EFFECT OF PGR-BIOFERTI ON THE GROWTH AND YIELD OF T. AMAN

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CERTIFICATE

This is to certify that the thesis entitled **'Effect of PGR-Bioferti on the Growth and Yield of T. Aman'** submitted to the Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in SOIL SCIENCE,** embodies the results of a piece of bonafide research work carried out by **Syeda Sadia Sabrin,** Registration No. **15-06874** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
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DEDICATED

TO

MY BELOVED PARENTS

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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 to November, 2015 to study the effect of PGR-Bioferti on the growth and yield of T. Aman. BRRI dhan BR 11 (Mukta) was used as the test crop in this experiment. The experiment comprised of 9 treatments as- T_1: Control condition (No chemical fertilizer, no PGR-Bioferti), T_2: Recommended Fertilizer Doses-RFD (120, 20, 80, 16 and 2 kg ha^{-1} of N, P, K, S and Zn, respectively), T_3: RFD + 2 times spray of PGR-Bioferti, T_4: RFD + 1 time spray of PGR-Bioferti, T_5: ½ RFD + 2 times spray of PGR-Bioferti, T_6: ½ RFD + 1 time spray of PGR-Bioferti, T_7: No chemical fertilizer + 2 times spray of PGR-Bioferti, T_8: No chemical fertilizer + 1 time spray of PGR-Bioferti and T_9: RFD + soil application of PGR-Bioferti. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data on different yield attributes, yield, nutrient content in grain and straw, nutrient uptake by grain and straw and status of post harvest soil were recorded and significant variation was observed for different treatments. At the time of final harvest, the longest plant (128.23 cm) was recorded from T_3, whereas the shortest plant (104.42 cm) from T_1. The maximum number of tillers hill^{-1} (15.60) was observed from T_3 and the minimum number (11.87) from T_1. The highest grain yield (4.91 t ha^{-1}) was recorded from T_3, whereas the lowest (2.64 t ha^{-1}) from T_1 treatment. The highest N, P and K uptake by grain (33.71 kg ha^{-1}, 13.38 kg ha^{-1} and 17.89 kg ha^{-1}) was observed from T_3, whereas the lowest N, P and K uptake by grain (11.88 kg ha^{-1}, 5.64 kg ha^{-1} and 5.89 kg ha^{-1}) was recorded from T_1. The highest N, P and K by straw (27.40 kg ha^{-1}, 3.94 kg ha^{-1} and 72.17 kg ha^{-1}) was found from T_3, while the lowest N, P and K uptake by straw (14.44 kg ha^{-1}, 1.64 kg ha^{-1} and 36.68 kg ha^{-1}) from T_1. The highest organic matter (1.42%) was found from T_3 and the lowest organic matte (1.31%) was observed from T_1 treatment. Applications of RFD + 2 times spray of PGR-Bioferti was the superior among the other treatments in consideration of yield attributes and yield of BR 11 transplanted aman rice under the climatic condition of Bangladesh.

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INTRODUCTION

Rice (*Oryza sativa* L.), belongs to the family Poaceae, is one of the most important cereal crops of the world in terms of food, area and production (Niamatullah *et al*., 2010). It is the staple food for at least 62.8% of total planet inhabitants and it contributes on an average 20% of apparent calorie intake of the world and 30% of Asian populations (Hien *et al.*, 2006). It is the most important food in tropical and subtropical regions (Singh *et al*., 2012). More than three billion people in the world are taking rice as main food (IRRI, 2009). In Bangladesh about 84.67% (10.4 million hectares) of cropped area of is used for rice cultivation with annual production of 30.42 million tons (BBS, 2014). In Asia, more than 90% of all produced rice has been consumed (FAO, 2006).

The population of Bangladesh is increasing at an alarming rate and the cultivable land is decreasing due to urbanization and industrialization. The nation is adding about 2.3 million every year to its total population (Momin and Husain, 2009). Thus, the present population will swell progressively to 223 million by the year 2030 which will demand additional 48 million tons of food grains (Julfiquar *et al*., 2008). Population growth required a continuous increase in rice production in Bangladesh. So, the highest priority has been given to produce more rice (Bhuiyan, 2004). Production of rice has to be increased by at least 60% to meet up food requirement of the increasing population by the year 2020 (Masum, 2009). According to FAO (2009) in Bangladesh, the average yield of rice is about 2.92 t ha^{-1} which is very low compared to other rice growing countries of the world, like China (6.30 t ha^{-1}), Japan (6.60 t ha^{-1}) and Korea (6.30 t ha^{-1}). Rice yields are either stagnating/declining in post green revolution era mainly due to late or early planting, imbalance use of fertilizer, irrigation and weeding schedule, type of cropping system practiced, lack of suitable rice genotypes for low moisture adaptability and disease resistance (Prakash, 2010).

The possibility of horizontal expansion of rice production area has come to a standstill for that in Bangladesh, farmers and scientists are diverting their attention towards vertical expansion. Therefore, attempts should be taken to increase the rice yield per unit area. For vertical expansion it is necessary to use of modern production technologies such as use of quality high yielding and hybrid varieties, optimum time of planting, seedling hill^{-1}, adopting proper plant protection measures, seedlings raising techniques, fertilizer management and so on. Among the production factors affecting crop yield, essential nutrient is the single most important factor that plays a dominant role in yield increase if other production factors are not limiting. It is reported that chemical fertilizers today hold the key to success of production systems and being responsible for about 50% of the total crop production (BARC, 1997). Nutrient imbalance can be minimized by judicious application of different fertilizers.

In Bangladesh, there is tendency to use indiscriminate amount of nitrogenous fertilizers and very limited amount of other nutrients' containing high analysis chemical fertilizers (Rahman *et al.*, 2008). Intensive crop cultivation using high yielding varieties with imbalanced fertilization has lead to mining out the inherent plant nutrients and thereby fertility status of soils severely declined. On an average to produce one ton of rice grain of high-yielding varieties is removed about 22 kg N, 7 kg P_2O_5, 32 kg K_2O, 5 kg MgO, 4 kg CaO, 1 kg S and 40 g Zn from the soil (Chaudhary *et al.*, 2007). Emergence of widespread multi-nutrient deficiencies, depletion of native nutrient reserves, imbalanced fertilization are of utmost concern, causing serious stagnation in yields and declining productivity of various rice ecosystems (Mangala Rai, 2006). Excess use of fertilizer nutrients implies increase of cost and decrease of returns and risk of environmental pollution. On the other hand, under use of nutrients depress the scope for increasing the present level of nutrients to the economically optimum level to exploit production potential to a larger extent (Singh *et al.*, 2001). Application of inadequate and unbalanced fertilization to crops not only results in low crop yields but also deteriorate the soil health (Sharma *et al.* 2003).

Plant growth regulators are organic compounds, other than nutrients, that modify plant physiological processes and are active at very low concentrations in plants (Gianfagna, 1987). These compounds have now been applied to a large variety of plant organs in several ways and it has been found to greatly enhance stem elongation as its most striking effect. They act inside plant cells and play important roles in plant growth, yield and quality formation of crops (Ekamber and Kumar, 2007). Furthermore, PGRs regulate the amount, type and direction of plant growth with remarkable accomplishments of improved plant development and enhanced yield in several crops been documented (Shah *et al*., 2006; Emongor, 2007). PGR regulators cell elongation, tissue swelling, cell division and formation of adventitious roots, among others (Woodward and Bartel, 2005; Abel and Theologis, 2010). Similarly, PGR also participates in the regulation of many growth and development processes in various plants, including rice (Richards *et al*., 2001; Sakamoto *et al*. 2004; Sun, 2004). Various combinations of PGR have been reported to improve the heat tolerance and stand establishment of rice (Mohammed and Tarpley, 2011; Fahad *et al*., 2015). Reports so far been made to indicate a promising results on yield of rice due to the use of PGR.

Under the above mentioned circumstance the present research work has been taken with the following objectives:

1. To find out the effect of foliar application of PGR-Bioferti on the growth, yield attributes and yield of BR 11 transplanted aman rice.

2. To study the nutrient status of post harvest soil for the foliar application of PGR-Bioferti.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Recommended dose of chemical fertilizer is the essential factor for sustainable soil fertility and crop productivity. Sole and combined use of inorganic recommended fertilizers and plant growth regulators (PGR) increase plant growth, yield attributes and yield of rice. Experimental evidences that the use of recommended dose of fertilizers (nitrogen, phosphorus, potassium, sulphur and zinc) and PGR have an intimate effect on the yield and yield attributes of rice. But research works related to recommended fertilizer doses of fertilizers and PGR on rice are limited in Bangladesh context. However, some of the important and informative research findings on these aspects so far been done at home and abroad have been reviewed in this chapter under the following headings-

2.1 Effect of recommended doses of chemical fertilizers on rice

2.1.1 Effect of nitrogen on yield attributes and yield of rice

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

Adhikary and Rhaman (1996) reported that rice grain yield ha^{-1} in various treatments of N showed significant effect. The highest yield was obtained from 100 kg N ha^{-1} (4.52 t ha^{-1}) followed by 120 kg N ha^{-1} (4.46 t ha^{-1}) and 80 kg N ha^{-1} (4.40 t ha^{-1}).

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

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

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

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

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

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

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

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

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

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

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

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

Naznin *et al*. (2013) investigate the effects of prilled urea (PU), urea super granule (USG) and NPK briquette on NH4- N concentration in field water, yield and nitrogen (N) use efficiency (NUE) of BR22 rice under reduced water conditions and reported that the highest grain yield of 3.93 t ha^{-1} from 104 kg N ha^{-1} as USG and the lowest value of 2.12 t ha^{-1} was obtained from control. The N use efficiency was increased when the N was applied as USG. The overall results revealed that application of USG and NPK briquette may be practiced for obtaining better yields in addition to increasing the efficiency of N fertilizer.

Murthy *et al*. (2015) conducted an experiment with an objective to revise the existing fertilizer doses of major nutrients in Krishna Godavari delta regions of Andhra Pradesh. Grain yield was increased by 11.5% and 6.3% due to increase in recommended dose of N from 100% (120 kg ha^{-1}) to 125% and 150%.

Lukman *et al*. (2016) reported that the combined application of cow dung and NPK fertilizer significantly increased most of the results obtained with regards to locations compared to the control plots. The growth and yield parameters of rice considered were significantly affected by the treatments except one thousand grain weight. Application of 8 t ha^{-1} of cowdung in combination with 400 kg ha^{-1} NPK 20:10:10 gave the highest grain yield (5.77 t ha^{-1}) at Sokoto and it is recommended that application of 12 t ha^{-1} of cowdung in combination with 300 kg ha^{-1} NPK 20:10:10 resulted in the best soil nutrient enrichment and yield of rice in Sokoto and Talata Mafara.

2.1.2 Effect of phosphorus on yield attributes and yield of rice

Ghosal *et al*. (1998) conducted a field experiment in Bihar on rice cv. Pankaj with 10–40 kg P/ha as triple super phosphate (TSP), highly reactive Morocco Rock Phosphate (HRMRP), Florida Rock Phosphate (FRP) and stated that yield increased with increasing P rates of four sources. They further proposed that grain yield was the highest with TSP followed by PAPR, HRMRP and FRP.

Sarkunan *et al*. (1998) conducted a pot experiment to find out the effect of P and S on yield of rice under flooded condition, on a P and S deficient sandy loam soil. They found increased yield with increasing level of P from 16.9 to 42.5 g/pot. Sulphur addition at 25 mg/kg resulted in 9% increase in grain yield. The treatment combination of 100 mg P and 10 mg S/kg soil gave significantly higher grain yield than other treatments.

