in post-harvest soil of T. Aman rice

Available P content in the post-harvest soil of T. Aman rice showed significant difference due to the effect of nitrogen and sulphur fertilizer management (Table 3). The highest available P content of the soil (27.03 ppm) was recorded from the plot treated with treatment T_8 ($N_{120}S_{12}$) followed by treatment T_{12} ($N_{120}S_{16}$) where the lowest available P content of the soil (16.96 ppm) was recorded from the plot treated with treatment T_1 (control).

4.3.5 Effect of nitrogen and sulphur on the available S (ppm) in post-harvest soil of T. Aman rice

Non-significant difference was found in case of effect of nitrogen and sulphur on the available S in post-harvest soil of T. Aman rice (Table 3).

Table 3: Effect of nitrogen and sulphur on pH, OM, N (%), P (ppm) and S (ppm) in post-harvest soil of T. Aman rice

Treatment	pH	Organic matter	Total N (%)	Available P (ppm)	Available S (ppm)
T_1: Control	6.10	0.91d	0.046 d	16.96 d	11.73
T_2: $N_{60}S_0$	6.33	1.24abc	0.056bc	22.20abcd	13.82
T_3: $N_{90}S_0$	6.23	1.31abc	0.059abc	23.71abc	14.72
T_4: $N_{120}S_0$	6.30	1.29abc	0.061abc	23.16abc	16.25
T_5: N_0S_{12}	6.27	1.15 c	0.052 cd	21.17bcd	13.23
T_6: $N_{60}S_{12}$	6.10	1.29abc	0.058abc	18.31 cd	13.58
T_7: $N_{90}S_{12}$	6.34	1.28abc	0.059abc	23.42abc	14.07
T_8: $N_{120}S_{12}$	6.30	1.42 a	0.066 a	27.03 a	16.15
T_9: N_0S_{16}	6.53	1.17bc	0.053bcd	21.48bcd	14.17
T_{10}: $N_{60}S_{16}$	6.40	1.30abc	0.055bcd	23.88abc	14.35
T_{11}: $N_{90}S_{16}$	6.20	1.31abc	0.058abc	23.56abc	14.42
T_{12}: $N_{120}S_{16}$	6.37	1.36ab	0.062ab	26.04ab	15.36
CV (%)	**6.39**	**5.62**	**5.61**	**8.76**	**8.66**
Level of sig.	**NS**	**	**	**	**NS**
SE (±)	**0.3261**	**0.0575**	**0.0262**	**1.61**	**1.00**

Means followed by same letter in a column are not significantly different at 5 % level by DMRT. SE (±) = Standard error of means, CV= Coefficient of variation, **= Significant at 1% level, *= Significant at 5% level.