Sahrawat *et al*. (2001) conducted a field experiment for six years (1993-1998) to determine the response of four promising upland rice cultivars with 0, 45, 90, 135, and 180 kg/ha as triple super phosphate (TSP). Only once used in 1993 and its residual value in 1994, 1995, 1996 and 1998 stated that grain yields of the rice cultivars were significantly increased by fertilizer P in 1993 and by the fertilizer P residues in the subsequent years although the magnitude of response decreased rapidly with time since the fertilizer was not applied.

Nair and Rajasree (2004) conducted a field experiment to assess comparative efficiency of super phosphate and PR (34/74) at different levels in the yield characters and composition of rice. The treatments were 30 and 45 kg P_2O_5 ha^{-1} in the form of superphosphate and PR (34/74) with and without organic matter. The results showed that high grade phosphate rock (M, 34/74) with organic manure performed well and were followed by PR (34/74) with iron pyrites and green manure. Thus, PR (34/74) performed well with organic matter, FeS_2 and green manure in deciding growth and yield of rice. Higher contents of N, P, K, Ca and Mg of grain and straw were obtained at higher levels of 45 kg P_2O_5 ha^{-1} treatment.

Li *et al.* (2007) conducted an experiment to evaluate the contributions of rice root morphology and phosphorus uptake kinetics to P uptake by rice from iron phosphates. The Fe-P treatment significantly decreased plant dry weight, P uptake per plant, and P concentration in plant dry matter of all cultivars in comparison with the control plants.

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

Islam *et al*. (2010) conducted a field experiment with five phosphorus rates (0, 5, 10, 20 and 30 kg P ha^{-1}) with four rice genotypes in Boro and T. Aman season. Phosphorus rates did not influence grain yield irrespective of varieties in T. aman season while in Boro season P response was observed among the P rates. Application of P @ 10 kg ha^{-1} significantly increased the grain yield. But when P was applied @ 20 and 30 kg P ha^{-1}, the grain yield difference was not significant. The optimum and economic rate of P for T. Aman was 20 kg P ha^{-1} but in Boro rice the optimum and economic doses of P were 22 and 30 kg ha^{-1}, respectively. Hybrid entries (EH_1 and EH_2) used P more efficiently than inbred varieties. A negative P balance was observed up to 10 kg P ha^{-1}.

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

2.1.3 Effect of potassium on yield attributes and yield of rice

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

Sarkar and Singh (2002) conducted a field experiment to determine the effect of potassium and sulphur. They applied 110 kg N: 90 kg P: 70 kg K: 20 Kg S ha^{-1}. They observed that the number of tillers m^{-2}, 1000-grain weight, paddy and straw yield significantly increased with the application K with other fertilizer.

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

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

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

Krishnappa *et al.* (2006) reported that increasing K rates increased paddy yields. Potassium applied in split dressings were more effective than when applied at transplanting time. Application of potassium fertilizer with organic manure increased soil K availability, K content and the number of grains $panicle^{-1}$.

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

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

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

Wang (2011) conducted a field experiment to study the effects of N, P and K fertilizer application on grain yield, grain quality as well as nutrient uptake with four levels of nitrogen (N), phosphorus (P) and potassium (K) fertilizers. The results revealed that the application of N, P and K fertilizer significantly increased grain yield, and the highest yield was found under the combined application of N, P and K fertilizer.

2.1.4 Effect of sulphur on yield attributes and yield of rice

Peng *et al*. (2002) carried out a field experiment where the average content of available S in these soil samples was 21.7 mg kg^{-1}. The soil with available S content was lower than the critical value of 16 mg kg^{-1} accounted for 57.8%. Field experiments showed that there was a different yield-increasing efficiency by applying S at the doses of 20-60 kg ha^{-1} to rice plant.

Singh and Singh (2002) carried out a field experiment to see the effect of different nitrogen levels and S levels (0, 20 and 40 kg ha^{-1}) on rice cv. Swarna and PR-108 in Varanasi, Uttar Pradesh. India. They reported that plant height, tillers m^{-2} row length, dry matter production, panicle length and grains panicle $^{-1}$ were significant with increasing levels of S up to 40 kg S ha^{-1}. They also found that total N uptake, grain, straw and grain protein yields significantly improved with the increasing level S application being the maximum at 40 kg S ha^{-1} respectively.

Chandel *et al*. (2003) conducted a field experiment to investigate the effect of sulphur nutrition on the growth and S content of rice and mustard grown in sequence with 4 S levels (0, 15, 30 and 45 kg ha^{-1}). They stated that increasing S levels in rice significantly improved yield attributes i.e. tiller number, leaf number, dry matter production and harvest index of rice up to 45 kg ha^{-1}.

Biswas *et al*. (2004) reported the effect of S in different region of India. The optimum S varied between 30-45 kg ha^{-1}. Rice yields increased from 5 to 51%. Across the crops and regions the agronomic efficiency varied from 2 to 27%.

Islam *et al*. (2006) to evaluated the effect of gypsum (100 kg ha^{-1}) applied before planting, and at 30 and 60 days after planting, on the nutrient content of transplanted Aus rice (BR-2) in the presence of basal doses of N,P,K, fertilizers. Application of gypsum at different dates increased N, P, K, S, Ca and Mg contents progressively, whereas the Na content was found to decrease. The highest increase of N, P, K, S, Ca and Mg was obtained when the gypsum was applied at 30 days after planting. Synthesis of protein was accelerated with all the treatments of gypsum, and the content was much higher due to application of gypsum at 30 days after planting.

Basumatary and Talukdar (2007) carried out a field experiment at the Jorhat University, Assam, India to observe the direct effect of sulphur alone and in combination with graded doses of farmyard manure on rapeseed and also its residual effects on rice for yield, uptake and protein content. The N:S ratio in both crops progressively decreased with increasing sulphur levels up to 45 kg ha^{-1}. The lowest N:S ratio was observed upon treatment with 45 kg S ha^{-1} alone with 3.0 t/ha farmyard manure.

Bhuvaneswari *et al*. (2007) conducted a field experiment during kharif season, to observe the effect of sulphur (S) at different levels, i.e. 0, 20, 40 and 60 kg ha^{-1}, with different organics, each applied at 12.5 t ha^{-1}, on yield, S use efficiency. The results showed that rice responded significantly to the application of S and organics compared to the control. The highest grain (5065 kg ha^{-1}) and straw yield (7524 kg ha^{-1}) was found with 40 kg S ha^{-1}.

Alamdari *et al*. (2007) conducted a field experiment to observe the effect of sulphur (S) and sulfate fertilizers on zinc (Zn) and copper (Cu) by rice and reported that both Zn and Cu contents in the grain increased when N, P, K, S and Zn, Cu and Mn sulfate were applied together.

Mrinal and Sharma (2008) carried a field trials during the kharif season to study the relative efficiency of different sources (gypsum, elemental sulphur and cosavet) and differnt levels of sulphur (0, 10, 20, 30 and 40 kg S ha^{-1}) in rice. The growth and yield of rice increased with the sulphur application. The grain and straw yield of rice increased significantly with increasing levels of sulphur up to 30 kg S ha^{-1}. The difference between sulphur sources was generally insignificant.

An experiment was conducted by Rahman *et al.* (2009) to know the effect of different levels of sulphur on growth and yield of BRRI dhan41 at Soil Science laboratory field of Bangladesh Agricultural University, Mymensingh during T. Aman season. There were eight treatments and they were T_0 (without S), T_1 (50% RFD of S), T_2 (75% RFD of S), T_3 (100% RFD of S), T_4 (125% RFD of S), T_5 (150% RFD of S), T_6 (175% RFD of S) and T_7 (200% RFD of S). All yield contributing characters like effective tillers hill^{-1}, filled grain panicle^{-1}, grain yield, straw yield, biological yield and 1000-grain weight except plant height and panicle length of BRRI dhan41 significantly increased due to different levels of S application.

A field experiment was carried out by Jawahar and Vaiyapuri (2011) at Experimental Farm, Annamalai University, Annamalai Nagar, Tamil Nadu, India to study the effect of sulphur and silicon fertilization on yield and nutrient uptake. The treatments comprised four levels of sulphur as 0, 15, 30 and 45 kg ha^{-1} and they observed highest yield and nutrient uptake of rice due to application 45 kg S ha^{-1}.

Dixit *et al.* (2012) carried out a field experiment to study the effect of sulphur and zinc on yield, quality and nutrient uptake by hybrid rice grown in sodic soil and found that application of 40 kg S ha^{-1} recorded significantly high grain and straw yield, protein content and sulphur uptake.

The productivity of wheat–rice cropping system is declining over time despite adequate supply of major nutrients is reported by Singh and Singh (2014). It may be due to deficiency of nutrients like sulphur. A field experiment was conducted with treatments consisting of three levels of sulphate-sulphur (0, 15, 30 and 45 kg ha^{-1}) to study the sulphur balance and productivity in wheat-rice cropping sequence in a sandy clay loam soil. The agronomic efficiency and apparent sulphur recovery decreased with increase in levels of sulphate but the percent response increased with increasing sulphate application. Application of sulphur showed the positive sulphur balance, while it was negative for control.

2.1.5 Effect of zinc on rice yield attributes and yield

A field experiment was conducted by Ullah *et al*. (2001) in Mymensingh, Bangladesh, to study the effect of zinc sulfate (0, 10, and 20 kg ha^{-1}) on rice cv. BR30. Zinc sulfate, along with 60 kg P_2O_5 and 40 kg K_2O ha^{-1}, was incorporated during land preparation. 80 kg N ha^{-1} was applied by 3 equal installments during land preparation, and at 25 and 60 days after transplanting. Plant height; tiller number; 1000-grain weight; grain and straw yields; and grain, straw, and soil Zn contents increased with zinc sulfate application. The tallest plants (75.667 cm) and the highest number of tillers (10.60 $hill^{-1}$), 1000-grain weight (28.700 g), and the concentration of Zn in straw (101.93 ppm) and grain (73.33 ppm) were obtained with 20 kg zinc sulfate ha^{-1}.

A study was carried out by Cheema *et al*. (2006) to evaluate the effect of four zinc levels on the growth and yield of coarse rice cv. IR-6 at Faisalabad, Pakistan. Four zinc levels viz., 2.5, 5.0, 7.5 and 10.kg $ZnSO_4$ ha^{-1} increased yield and yield component as compared with control. Plant height, number of tillers $hill^{-1}$, panicle bearing tillers, number of primary and secondary spikelets, panicle size, 1000 grain weight, paddy and straw yield and harvest index showed positive correlation with the increase in $ZnSO_4$ levels from 2.5 to 10 kg ha^{-1}.

Naik and Das (2007) reported that rice is mostly transplanted under puddled low land soil conditions in India, where zinc (Zn) deficiency is a common problem. The objective of this study was to find out the efficacy of split application of Zn on growth and yield of rice in an inceptisol. The split application of Zn as $dZnSO_4.7H_2O$ performed better than its single basal application, while the split application of Zn-EDTA did not show any significant difference on yield and yield components of rice over its single basal application. Zn-EDTA was found to be better for growth and yield of rice among the two sources of Zn. The soil application of Zn at 1.0 kg ha^{-1} as Zn-EDTA (T_7) recorded highest grain yield of 5.42 t ha^{-1}, filled grain percentage of 90.2%, 1000-grain weight of 25.41 g and number of panicles m^{-2} of 452. The Zn content of grain and straw were also found to be maximum in the treatment T_7 i.e. 38.19 and 18.27 mg Zn kg^{-1}, respectively. Linear regression studies indicated that grain yield of rice is significantly influenced by Zn content of grain, Zn content of straw and DTPA extractable Zn content of soil at the level of 95.96, 96.74 and 95.57%, respectively.

The study was conducted by Mustafa *et al.* (2011) at agronomic research area, University of Agriculture, Faisalabad, to evaluate the effect of different methods and timing of zinc application on growth and yield of rice. Experiment was comprised of eight treatments viz., control, rice nursery root dipping in 0.5% Zn solution, $ZnSO_4$ application at the rate of 25 kg ha^{-1} as basal dose, foliar application of 0.5% Zn solution at 15, 30, 45, 60 and 75 days after transplanting. Maximum productive tillers per m^2 (249.80) were noted with basal application at the rate 25 kg ha^{-1} of $ZnSO_4$ (21% Zn) and minimum (220.28) were recorded with foliar application at 60 DAT @ 0.5% Zn solution. Zinc application methods and timing had significantly pronounced effect on paddy yield. Maximum paddy yield (5.21 t ha^{-1}) was achieved in treatment Zn_2 (Basal application at the rate of 25 kg ha^{-1} of $ZnSO_4.7H_2O$) and minimum paddy yield (4.17 t ha^{-1}) was noted in Zn_7 (foliar application at 75 DAT @ 0.5% Zn solution).

Muthukumararaja and Sriramachandrasekhara (2012) reported that zinc deficiency in flooded soil is impediment to obtain higher rice yield. Zinc deficiency is corrected by application of suitable zinc fertilizer. The results revealed that rice responded significantly to graded dose of zinc. The highest grain (37.53 g pot^{-1}) and straw yield (48.54 g pot^{-1}) was noticed at 5 mg Zn kg^{-1}, which was about 100% and 86% greater than control (no zinc) respectively. The highest zinc concentration and uptake in grain and straw and DTPA-Zn at all stages was noticed at 7.5 mg Zn kg^{-1}. The linear regression analysis showed grain zinc concentration and grain Zn uptake caused 89.64 and 89.01% variation in rice yield. Similarly, the linear regression analysis of DTPA-Zn caused 98.31, 96.34 and 93.12% variation in yield of rice at tillering, panicle initiation and harvesting stages, respectively. The agronomic, physiological and agrophysiological apparent recovery and utilization efficiencies was highest at lower level of zinc application and decreased with Zn doses.

An experiment was carried out by Singh *et al.* (2012) at Sari, Mazandaran, Iran. This experiment was done as split plot in randomized complete blocks design based three replications. Zinc fertilizer application was chosen as main plots (0, 2 and 4 kg ha^{-1}) and genotypes as sub plots. The maximum panicle number m^{-2} and harvest index were observed with 4 kg Zn ha^{-1} and the least of those was obtained in control treatment. The highest zinc content in grain, zinc uptake in grain and straw, and nitrogen uptake in grain were observed with 4 kg Zn ha^{-1}, as the most zinc content in straw, nitrogen, potassium, phosphorus and sulphur content in grain and straw, and nitrogen uptake in straw were observed highest with application of 4 and 2 kg Zn ha^{-1}.

A field experiment was conducted by Dixit *et al*. (2012) to study the effect of sulphur and zinc on yield, quality and nutrient uptake by hybrid rice grown in sodic soil and that positive response of hybrid rice to zinc application was noticed significantly up to the zinc dose @ 10 kg ha^{-1}.

Kabeya and Shankar (2013) reported that rice (*Oryza sativa*) is the worlds' most important cereal and potentially an important source of zinc (Zn) for people who eat mainly rice. Zinc deficiency being a major constraint to reduce the potential yield of rice. To improve Zn delivery by rice, plant Zn uptake and internal allocation need to be better investigated. Field experiments were carried out to find out the effect of three different levels of zinc on rice zinc contrasting lines, high zinc groups and low zinc groups. The experiments revealed that increased Zn supply induced increased plant Zn uptake rate throughout the crop development in both high zinc groups and low zinc groups. The highest effect was observed when treated with 30 kg $ZnSO_4$ ha^{-1} irrespective of zinc groups. However, high zinc groups showed better uptake ability in zinc content and overall performance in growth characteristics.

2.2 Effect of plant growth regulators on rice

A pot experiment was conducted by Gurmani *et al*. (2006) in glass-house to assess the role of Abscisic acid (ABA), Benzyleadenine (BA) and Cycocel (CCC) on growth, yield, ion accumulation and proline production in three rice cultivars viz, Super Basmati, Shaheen Basmati (fine cultivar) and IR-6 (coarse cultivar) differing in yield. Seeds of each cultivar were soaked prior to sowing with ABA and BA each at 10-5 M and CCC 10-6 M for 24h. Shoot and root dry weight decreased at salinity stress as compared to control, however ABA, BA and CCC treatment caused a substantial increase in shoots and root dry weight over that of salt alone. Salt treatment increased the level of Na^+ and Cl^- but decreased K^+ content in flag leaves as well as in roots of three rice cultivars. ABA and CCC treated plants showed significant decrease in Na^+ content but increased K^+ content in flag leaves of all the cultivars at salt stress. ABA was more effective to increase Ca^{2+} content in flag leaf as well as in roots of all the cultivars as compared with BA and CCC. The levels of ions (Na^+, K^+, Ca^{2+} and Cl^-) were relatively higher in roots than in flag leaves, however higher accumulation of K^+ and Ca^{2+} content with lower accumulation of Na^+ and Cl^- in IR-6. The ranking of growth regulators for their effects on grain yield and 1000-grain weights were ABA>BA>CCC. Higher grain yield and 1000-grain weight was recorded by IR-6. The findings revealed that traits are augmented by ABA more effectively than BA.

Bakhsh *et al*. (2011) conducted an experiment to find out the growth behaviour of transplanted coarse rice (IR-6) as influenced by plant growth regulator (NAA) under the agro climatic conditions of Dera Ismail Khan, Pakistan and contained four levels of 0, 60, 90 and 120 ml ha^{-1} of plant growth regulator (Naphthalene Acetic Acid). The findings revealed that the effect of plant growth regulator levels, growth stages of paddy rice and interactions between them were found highly significant in term of enhancement in paddy yield and yield components. The application of plant growth regulator @ 90 ml ha^{-1} at the stage of panicle initiation proved most beneficial in terms of attaining 130.4 cm and 130 cm as maximum plant height, 324.5 m^2 and 328 m^2 as highest number of panicles, 164.3 and 168.5 as maximum number of spikelets panical^{-1}, 78.5% and 80.5% as maximum normal kernels, 20.76 g and 21.02 g as higher 1000-grain weight.

Pan *et al*. (2013) reported that plant growth regulators play important roles in plant growth and development, but little is known about roles of plant growth regulators in yield, grain qualities and antioxidant enzyme activities in super hybrid rice. In this study, gibberellic acid (GA_3) included (1) plots sprayed with distilled water (CK), (2) plots sprayed with 20 mg L^{-1} GA_3 prepared using 95% ethanol as surfactant (GA_3), (3) plots sprayed with 50 mg L-1 PBZ(PBZ), (4) plots sprayed with 30 mg L^{-1} 6-BA(6-BA). Result revealed that spraying PBZ with 50 mg L^{-1} or 6-BA with 30 mg L^{-1} at the heading stage could increase the number of spikelets per panicle, seed setting rate and grain yields in Peizataifeng and Huayou86 in both seasons. PBZ treatment also significantly improved head rice rate and amylose content in Peizataifeng and Huayou86 in early season. Application of PBZ or 6-BA partially alleviated the detrimental effects of rice senescence by modulating the activity of enzymatic antioxidants, and improving antioxidant system, which helped in sustaining plant growth. Therefore, spraying PBZ with 50 mg L^{-1} or 6-BA with 30 mg L^{-1} at the heading stage could increase grain yields and improve grain qualities.

Fahad *et al*. (2016) conducted an experiment to ascertain the effects of exogenously applied plant growth regulators (PGR) on rice grow than yield attributes under high day (HDT) and high night temperature (HNT). Two rice cultivars (IR-64 and Huanghuazhan) were subjected to temperature treatments in controlled growth chambers and four different combinations of ascorbic acid (Vc), alpha-tocopherol (Ve), brassino steroids (Br), methyl jasmonates (MeJA), and triazoles (Tr) were applied. High temperature severely affected rice morphology, and also reduced leaf area, above, and below –ground biomass, photosynthesis, and water use efficiency, while increase the leaf water potential of both rice cultivars. Grain yield and its related attributes except number of panicles, were reduced under high temperature. The HDT showed negative effects on rice physiological attributes, while HNT was more detrimental for grain formation and yield.

Banful and Attivor (2017) conducted at experiment at the Department of Horticulture, KNUST, Kumasi with the objectives to (i) determine the rate of ATONIK plant growth regulator (PGR) suitable for high yield of two varieties of hybrid rice (ii) determine the combined effects of PGR rates and varieties on the growth and yield performance of hybrid rice. The factors were varieties at two levels: Agra Rice and Jasmine 85 and PGR at five levels: ATONIK at 450 ml/ha, ATONIK at 500 ml/ha, ATONIK at 550 ml/ha, ATONIK at 0 ml/ha and GA3 at 60 ml/ha. Comparing the ATONIK rates with the GA3, ATONIK at 450 ml/ha resulted in a 14.3 % increase in the number of rice panicles. Application of ATONIK at 450 ml/ha, 500 ml/ha and 550 ml/ha resulted in 14.4%, 10.7% and 4.4% higher percentage of productive tillers, respectively, than that produced by GA3 at 60 ml/ha. ATONIK at 450 ml/ha application led to a 17.8 % increase in grain yield. For the harvest index, application of ATONIK at 450 ml/ha resulted in the highest harvest index of 45%, significantly greater than the other PGR treatments. In conclusion, the study clearly demonstrated that ATONIK PGR was superior to GA3 in the vegetative and productive performance of rice. The most suitable rate of ATONIK for increased rice productivity was 450 ml/ha.

From the above review of literature it is evident that recommended dose of fertilizers-RDF (nitrogen, phosphorus, potassium, sulphur and zinc) and plant growth regulators-PGR have a significant influence on yield and yield attributes of rice. The literature suggests that RDF and PGR increased the grain yield of rice. Reduction in grain yield is mainly attributed by the reduced number of tillers hill^{-1}, grains panicle^{-1} and thousand grain weight due to restriction of development of these parameters for the effect of RDF and PGR.

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh during the period from July to November, 2015 to study the effect of PGR-Bioferti on the growth and yield of T. Aman. 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 silty loam soil at the Sher-e-Bangla Agricultural University Farm, Dhaka. The morphological, physical and chemical characteristics of the soil are shown in the Table 1 and 2.

3.2 Climate

The climate of the experimental area is characterized by high temperature, high humidity and medium rainfall with occasional gusty winds during the *kharif* season (March-September) and a scanty rainfall associated with moderately low temperature in the *rabi* season (October-February). The weather information regarding temperature, rainfall, relative humidity and sunshine hours prevailed at the experimental site during the cropping season July to November 2015 have been presented in Appendix I.

3.3 Planting material

BRRIdhan BR 11 (Mukta) was used as the test crop in this experiment. This variety was developed at the Bangladesh Rice Research Institute from the cross between BR 52-87-1-HR88 and IR20/IR5-47-2 in 1980. It is recommended for *Aman* season. Average plant height of the variety is around 125 cm at the ripening stage. The grains are medium, round and coarse. It requires about 150 days completing its life cycle with an average grain yield of around 4.5 t ha^{-1} (BRRI, 2013).