CHAPTER V

SUMMARY AND CONCLUSIONS

CHAPTER 5

SUMMARY AND CONCLUSIONS

The experiment was conducted at the Agronomy Field Laboratory, Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagor, Dhaka-1207 to study the effect of nitrogen and Sulphur on the growth and yield of T.Aman rice (BRRI Dhan87) during the period from July, 2019 to December, 2019 with the following treatment T_1: Control(0 kg Nitrogen & 0 kg Sulphur per ha), T_2:$N_{60}S_0$(60 kg Nitrogen & 0 kg Sulphur per ha), T_3:$N_{90}S_0$(90 kg Nitrogen & 0 kg Sulphur per ha), T_4:$N_{120}S_0$(120 kg Nitrogen & 0 kg Sulphur per ha), T_5:N_0S_{12}(0 kg Nitrogen & 12 kg Sulphur per ha), T_6: $N_{60}S_{12}$(60 kg Nitrogen & 12 kg Sulphur per ha), T_7:$N_{90}S_{12}$(90 kg Nitrogen & 12 kg Sulphur per ha), T_8:$N_{120}S_{12}$(120 kg Nitrogen & 12 kg Sulphur per ha), T_9:N_0S_{16}(0 kg Nitrogen & 16 kg Sulphur per ha), T_{10}:$N_{60}S_{16}$(60 kg Nitrogen & 16 kg Sulphur per ha), T_{11}:$N_{90}S_{16}$(90 kg Nitrogen & 16 kg Sulphur per ha), T_{12}:$N_{120}S_{16}$(120 kg Nitrogen & 16 kg Sulphur per ha). The experiment found that at harvest stage significantly tallest plants (131.78 cm) were recorded from treatment T_8($N_{120}S_{12}$) and the shortest plant at harvest stage (105.94 and 102.33 cm) was recorded from T_5 and T_1($N_0S_{12}$and Control) respectively. The highest leaf length at the harvest stage (34.94 cm) was recorded from treatment T_8 ($N_{120}S_{12}$) followed by treatment T_{12} ($N_{120}S_{16}$), T_3 ($N_{90}S_0$), T_{11} ($N_{90}S_{16}$), T_4 ($N_{120}S_0$), T_{10} ($N_{60}S_{16}$) and T_{77} ($N_{90}S_{12}$) where the lowest leaf length (23.06 cm) was recorded from treatment T_1 (control).The highest number of effective tiller per hill (15.33) was recorded from treatment T_8($N_{120}S_{12}$) followed by treatment T_{12}($N_{120}S_{16}$) and the lowest number of effective tiller per hill (10.00) was recorded from treatment T_1 (control) followed by T_5 (N_0S_{12}), T_2 ($N_{60}S_0$) and T_{11} ($N_{90}S_{16}$).No significant difference was found in case of non-effective tiller per hill of rice due to effect of nitrogen and Sulphur fertilizer management. The highest number of total tillers per hill (16.34) was recorded from treatment T_8($N_{120}S_{12}$) followed by treatment T_{12}($N_{120}S_{16}$), T_4($N_{120}S_0$) and T_7($N_{90}S_{12}$) where the lowest number of total tiller per hill (10.99) was recorded from treatment T_1 (control) followed by T_5(N_0S_{12}). The highest panicle length (27.52 and 25.40 cm) was recorded from treatment T_8($N_{120}S_{16}$) and T_{12}

($N_{120}S_{16}$), respectively followed by treatment $T_6(N_{60}S_{12})$, $T_4(N_{120}S_0)$, $T_{10}(N_{60}S_{16})$ and $T_7(N_{90}S_{12})$ where the lowest panicle length (19.44 cm) was recorded from T_1 (control) followed by treatment $T_5(N_0S_{12})$ and $T_9(N_0S_{16})$.

The highest number of filled grain per panicle (140.37) was recorded from treatment $T_8(N_{120}S_{12})$ and the lowest number of filled grain per panicle (68.29) was recorded from treatment T_1 (control).The highest number of unfilled grain per panicle (24.15) was recorded from treatment T_1 (control) followed by all other treatment except treatment $T_{10}(N_{60}S_{16})$ and $T_7(N_{90}S_{12})$ where the lowest number of unfilled grain per panicle (19.26) was recorded from treatment $T_{10}(N_{60}S_{16})$ followed by treatment T_7 ($N_{90}S_{12}$). The highest number of total grain per panicle (156.44) was counted from treatment T_8 ($N_{120}S_{12}$) where the lowest number of total grain per panicle (92.44) was recorded from treatment T_1 (control).The highest 1000 seed weight of T.Aman rice (BRRI Dhan87) (57.00g) was recorded from treatment $T_8(N_{120}S_{12})$ followed by treatment T_8 ($N_{120}S_0$) where the lowest 1000 seed weight of T.Aman rice (BRRI Dhan87) (45.50 g) was recorded from treatment T_1(control). The highest grain yield (5.67 ton ha^{-1}) was recorded from $T_8(N_{120}S_{12})$ where the lowest grain yield (2.85 ton ha^{-1}) was recorded from treatment T_1 (control). The highest grain yield (6.88 ton ha^{-1}) was recorded from $T_8(N_{120}S_{12})$ where the lowest grain yield (3.75 ton ha^{-1}) was recorded from treatment T_1 (control).

Post-harvest soil test of T. Aman rice (BRRI Dhan87) filed showed that non-significant difference was found in case of soil pH and available P content in the soil. The highest amount of organic matter content of the soil (1.42) was recorded from the plot treated with treatment $T_8(N_{120}S_{12})$ followed by treatment $T_{12}(N_{120}S_{16})$ where the lowest organic matter content of the soil (0.91) was recorded from the plot treated with treatment T_1 (control). The highest total N content of the soil (0.066%) was recorded from the plot treated with treatment $T_8(N_{120}S_{12})$ followed by treatment $T_{12}(N_{120}S_{16})$ where the lowest total N content of the soil (0.046%) was recorded from the plot treated with treatment T_1 (control).The highest available P content of the soil (27.03 ppm) was recorded from the plot treated with treatment $T_8(N_{120}S_{12})$ followed by treatment $T_{12}(N_{120}S_{16})$ where the lowest available P content of the soil (16.96 ppm) was recorded from the plot treated with treatment T_1 (control).