Table 1. Morphological characteristics of the experimental field

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

(FAO and UNDP, 1988)

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

Characteristics	Value
Mechanical fractions:	
% Sand (2.0-0.02 mm)	18.60
% Silt (0.02-0.002 mm)	45.40
% Clay (<0.002 mm)	36.00
Textural class	Silty Clay Loam
Consistency	Granular and friable when dry
pH (1: 2.5 soil- water)	6.31
CEC (cmol/kg)	17.9
Organic Matter (%)	1.387
Total N (%)	0.06
Available P (mg kg^{-1})	19.85
Exchangeable K (mol kg^{-1})	0.12
Available S (mg kg^{-1})	14.40

3.4 Initial soil sampling

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

3.5 Treatment of the experiment

The experiment comprised of 9 treatments as-

T_1: Control condition (No chemical fertilizer, no PGR-Bioferti)

T_2: Recommended Fertilizer Doses-RFD (120, 20, 80, 16 and 2 kg ha^{-1} of N, P, K, S and Zn, respectively)

T_3: RFD + 2 times spray of PGR-Bioferti

T_4: RFD + 1 time spray of PGR-Bioferti

T_5: ½ RFD + 2 times spray of PGR-Bioferti

T_6: ½ RFD + 1 time spray of PGR-Bioferti

T_7: No chemical fertilizer + 2 times spray of PGR-Bioferti

T_8: No chemical fertilizer + 1 time spray of PGR-Bioferti

T_9: RFD + soil application of PGR-Bioferti

3.6 Land preparation

The land was first opened on 08 July, 2015 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 of plot was cleaned by removing the weeds, stubbles and crop residues. Finally each plot was prepared by puddling for seedling transplanting.

3.7 Experimental design and layout

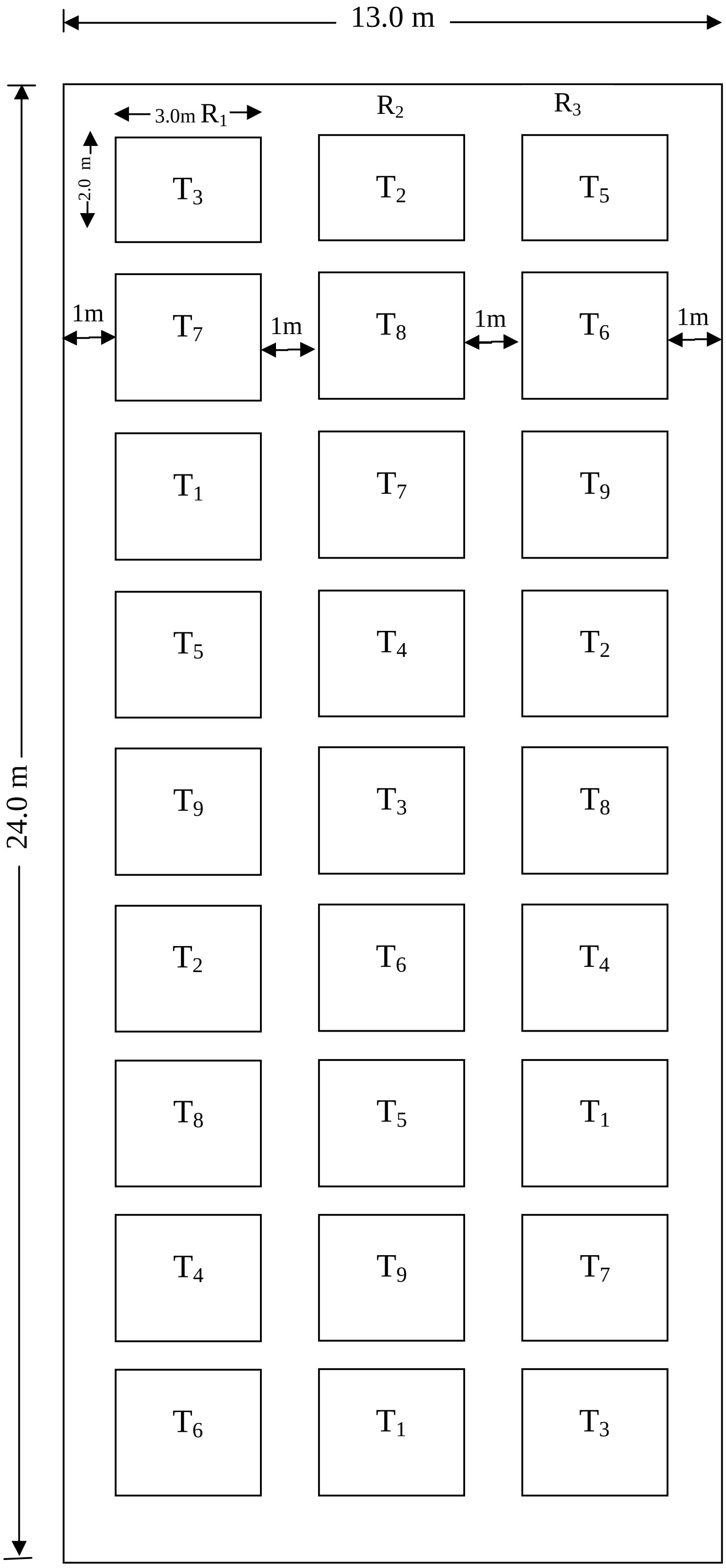
The experiment was laid out in a Randomized Complete Block Design (RCBD), where the experimental area was divided into three replications to reduce soil heterogenetic effects. Each replication was divided into 9 unit plots as per treatments of the experiment with raised bunds around. Thus the total numbers of plots were 27. The unit plot size was 3.0 m × 2.0 m and was separated from each other by 0.5 m ails. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m respectively. The layout of the experiment is shown in Figure 1.

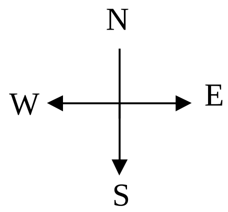
3.8 Fertilizer application

The fertilizers N, P, K, S and Zn in the form of urea, TSP, MoP, gypsum and zinc sulphate, respectively were applied. The one third amount of urea and entire amount of TSP, MoP, gypsum and zinc sulphate were applied during the final preparation of land. Rest urea was applied in two equal installments at tillering and panicle initiation stages. The dose and method of application of fertilizers are presented in Table 3.

Table 3. Dose and method of application of fertilizers in rice field

Fertilizers	Dose (ha^{-1})	Application (%)		
		Basal	1st installment	2nd installment
Cowdung	5 ton	100	--	--
Urea	120 kg	33.33	33.33	33.33
TSP	20 kg	100	--	--
MoP	80 kg	100	--	--
Gypsum	16 kg	100	--	--
Zinc sulphate	2 kg	100		





Plot size: 3.0 m × 2.0 m

Plot spacing: 50 cm

Between replication: 1.0 m

T_1: Control condition (No chemical fertilizer, no PGR-Bioferti

T_2: Recommended Fertilizer Doses-RFD 20, 80, 16 and 2 kg ha^{-1} of N, S and Zn, respectively)

T_3: RFD + 2 times spray of PGR-Bioferti

T_4: RFD + 1 time spray of PGR-Bioferti

T_5: ½ RFD + 2 times spray of PGR-Bioferti

T_6: ½ RFD + 1 time spray of PGR-Bioferti

T_7: No chemical fertilizer + 2 times spray of PGR-Bioferti

T_8: No chemical fertilizer + 1 time spray of PGR-Bioferti

T_9: RFD + soil application of PGR-Bioferti

Figure 1. Layout of the experimental plot

3.9 Raising of seedlings

The seedlings of rice were raised by wet-bed methods. Seeds (95% germination) @ 50 kg ha^{-1} 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.

3.10 Transplanting

Thirty days old seedlings of BR 11 were carefully uprooted from the seedling nursery and transplanted on 07 August, 2015 in well puddled 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.

3.11 Application of PGR-Bioferti

PGR-Bioferti was collected from Siddique Bazaar, Dhaka and applied as per treatment with mixing 1.5 ml Bioferti with 600 ml water for per plot. 1^{st} spray was done at 10 September and 2^{nd} spray at 25 September, 2015.

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

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

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 infection of diseases in the field but leaf roller (*Chaphalocrosis medinalis*, Pyralidae, Lepidoptera) was observed in the field and used Malathion @ 1.12 L ha^{-1} for control that pest.

3.13 Crop harvest

The crop was harvested at full maturity when 80-90% of the grains were turned into straw colored on 25 November, 2015. The crop was cut at the ground level and plot wise crop was bundled separately and brought to the threshing floor.

3.14 Collected data on yield components

3.14.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 40, 50, 60, 70 days and at harvesting stage. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the panicle.

3.14.2 Effective tiller $hill^{-1}$

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

3.14.3 Non-effective tiller $hill^{-1}$

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

3.14.4 Total tiller $hill^{-1}$

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

3.14.5 Filled grain panicle^{-1}

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

3.14.6 Unfilled grain panicle^{-1}

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

3.14.7 Total grain panicle^{-1}

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

3.14.8 Length of panicle

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

3.14.9 Weight of 1000 seeds

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

3.14.10 Grain yield

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

3.14.11 Straw yield

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

3.14.12 Biological yield

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

Biological yield = Grain yield + Straw yield.

3.14.13 Harvest index

Harvest index was calculated from the following formula:

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

3.15 Chemical analysis of grain and straw samples

3.15.1 Collection of grain and straw samples

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

3.15.2 Preparation of samples

At 70 ^{0}C the grain and straw samples were dried in an oven and then ground by a grinding machine. The grain and straw samples were analyzed for determination of N, P and K concentrations. The methods were as follows:

3.15.3 Digestion of plant samples with sulphuric acid for N

For nitrogen determination an amount of 0.2 g oven dry, ground sample were taken in a micro kjeldahl flask. 1.1 g catalyst mixture (K_2SO_4: $CuSO_{4.}$ $5H_2O$: Se in the ratio of 100: 10: 1), and 5 ml conc. H_2SO_4 were added. The flasks were heated at 120^{0}C and added 2.5 ml 30% H_2O_2 then heating was continued at 180^{0}C until the digests became clear and colorless. After cooling, the content was transfer into a 100 ml volumetric flask and the volume was made up to the mark with distilled water. A blank was prepared in a similar way. 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 H_2SO_4 of 0.1 N concentration.

3.15.4 Digestion of samples with nitric-perchloric acid for P and K

Sample weighing 0.5 g was taken into a dry, clean 100 ml digestion flask. 10 ml of di-acid (HNO_3: $HClO_4$ in the ratio 2:1) mixture were added to the flask. The flasks were heated at a temperature slowly raised to 200^0C. Heating were stopped when the dense white fumes of $HClO_4$ was formed. The content of the flask were boiled until they were became colorless. After cooling, the content was taken into a 100 ml volumetric flask and the volume was made with distilled water. P, K and S were determined from this digest.

3.15.5 Determination of P and K from grain and straw samples

3.15.5.1 Phosphorus

For p determination 1 ml for grain sample and 2 ml for straw sample from 100 ml extract was then determined by developing blue color with reduction of phosphomolybdate complex and the color intensity were measured colorimetrically at 660 nm wavelength (Page *et al.*, 1982).

3.15.5.2 Potassium

5 ml of digest sample for the grain and 10 ml for the straw were taken and diluted 50 ml volume to make desired concentration. The absorbance was measured by flame photometer.

3.16 Post harvest soil sampling

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

3.17 Soil analysis

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

3.17.1 Soil pH

Soil pH was measured with the help of a glass electrode pH meter, the soil water ratio being maintained at 1: 2.5.

3.17.2 Organic matter

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

3.17.3 Total nitrogen

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

Then 20 ml digest solution was taken into the distillation flask, Then 10 ml of H_3BO_3 indicator solution was taken into a 250 ml conical flask which is marked to indicate a volume of 50 ml and placed the conical flask under the condenser outlet so that the delivery end dipped in the acid. Add sufficient amount of 10N-NaOH solutions in the container with distillation apparatus. Water runs through the condenser of distillation apparatus was checked. The conical flask was removed by washing several times the delivery outlet with distilled water.

Finally the distillate was titrated with standard 0.01 N H_2SO_4 until the color changes from green to pink. The amount of N was calculated using the following formula:

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

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

3.17.4 Available phosphorus

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

3.17.5 Exchangeable potassium

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

3.18 Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference of different treatments on yield contributing characters, yield of BR 11 and nutrient uptake by plant and nutrient status of post harvest soil. The mean values of all the characters were calculated and analysis of variance was performed by the 'F' (variance ratio) test using MSTAT-C software. The significance of the difference among the treatment means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

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The experiment was conducted to study the effect of PGR-Bioferti on the growth and yield of T. Aman. Data on different yield attributes, yield, nutrient content in grain and straw, nutrient uptake by grain and straw and characteristics of post harvest soil was recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix II-VII. The results have been presented and discussed under the following headings:

4.1 Yield attributes and yield of rice

4.1.1 Plant height

Plant height of BR 11 were statistically significant differences due to the effect of different treatments at 40, 50, 60, 70 DAT and harvest (Appendix II). Data revealed that at 40, 50, 60, 70 DAT and at harvest plant height varied 30.55-37.18 cm, 64.89-50.27 cm, 87.30-71.57 cm, 100.53-117.12 cm and 104.42-128.23 cm, respectively. At the time of final harvest, the longest plant (128.23 cm) was recorded from T_3 (RFD + 2 times spray of PGR-Bioferti) which was statistically similar with all treatment except control, whereas the shortest plant (104.42 cm) was observed from T_1 (Control condition i.e. no chemical fertilizer, no PGR-Bioferti) treatment (Table 4). From the data, it was observed that all the treatments of this study produced significantly taller plants compared to the control treatment. It was revealed that plant growth was seriously hampered when no fertilizer were applied. Generally plant height is a genetical character and it is controlled by the genetic make up of the varieties and different varieties produced different size of plant. Plant height of rice was significantly influenced by the organic-inorganic fertilizer management that was earlier reported by Babu *et al.* (2001).

Table 4. Effect of PGR-Bioferti on plant height at different days after transplanting (DAT) and harvest of T. aman rice

Treatments	Plant height (cm) at				
	40 DAT	50 DAT	60 DAT	70 DAT	Harvest
T_1	30.55 c	50.27 d	71.57 c	100.53 d	104.42 b
T_2	34.23 a-c	60.36 ab	83.04 ab	110.37 a-d	124.59 a
T_3	37.18 a	64.89 a	87.30 a	117.12 a	128.23 a
T_4	36.54 ab	63.26 a	86.53 a	115.52 ab	126.99 a
T_5	34.32 a-c	59.96 a-c	81.21 a-c	106.25 b-d	121.53 a
T_6	34.06 a-c	58.77 a-c	79.66 a-c	108.23 a-d	117.07 ab
T_7	32.56 bc	53.67 b-d	74.87 bc	105.80 b-d	117.12 ab
T_8	32.42 bc	53.22 cd	74.57 bc	104.93 cd	115.56 ab
T_9	35.89 ab	62.19 a	84.69 ab	113.77 a-c	125.35 a
$LSD_{(0.05)}$	3.942	6.469	9.944	8.876	13.44
Significance level	0.05	0.01	0.05	0.05	0.05
CV(%)	6.66	5.39	7.15	4.70	6.47

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

T_1: Control condition (No chemical fertilizer, no PGR-Bioferti

T_2: Recommended Fertilizer Doses-RFD (120, 20, 80, 16 and 2 kg ha^{-1} of N, P, K, S and Zn, respectively)

T_3: RFD + 2 times spray of PGR-Bioferti

T_4: RFD + 1 time spray of PGR-Bioferti

T_5: ½ RFD + 2 times spray of PGR-Bioferti

T_6: ½ RFD + 1 time spray of PGR-Bioferti

T_7: No chemical fertilizer + 2 times spray of PGR-Bioferti

T_8: No chemical fertilizer + 1 time spray of PGR-Bioferti

T_9: RFD + soil application of PGR-Bioferti

4.1.2 Number of effective tillers hill^{-1}

Statistically significant variation was recorded due to the effect of different treatments on number of effective tillers hill^{-1} (Appendix III). The highest number of effective tillers hill^{-1} (13.73) was recorded from T_3 which was statistically similar (13.40, 12.87, 12.47 and 11.67) to T_4, T_9, T_2 and T_5 but closely followed (11.47) by T_6, whereas the lowest number of effective tillers hill^{-1} (8.13) was found from T_1 which was statistically similar (9.60 and 9.67) to T_8 and T_7 treatment (Table 5). Sarkar and Singh (2002) observed that the number of tillers m^{-2} significantly increased with the application recommended doses of fertilizer. Alamdari *et al*. (2007) reported that N, P, K, S and Zn, Cu and Mn increased number of effective tillers hill^{-1}.

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

Statistically significant variation was recorded due to the effect of different treatments on number of non-effective tillers hill^{-1} (Appendix III). The lowest number of non-effective tillers hill^{-1} (1.87) was found from T_3 which was statistically similar (2.07, 2.13 and 2.27) to T_4, T_9 and T_6, whereas the highest number of non-effective tillers hill^{-1} (3.73) was observed from T_1 which was statistically similar (3.47 and 3.27) to T_8 and T_7 treatment (Table 5).

4.1.4 Total tillers hill^{-1}

Number of total tillers hill^{-1} showed statistically significant variation due to the effect of different treatments (Appendix III). The highest number of total tillers hill^{-1} (15.60) was observed from T_3 which was statistically similar with other treatments except T_1 and T_7. On the other hand, the lowest number of total tillers hill^{-1} (11.87) was recorded from T_1 which was statistically similar (12.93) to T_7 treatment (Figure 2). Wan *et al*. (2010) reported that application of K fertilizer (NPK) increased total tiller over that obtained with no K application (NP).

Table 5. Effect of PGR-Bioferti on yield contributing characters of T. aman rice

Treatments	Number of effective tiller $hill^{-1}$	Number of non-effective tiller $hill^{-1}$	Number of filled grain $panicle^{-1}$	Number of unfilled grain $panicle^{-1}$	Length of panicle (cm)
T_1	8.13 d	3.73 a	63.53 d	9.73 a	17.22 c
T_2	12.47 ab	2.53 a-d	83.13 a-c	5.27 cd	21.92 ab
T_3	13.73 a	1.87 d	94.20 a	4.20 e	23.92 a
T_4	13.40 ab	2.07 cd	91.53 ab	4.73 de	23.59 a
T_5	11.67 a-c	3.00 a-d	80.33 a-c	5.73 c	21.04 ab
T_6	11.47 bc	2.27 b-d	78.60 bc	5.53 cd	19.81 bc
T_7	9.67 cd	3.27 a-c	75.27 cd	8.27 b	19.04 bc
T_8	9.60 cd	3.47 ab	74.93 cd	8.73 b	18.86 bc
T_9	12.87 ab	2.13 cd	86.40 a-c	5.00 c-e	22.51 ab
$LSD_{(0.05)}$	1.976	1.165	12.64	0.896	3.338
Significance level	0.01	0.05	0.01	0.01	0.01
CV(%)	9.97	14.90	9.03	8.14	9.24

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

T_1: Control condition (No chemical fertilizer, no PGR-Bioferti

T_2: Recommended Fertilizer Doses-RFD (120, 20, 80, 16 and 2 kg ha^{-1} of N, P, K, S and Zn, respectively)

T_3: RFD + 2 times spray of PGR-Bioferti

T_4: RFD + 1 time spray of PGR-Bioferti

T_5: ½ RFD + 2 times spray of PGR-Bioferti

T_6: ½ RFD + 1 time spray of PGR-Bioferti

T_7: No chemical fertilizer + 2 times spray of PGR-Bioferti

T_8: No chemical fertilizer + 1 time spray of PGR-Bioferti

T_9: RFD + soil application of PGR-Bioferti

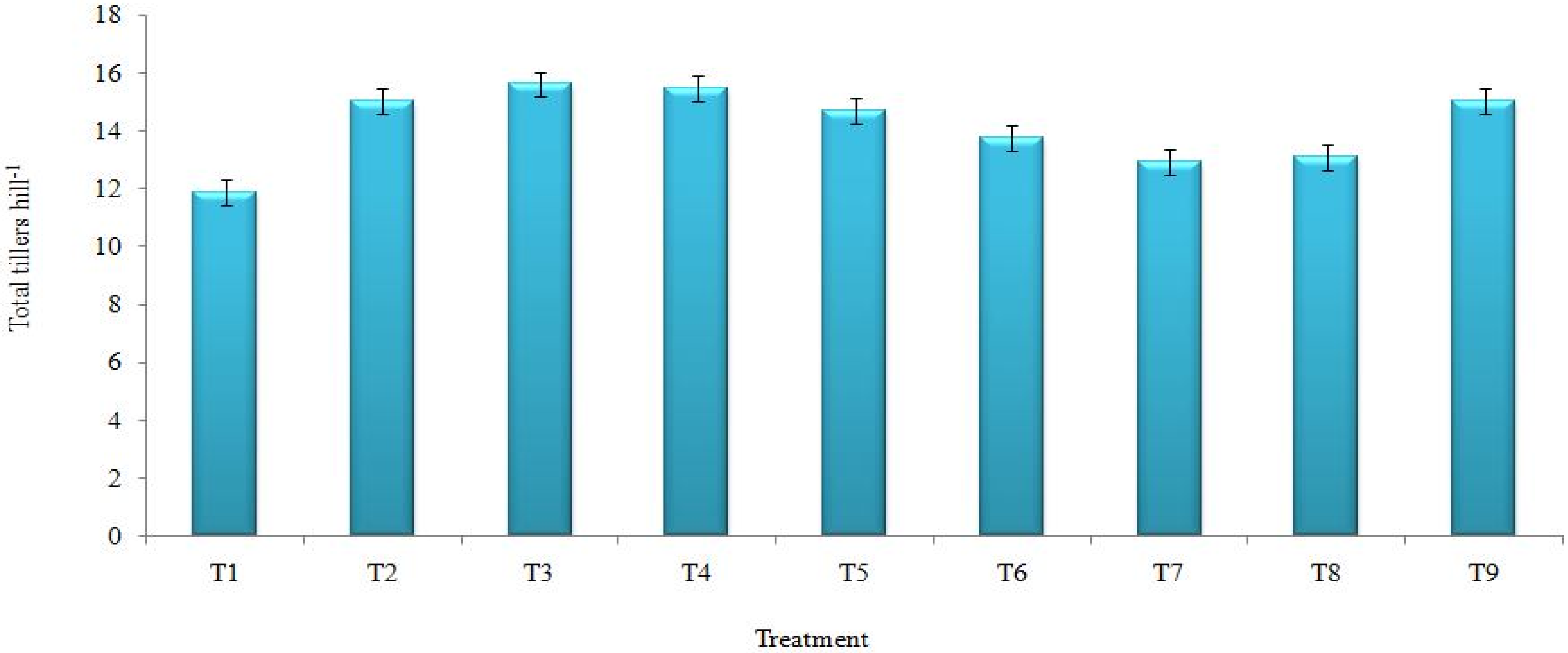

Figure 2. Effect of PGR-Bioferti on total tillers hill^{-1} of transplanted aman rice. Vertical bars represent LSD value

4.1.5 Number of filled grain plant^{-1}

Statistically significant variation was recorded due to the effect of different treatments on number of filled grains panicle^{-1} (Appendix III). The highest number of filled grains plnicle^{-1} (94.20) was recorded from T_3 which was statistically similar (91.53, 86.40, 83.13 and 80.33) to T_4, T_9, T_2 and T_5 but closely followed (78.60) by T_6, whereas the lowest number of filled grains panicle^{-1} (63.53) was observed from T_1 which was statistically similar (74.93 and 75.27) to T_8 and T_7 treatment (Table 5).