From the above result and discussion it was found that treatment T_8:$N_{120}S_{12}$ (120 kg Nitrogen & 12 kg Sulphur per ha) showed best result in case of growth, yield and available nutrient in the soil after harvest of T. Aman rice (BRRI Dhan-87) where the minimum result was found from T_1: Control (0 kg Nitrogen & 0 kg Sulphur per ha).

So, it can be concluded that the treatment T_8:$N_{120}S_{12}$ (120 kg Nitrogen & 12 kg Sulphur per ha) is the best for T. Aman rice (BRRI Dhan-87) cultivation during the aman season. Therefore, further experiment would be conducted for more efficient and successful result.

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APPENDICES

Appendix I: Morphological characteristics of experimental field

Morphology	Value
Agro-ecological zone	Madhupur tract (AEZ-28)
General soil type	Deep red brown terrace soil
Parent material	Madhupur clay
Topography	Fairly level
Drainage	Well drained
Flood level	Above flood level

Source: BARC, 2018

Appendix II: Initial soil analysis data of experimental field for Aman season, 2020

Soil properties	Value
Sand (%)	30
Silt (%)	40
Clay (%)	30
pH	5.63
Organic matter (%)	0.87
Total N (%)	0.44
Available P (ppm)	15.75
Available S (ppm)	11.5

Appendix III: Effect of nitrogen and sulphur on the growth of T. Aman rice.

Treatment	Plant height (cm)	Leaf length (cm)	Panicle length (cm)
T_1: Control	102.33 d	23.06 c	19.44 c
T_2:$N_{60}S_0$	121.56 b	29.98 b	23.19 abc
T_3:$N_{90}S_0$	122.89 b	30.71 ab	23.41 abc
T_4:$N_{120}S_0$	121.61 b	30.68 ab	24.64 ab
T_5:N_0S_{12}	105.94 d	28.91 b	20.43 bc
T_6: $N_{60}S_{12}$	120.94 b	29.33 b	24.70 ab
T_7:$N_{90}S_{12}$	125.33 b	31.39 ab	24.98 ab
T_8:$N_{120}S_{12}$	131.78 a	34.94 a	27.52 a
T_9:N_0S_{16}	114.78 c	29.16 b	20.51 bc
T_{10}:$N_{60}S_{16}$	122.67 b	31.05 ab	24.67 ab
T_{11}:$N_{90}S_{16}$	120.33 b	30.43 ab	24.24 abc
T_{12}:$N_{120}S_{16}$	125.11 b	33.23 ab	25.40 a
CV (%)	2.56	8.35	6.93
Level of significance	**	*	**
SE (±)	2.50	2.06	1.33

Means followed by same letter in a column are not significantly different at 5 % level by DMRT

SE (±) = Standard error of means

CV= Coefficient of variation

*= Significant at 5% level, **= Significant at 1% level

Appendix IV: Effect of nitrogen and sulphur on the yield of T. Aman rice

Treatment	1000 grain weight (g)	Grain yield tons ha^{-1}	Straw yield tons ha^{-1}
T_1: Control	45.50d	2.85e	3.75i
T_6:$N_{60}S_0$	53.20abc	4.70c	5.44f
T_4:$N_{90}S_0$	54.33abc	4.80c	5.95e
T_8:$N_{120}S_0$	56.67ab	5.37b	6.40b
T_5:N_0S_{12}	52.00c	3.95d	4.38h
T_2: $N_{60}S_{12}$	54.83abc	5.19b	6.25cd
T_{12}:$N_{90}S_{12}$	55.33abc	5.30b	6.37bc
T_{10}:$N_{120}S_{12}$	57.00a	5.67a	6.88a
T_9:N_0S_{16}	52.67bc	4.05d	5.09g
T_{11}:$N_{60}S_{16}$	53.33abc	5.25b	6.16d
T_7:$N_{90}S_{16}$	55.07abc	5.29b	6.23cd
T_3:$N_{120}S_{16}$	56.00abc	5.36b	6.36bc
CV (%)	4.08	3.83	3.56
Level of significance	**	**	**
SE (±)	1.79	0.111	0.0735

Means followed by same letter in a column are not significantly different at 5 % level by DMRT

SE (±) = Standard error of means

CV= Coefficient of variation

*= Significant at 5% level, **= Significant at 1% level