4.1.6 Number of unfilled grain plant^{-1}

Number of unfilled grains panicle^{-1} varied significantly due to the effect of different treatments on (Appendix III). The lowest number of unfilled grains panicle^{-1} (4.20) was found from T_3 which was statistically similar (4.73 and 5.00) to T_4 and T_9 but closely followed (5.27 and 5.53) by T_2 and T_6, whereas the highest number of unfilled grains panicle^{-1} (9.73) was observed from T_1 treatment (Table 5).

4.1.7 Number of total grain plant^{-1}

Statistically significant variation was recorded due to the effect of different treatments on number of total grains panicle^{-1} (Appendix III). The highest number of total grains plnicle^{-1} (98.40) was observed from T_3 which was statistically similar (96.27, 91.40, 88.40 and 86.07) to T_4, T_9, T_2 and T_5, whereas the lowest number of total grains panicle^{-1} (73.27) was observed from T_1 treatment (Figure 3).

4.1.8 Length of panicle

Length of panicle showed statistically significant variation due to the effect of different treatments (Appendix III). The longest panicle (23.92 cm) was recorded from T_3 which was statistically similar (23.59, 22.51, 21.92 and 21.04 cm) to T_4, T_9, T_2 and T_5, while the lowest shortest panicle (17.22 cm) was found from T_1 treatment (Table 5).

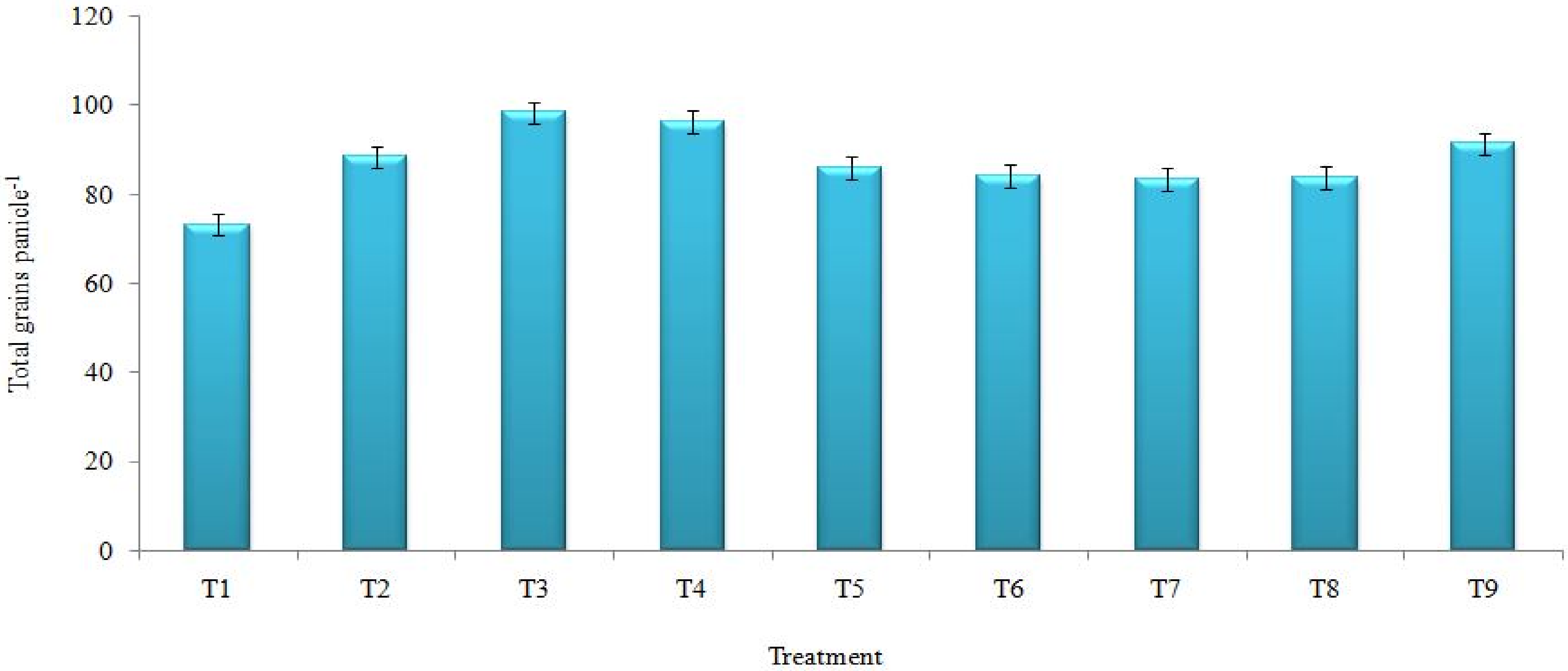

Figure 3. Effect of PGR-Bioferti on total grains panicle^{-1} of transplanted aman rice. Vertical bars represent LSD Value

4.1.9 Weight of 1000 grains

Statistically significant variation was recorded due to the effect of different treatments in terms of weight of 1000 grains (Appendix IV). The highest weight of 1000 grains (17.97 g) was recorded from T_3 which was statistically similar (17.82, 17.48, 16.88, 16.42 and 15.72 g) to T_4, T_9, T_2, T_5 and T_6, whereas the lowest weight of 1000 grains (14.57 g) was observed from T_1 treatment which was statistically simialr (14.65 and 14.87 g) to T_8 and T_7 (Table 6). Sarkar and Singh (2002) observed that the 1000-grain weight significantly increased with the application recommended doses of fertilizer.

4.1.10 Grain yield

Statistically significant variation was recorded due to the effect of different treatments in terms of grain yield (Appendix IV). The highest grain yield (4.91 t ha^{-1}) was recorded from T_3 which was followed (4.16, 4.03, 3.91, 3.78 and 3.64 t ha^{-1}) to T_4, T_9, T_2, T_5 and T_6, whereas the lowest grain yield (2.64 t ha^{-1}) was found from T_1 treatment which was statistically simialr (2.84 and 2.88 t ha^{-1}) to T_8 and T_7 (Table 6). Sarkar and Singh (2002) observed that the paddy yield significantly increased with the application recommended doses of fertilizer. Rahman (2001) reported that in rice-rice cropping pattern, the highest grain yield of Boro rice was recorded in the soil test basis (STB) N P K S Zn fertilizers treatment while in T. Aman rice the 75% or 100% of N P K S Zn (STB) fertilizers plus green manure (GM) with or without cowdung gave the highest or a comparable yield.

Table 6. Effect of PGR-Bioferti on weight of 1000 grains, yield and harvest index of T. aman rice

Treatments	Weight of 1000 grains (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
T_1	14.57 b	2.64 c	3.73 c	6.37 c	41.40
T_2	16.88 ab	3.91 b	4.87 b	8.78 b	44.27
T_3	17.97 a	4.91 a	5.29 a	10.21 a	48.14
T_4	17.82 a	4.16 b	5.16 a	9.32 ab	44.59
T_5	16.42 ab	3.78 b	4.68 ab	8.46 b	44.70
T_6	15.72 ab	3.64 b	4.61 ab	8.25 b	43.98
T_7	14.87 b	2.88 c	4.06 bc	6.94 c	41.50
T_8	14.65 b	2.84 c	3.89 c	6.73 c	42.02
T_9	17.48 a	4.03 b	5.07 a	9.10 ab	44.39
$LSD_{(0.05)}$	2.363	0.705	0.627	1.194	--
Significance level	0.05	0.01	0.01	0.01	NS
CV(%)	8.39	11.20	7.89	8.38	5.55

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

T_1: Control condition (No chemical fertilizer, no PGR-Bioferti

T_2: Recommended Fertilizer Doses-RFD (120, 20, 80, 16 and 2 kg ha^{-1} of N, P, K, S and Zn, respectively)

T_3: RFD + 2 times spray of PGR-Bioferti

T_4: RFD + 1 time spray of PGR-Bioferti

T_5: ½ RFD + 2 times spray of PGR-Bioferti

T_6: ½ RFD + 1 time spray of PGR-Bioferti

T_7: No chemical fertilizer + 2 times spray of PGR-Bioferti

T_8: No chemical fertilizer + 1 time spray of PGR-Bioferti

T_9: RFD + soil application of PGR-Bioferti

4.1.11 Straw yield

Straw yield showed statistically significant differences due to the effect of different treatments (Appendix IV). The highest straw yield (5.29 t ha^{-1}) was recorded from T_3 which was statistically similar (5.16, 5.07, 4.87, 4.68 and 4.61 t ha^{-1}) to T_4, T_9, T_2, T_5 and T_6, whereas the lowest straw yield (3.73 t ha^{-1}) was observed from T_1 treatment which was statistically simialr (3.89 and 4.06 t ha^{-1}) to T_8 and T_7 (Table 6). Sarkar and Singh (2002) observed that the straw yield significantly increased with the application recommended doses of fertilizer.

4.1.12 Biological yield

Biological yield showed statistically significant differences due to the effect of different treatments (Appendix IV). The highest biological yield (10.21 t ha^{-1}) was found from T_3 which was statistically similar (9.32 and 9.10 t ha^{-1}) to T_4 and T_9, while the lowest biological yield (6.37 t ha^{-1}) was observed from T_1 treatment which was statistically simialr (6.73 and 6.94 t ha^{-1}) to T_8 and T_7 (Table 6).

4.1.13 Harvest index

Harvest index showed statistically non significant differences due to the effect of different treatments (Appendix IV). The highest harvest index (48.14%) was recorded from T_3 and the lowest harvest index (41.40%) was observed from T_1 treatment (Table 6).

4.2 N, P and K concentration in grain and straw

4.2.1 N concentration in grain

Statistically significant variation was recorded for N concentration in grain due to the effect of different treatments (Appendix V). The highest N concentration in grain (0.778%) was recorded from T_3 which was statistically similar (0.766%, 0.742%, 0.715%, 0.708% and 0.693%) to T_4, T_9, T_2, T_5 and T_6, whereas the lowest N concentration in grain (0.451%) was found from T_1 treatment which was closely followed (0.594% and 0.571%) by T_8 and T_7 (Table 7).

4.2.2 P concentration in grain

Statistically significant variation was recorded for P concentration in grain due to the effect of different treatments (Appendix V). The highest P concentration in grain (0.309%) was found from T_3 which was statistically similar (0.301%, 0.288%, 0.267%, 0.264% and 0.259%) to T_4, T_9, T_2, T_5 and T_6, while the lowest P concentration in grain (0.214%) was observed from T_1 treatment which was statistically similar (0.237% and 0.241%) to T_8 and T_7 (Table 7).

4.2.3 K concentration in grain

Statistically significant variation was recorded for K concentration in grain due to the effect of different treatments (Appendix V). The highest K concentration in grain (0.413%) was recorded from T_3 which was statistically similar (0.393%, 0.358%, 0.340% and 0.337%) to T_4, T_9, T_2 and T_5 but closely followed (0.307%) by T_6 whereas the lowest K concentration in grain (0.223%) was found from T_1 treatment which was statistically similar (0.238% and 0.250%) by T_8 and T_7 (Table 7).

Table 7. Effect of PGR-Bioferti on N, P and K concentrations in grain of T. aman rice

Treatments	Concentration (%) in grain		
	N	P	K
T_1	0.451 c	0.214 d	0.223 d
T_2	0.715 a	0.267 a-d	0.340 ab
T_3	0.778 a	0.309 a	0.413 a
T_4	0.766 a	0.301 ab	0.393 a
T_5	0.708 a	0.264 a-d	0.337 ab
T_6	0.693 a	0.259 a-d	0.307 bc
T_7	0.594 b	0.241 b-d	0.250 cd
T_8	0.571 b	0.237 cd	0.238 cd
T_9	0.742 a	0.288 a-c	0.358 ab
$LSD_{(0.05)}$	0.077	0.055	0.077
Significance level	0.01	0.01	0.01
CV(%)	6.92	10.66	11.65

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

T_1: Control condition (No chemical fertilizer, no PGR-Bioferti

T_2: Recommended Fertilizer Doses-RFD (120, 20, 80, 16 and 2 kg ha^{-1} of N, P, K, S and Zn, respectively)

T_3: RFD + 2 times spray of PGR-Bioferti

T_4: RFD + 1 time spray of PGR-Bioferti

T_5: ½ RFD + 2 times spray of PGR-Bioferti

T_6: ½ RFD + 1 time spray of PGR-Bioferti

T_7: No chemical fertilizer + 2 times spray of PGR-Bioferti

T_8: No chemical fertilizer + 1 time spray of PGR-Bioferti

T_9: RFD + soil application of PGR-Bioferti

4.2.4 N concentration in straw

N concentration in straw showed statistically significant variation due to the effect of different treatments (Appendix VI). The highest N concentration in straw (0.517%) was recorded in T_3 which was statistically similar (0.504% and 0.478%) with T_4 and T_9 but closely followed (0.457% and 0.449%) by T_2 and T_5, whereas the lowest N concentration in straw (0.386%) was observed from T_1 treatment which was statistically similar (0.0.405%, 0.407% and 0.424%) by T_8, T_7 and T_6 (Table 8).

4.2.5 P concentration in straw

Statistically significant variation was recorded for P concentration in straw due to the effect of different treatments (Appendix VI). The highest P concentration in straw (0.075%) was found from T_3 which was statistically similar (0.072%, 0.069% and 0.061%) to T_4, T_9 and T_2, while the lowest P concentration in straw (0.044%) was observed from T_1 treatment which was statistically similar (0.049% and 0.051%) to T_8 and T_7 (Table 8).

4.2.6 K concentration in straw

Statistically significant variation was recorded for K concentration in straw due to the effect of different treatments (Appendix VI). The highest K concentration in straw (1.36%) was recorded from T_3 which was statistically similar (1.34%, 1.21%) to T_4 and T_9 but closely followed (1.18%) by T_2, whereas the lowest K concentration in straw (0.98%) was found from T_1 treatment which was statistically similar (1.02% and 1.03%) by T_8, T_7 and T_6 (Table 8).

Table 8. Effect of PGR-Bioferti on N, P and K concentrations in straw of T. aman rice

	Concentration (%) in straw		
	N	P	K
T_1	0.386 e	0.044 c	0.98 e
T_2	0.457 b-d	0.061 a-c	1.18 b-d
T_3	0.517 a	0.075a	1.36 a
T_4	0.504 ab	0.072 a	1.34 ab
T_5	0.449 b-d	0.056 abc	1.13 c-e
T_6	0.424 c-e	0.052 bc	1.03 de
T_7	0.407 de	0.051 bc	1.02 de
T_8	0.405 de	0.049 bc	1.02 de
T_9	0.478 a-c	0.069 ab	1.21 abc
$LSD_{(0.05)}$	0.055	0.017	0.164
Significance level	0.01	0.01	0.01
CV(%)	8.40	13.75	8.32

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

T_1: Control condition (No chemical fertilizer, no PGR-Bioferti

T_2: Recommended Fertilizer Doses-RFD (120, 20, 80, 16 and 2 kg ha^{-1} of N, P, K, S and Zn, respectively)

T_3: RFD + 2 times spray of PGR-Bioferti

T_4: RFD + 1 time spray of PGR-Bioferti

T_5: ½ RFD + 2 times spray of PGR-Bioferti

T_6: ½ RFD + 1 time spray of PGR-Bioferti

T_7: No chemical fertilizer + 2 times spray of PGR-Bioferti

T_8: No chemical fertilizer + 1 time spray of PGR-Bioferti

T_9: RFD + soil application of PGR-Bioferti

4.3 N, P and K uptake by grain and straw

4.3.1 N uptake by grain

N uptake by grain showed statistically significant variation due to the effect of different treatments (Appendix VII). The highest N uptake by grain (33.71 kg ha^{-1}) was recorded from T_3 which was statistically similar (31.96, 29.85, 27.94 and 26.81 kg ha^{-1}) to T_4, T_9, T_2 and T_5 but closely followed (25.41 kg ha^{-1}) by T_6, whereas the lowest N uptake by grain (11.88 kg ha^{-1}) was observed from T_1 treatment which was statistically similar (16.51 and 17.07 kg ha^{-1}) by T_8 and T_7 treatment (Table 9).

4.3.2 P uptake by grain

P uptake by grain showed statistically significant variation due to the effect of different treatments (Appendix VII). The highest P uptake by grain (13.38 kg ha^{-1}) was found from T_3 which was statistically similar (12.65, 11.60 and 10.38 kg ha^{-1}) to T_4, T_9 and T_2 but closely followed (10.02 and 9.41 kg ha^{-1}) by T_5 and T_6, whereas the lowest P uptake by grain (5.64 kg ha^{-1}) was observed from T_1 treatment which was statistically similar (6.70 and 6.92 kg ha^{-1}) by T_8 and T_7 treatment (Table 9).

4.3.3 K uptake by grain

K uptake by grain showed statistically significant variation due to the effect of different treatments (Appendix VII). The highest K uptake by grain (17.89 kg ha^{-1}) was recorded from T_3 which was statistically similar (16.44, 14.45, 13.68 and 12.81 kg ha^{-1}) to T_4, T_9, T_2 and T_5, while the lowest K uptake by grain (5.89 kg ha^{-1}) was observed from T_1 treatment which was statistically similar (6.69 and 7.19 kg ha^{-1}) by T_8 and T_7 treatment (Table 9).

Table 9. Effect of PGR-Bioferti on the on N, P and K uptake by grain of T. aman rice

Treatments	Uptake by grain (kg ha^{-1})		
	N	P	K
T_1	11.88 c	5.64 e	5.89 d
T_2	27.94 ab	10.38 ab	13.68 ab
T_3	33.71 a	13.38 a	17.89 a
T_4	31.96 ab	12.65 ab	16.44 ab
T_5	26.81 ab	10.02 bc	12.81 a-c
T_6	25.41 b	9.41 b-d	11.50 b-d
T_7	17.07 c	6.92 c-e	7.19 cd
T_8	16.51 c	6.70 de	6.69 d
T_9	29.85 ab	11.60 ab	14.45 ab
$LSD_{(0.05)}$	6.911	2.968	5.384
Significance level	0.01	0.01	0.01
CV(%)	11.25	7.80	13.27

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

T_1: Control condition (No chemical fertilizer, no PGR-Bioferti

T_2: Recommended Fertilizer Doses-RFD (120, 20, 80, 16 and 2 kg ha^{-1} of N, P, K, S and Zn, respectively)

T_3: RFD + 2 times spray of PGR-Bioferti

T_4: RFD + 1 time spray of PGR-Bioferti

T_5: ½ RFD + 2 times spray of PGR-Bioferti

T_6: ½ RFD + 1 time spray of PGR-Bioferti

T_7: No chemical fertilizer + 2 times spray of PGR-Bioferti

T_8: No chemical fertilizer + 1 time spray of PGR-Bioferti

T_9: RFD + soil application of PGR-Bioferti

4.3.4 N uptake by straw

N uptake by straw showed statistically significant variation due to the effect of different treatments (Appendix VIII). The highest N uptake by straw (27.40 kg ha^{-1}) was recorded from T_3 which was statistically similar (26.07, 24.26 and 22.28 kg ha^{-1}) to T_4, T_9 and T_2 but closely followed (21.19 kg ha^{-1}) by T_5, whereas the lowest N uptake by straw (14.44 kg ha^{-1}) was found from T_1 treatment which was statistically similar (15.76 and 16.50 kg ha^{-1}) by T_8 and T_7 treatment (Table 10).

4.3.5 P uptake by straw

P uptake by straw showed statistically significant variation due to the effect of different treatments (Appendix VIII). The highest P uptake by straw (3.94 kg ha^{-1}) was found from T_3 which was statistically similar (3.73 and 3.46 kg ha^{-1}) to T_4 and T_9 but closely followed (2.95 kg ha^{-1}) by T_2, whereas the lowest P uptake by straw (1.64 kg ha^{-1}) was observed from T_1 treatment which was statistically similar (1.92 and 2.09 kg ha^{-1}) by T_8 and T_7 treatment (Table 10).

4.3.6 K uptake by straw

K uptake by straw showed statistically significant variation due to the effect of different treatments (Appendix VIII). The highest K uptake by straw (72.17 kg ha^{-1}) was recorded from T_3 which was statistically similar (69.49, 61.59 and 57.76 kg ha^{-1}) to T_4, T_9 and T_2, while the lowest K uptake by straw (36.68 kg ha^{-1}) was observed from T_1 treatment which was statistically similar (39.57 and 41.40 kg ha^{-1}) by T_8 and T_7 treatment (Table 10).

Table 10. Effect of PGR-Bioferti on the on N, P and K uptake by straw of T. aman rice

Treatments	Uptake by straw (kg ha^{-1})		
	N	P	K
T_1	14.44 f	1.64 f	36.68 d
T_2	22.28 a-d	2.95 b-d	57.76 ab
T_3	27.40 a	3.94 a	72.17 a
T_4	26.07 ab	3.73 ab	69.49 a
T_5	21.19 b-e	2.61 c-e	53.39 bc
T_6	19.83 c-f	2.42 d-f	48.47 b-d
T_7	16.50 d-f	2.09 d-f	41.40 cd
T_8	15.76 ef	1.92 ef	39.57 cd
T_9	24.26 a-c	3.46 a-c	61.59 ab
$LSD_{(0.05)}$	5.473	0.837	14.06
Significance level	0.01	0.01	0.01
CV(%)	15.16	7.58	5.21

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

T_1: Control condition (No chemical fertilizer, no PGR-Bioferti

T_2: Recommended Fertilizer Doses-RFD (120, 20, 80, 16 and 2 kg ha^{-1} of N, P, K, S and Zn, respectively)

T_3: RFD + 2 times spray of PGR-Bioferti

T_4: RFD + 1 time spray of PGR-Bioferti

T_5: ½ RFD + 2 times spray of PGR-Bioferti

T_6: ½ RFD + 1 time spray of PGR-Bioferti

T_7: No chemical fertilizer + 2 times spray of PGR-Bioferti

T_8: No chemical fertilizer + 1 time spray of PGR-Bioferti

T_9: RFD + soil application of PGR-Bioferti

4.4 Soil pH, organic matter total N, available P and exchangeable K in post harvest soil

4.4.1 Soil pH

Statistically non significant variation was recorded in terms of soil pH in post harvest soil due to the effect of different treatments (Appendix IX). The highest soil pH (6.34) was recorded from T_3 and the lowest soil pH (6.05) was found from T_1 treatment (Table 11).

4.4.2 Organic matter

Statistically non significant variation was recorded in terms of organic matter in post harvest soil due to the effect of different treatments (Appendix IX). The highest organic matter (1.42%) was found from T_3 and the lowest organic matte (1.31%) was observed from T_1 treatment (Table 11).

4.4.3 Total Nitrogen

Total N in post harvest soil showed statistically significant variation due to the effect of different treatments (Appendix IX). The highest total N (0.065%) was recorded from T_3 which was statistically similar (0.063% and 0.052%) to T_4 and T_9, while the lowest total N (0.024%) was observed from T_1 treatment which was statistically similar (0.039% and 0.040%) by T_8 and T_7 treatment (Table 11).

4.4.4 Available phosphorus

Available P in post harvest soil showed statistically significant variation due to the effect of different treatments (Appendix IX). The highest available P (39.09 ppm) was recorded from T_3 which was statistically similar (38.86 ppm and 34.04 ppm) to T_4 and T_9, while the lowest available P (15.03 ppm) was found from T_1 treatment which was statistically similar (20.53 ppm and 20.70 ppm) by T_8 and T_7 treatment (Table 11).

Table 11. Effect of PGR-Bioferti on nutrient content of post harvest soil of T. aman rice

Treatments	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me%)
T_1	6.05	1.32	0.024 c	15.03 f	0.123 e
T_2	6.26	1.31	0.044 b	31.46 bc	0.160 bc
T_3	6.34	1.42	0.065 a	39.09 a	0.179 a
T_4	6.33	1.35	0.063 a	38.86 a	0.176 ab
T_5	6.26	1.36	0.043 bc	26.81 cd	0.158 bc
T_6	6.04	1.36	0.043 bc	22.08 de	0.149 cd
T_7	6.33	1.34	0.040 bc	20.70 ef	0.134 de
T_8	6.20	1.35	0.039 bc	20.53 ef	0.132 de
T_9	6.31	1.37	0.052 ab	34.04 ab	0.170 ab
$LSD_{(0.05)}$	--	--	0.017	5.740	0.017
Significance level	NS	NS	0.01	0.01	0.01
CV(%)	4.76	7.05	6.44	12.01	9.40

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

T_1: Control condition (No chemical fertilizer, no PGR-Bioferti

T_2: Recommended Fertilizer Doses-RFD (120, 20, 80, 16 and 2 kg ha^{-1} of N, P, K, S and Zn, respectively)

T_3: RFD + 2 times spray of PGR-Bioferti

T_4: RFD + 1 time spray of PGR-Bioferti

T_5: ½ RFD + 2 times spray of PGR-Bioferti

T_6: ½ RFD + 1 time spray of PGR-Bioferti

T_7: No chemical fertilizer + 2 times spray of PGR-Bioferti

T_8: No chemical fertilizer + 1 time spray of PGR-Bioferti

T_9: RFD + soil application of PGR-Bioferti

4.4.5 Exchangeable potassium

Exchangeable K in post harvest soil showed statistically significant variation due to the effect of different treatments (Appendix IX). The highest exchangeable K (0.179 me%) was found from T_3 which was statistically similar (0.176 me% and 0.170 me%) to T_4 and T_9, while the lowest exchangeable K (0.123 me%) was observed from T_1 treatment which was statistically similar (0.132 and 0.134 me%) by T_8 and T_7 treatment (Table 11).

CHAPTER V

SUMMARY AND CONCLUSION

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The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from July to November, 2015 to study the effect of PGR-Bioferti on the growth and yield of T. Aman. BRRI dhan BR 11 (Mukta) was used as the test crop in this experiment. The experiment comprised of 9 treatments as- T_1: Control condition (No chemical fertilizer, no PGR-Bioferti), T_2: Recommended Fertilizer Doses-RFD (120, 20, 80, 16 and 2 kg ha^{-1} of N, P, K, S and Zn, respectively), T_3: RFD + 2 times spray of PGR-Bioferti, T_4: RFD + 1 time spray of PGR-Bioferti, T_5: ½ RFD + 2 times spray of PGR-Bioferti, T_6: ½ RFD + 1 time spray of PGR-Bioferti, T_7: No chemical fertilizer + 2 times spray of PGR-Bioferti, T_8: No chemical fertilizer + 1 time spray of PGR-Bioferti and T_9: RFD + soil application of PGR-Bioferti. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data on different yield attributes, yield, nutrient content in grain and straw, nutrient uptake by grain and straw and status of post harvest soil were recorded and significant variation was observed for different treatments.

At the time of final harvest, the longest plant (128.23 cm) was recorded from T_3, whereas the shortest plant (104.42 cm) was observed from T_1. The highest number of effective tillers hill^{-1} (13.73) was recorded from T_3, whereas the lowest number of effective tillers hill^{-1} (8.13) was found from T_1. The lowest number of ineffective tillers hill^{-1} (1.87) was found from T_3, whereas the highest number of ineffective tillers hill^{-1} (3.73) was observed from T_1. The highest number of total tillers hill^{-1} (15.60) was observed from T_3 and the lowest number of total tillers hill^{-1} (11.87) was recorded from T_1. The highest number of filled grains plnicle^{-1} (94.20) was recorded from T_3, whereas the lowest number of filled grains panicle^{-1} (63.53) was observed from T_1. The lowest number of unfilled grains panicle^{-1} (4.20) was found from T_3, whereas the highest number of unfilled grains panicle^{-1} (9.73) was observed from T_1 treatment. The highest number of total grains plnicle^{-1} (98.40) was observed from T_3, whereas the lowest number of total grains panicle^{-1} (73.27) was observed from T_1 treatment. The longest panicle (23.92 cm) was recorded from T_3, while the lowest shortest panicle (17.22 cm) was found from T_1 treatment.The highest weight of 1000 grains (17.97 g) was recorded from T_3, whereas the lowest weight of 1000 grains (14.57 g) was observed from T_1 treatment. The highest grain yield (4.91 t ha^{-1}) was recorded from T_3, whereas the lowest grain yield (2.64 t ha^{-1}) was found from T_1 treatment. The highest straw yield (5.29 t ha^{-1}) was recorded from T_3, whereas the lowest straw yield (3.73 t ha^{-1}) was observed from T_1 treatment. The highest biological yield (10.21 t ha^{-1}) was found from T_3, while the lowest biological yield (6.37 t ha^{-1}) was observed from T_1 treatment. The highest harvest index (48.14%) was recorded from T_3 and the lowest harvest index (41.40%) was observed from T_1 treatment.

The highest N, P and K concentration in grain (0.778%, 0.309% and 0.413%) was observed from T_3, whereas the lowest N, P and K concentration in grain (0.451%, 0.214% and 0.223%) was found from T_1. The highest N, P and K concentration in straw (0.517%, 0.075% and 1.36%) was recorded from T_3, while the lowest N, P and K concentration in straw (0.386%, 0.044% and 0.98%) was observed from T_1. The highest N, P and K uptake by grain (33.71 kg ha^{-1}, 13.38 kg ha^{-1} and 17.89 kg ha^{-1}) was observed from T_3, whereas the lowest N, P and K uptake by grain (11.88 kg ha^{-1}, 5.64 kg ha^{-1} and 5.89 kg ha^{-1}) was recorded from T_1. The highest N, P and K uptake by straw (27.40 kg ha^{-1}, 3.94 kg ha^{-1} and 72.17 kg ha^{-1}) was found from T_3, while the lowest N, P and K uptake by straw (14.44 kg ha^{-1}, 1.64 kg ha^{-1} and 36.68 kg ha^{-1}) was observed from T_1. The highest soil pH (6.34) was recorded from T_3 and the lowest soil pH (6.05) was found from T_1 treatment. The highest organic matter (1.42%) was found from T_3 and the lowest organic matte (1.31%) was observed from T_1 treatment. The highest total N (0.065%) was recorded from T_3, while the lowest total N (0.024%) was observed from T_1 treatment. The highest available P

(39.09 ppm) was recorded from T_3, while the lowest available P (15.03 ppm) was found from T_1 treatment. The highest exchangeable K (0.179 me%) was found from T_3, while the lowest exchangeable K (0.123 me%) was observed from T_1 treatment.

Applications of RFD + 2 times spray of PGR-Bioferti was the superior among the other treatments in consideration of yield attributes and yield of BR 11 transplanted aman rice under the climatic condition of Bangladesh.

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

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

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APPENDICES

APPENDICES

Appendix I. Monthly record of air temperature, relative humidity, rainfall, and sunshine (average) of the experimental site during the period from July to November 2015

Month (2015)	Air temperature (^{0}c)		Relative humidity (%)	Rainfall (mm)	Sunshine (hr)
	Maximum	Minimum			
July	36.0	24.6	83	563	3.1
August	36.0	23.6	81	319	4.0
September	34.8	24.4	81	279	4.4
October	26.5	19.4	81	22	6.9
November	25.8	16.0	78	00	6.8

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka–1207*

Appendix II. Analysis of variance of the data on plant height at different days after transplanting (DAT) and harvest as influenced by PGR-Bioferti

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at				
		40 DAT	50 DAT	60 DAT	70 DAT	Harvest
Replication	2	1.965	0.513	0.980	11.850	41.880
Treatment	8	13.637*	75.669**	95.362*	89.785*	167.953*
Error	16	5.187	13.969	33.004	26.299	60.287

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

Appendix III. Analysis of variance of the data on yield contributing characters of T. aman rice as influenced by PGR-Bioferti

Source of variation	Degrees of freedom	Mean square					
		Number of effective tiller $hill^{-1}$	Number of in-effective tiller $hill^{-1}$	Total tiller $hill^{-1}$	Number of filled grain $panicle^{-1}$	Number of unfilled grain $panicle^{-1}$	Total grain $panicle^{-1}$
Replication	2	1.351	0.001	1.317	40.130	0.231	46.050
Treatment	8	11.140**	1.387*	5.096*	262.403**	12.030**	171.550*
Error	16	1.303	0.453	1.710	53.329	0.268	49.714

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

Appendix IV. Analysis of variance of the data on length of panicle, weight of 1000 grains, yield and harvest index of T. aman rice as influenced by PGR-Bioferti

Source of variation	Degrees of freedom	Mean square					
		Length of panicle (cm)	Weight of 1000 grains (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	0.819	0.183	0.052	0.087	0.069	9.007
Treatment	8	15.872**	5.603*	1.637**	0.995**	5.108**	13.148
Error	16	3.720	1.864	0.166	0.131	0.476	5.942

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

Appendix V. Analysis of variance of the data on N, P and K concentrations in grain and straw of T. aman rice as influenced by PGR-Bioferti

Source of variation	Degrees of freedom	Mean square					
		Concentration (%) in grain			Concentration (%) in straw		
		N	P	K	N	P	K
Replication	2	0.002	0.0001	0.0001	0.000	0.0001	0.003
Treatment	8	0.035**	0.003**	0.014**	0.006**	0.0001**	0.061**
Error	16	0.002	0.001	0.002	0.001	0.00001	0.009

**: Significant at 0.01 level of probability:

Appendix VI. Analysis of variance of the data on N, P and K uptake by grain and straw of T. aman rice as influenced by PGR-Bioferti

Source of variation	Degrees of freedom	Mean square					
		Uptake by grain (kg ha^{-1})			Uptake by straw (kg ha^{-1})		
		N	P	K	N	P	K
Replication	2	6.366	0.030	0.275	3.215	0.063	35.012
Treatment	8	174.502**	22.390**	57.172**	64.096**	2.037**	501.191**
Error	16	15.942	2.940	9.674	9.997	0.234	65.989

**: Significant at 0.01 level of probability:

Appendix VII. Analysis of variance of the data on nutrient content of post harvest soil of T. aman rice as influenced by PGR-Bioferti

Source of variation	Degrees of freedom	Mean square				
		pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me%)
Replication	2	0.014	0.004	0.0001	6.033	0.0001
Treatment	8	0.041	0.003	0.0008**	225.656**	0.001**
Error	16	0.088	0.009	0.0001	10.996	0.0001

**: Significant at 0.01 level of probability: