EFFECT OF PLANT GROWTH REGULATOR-FLORA ON THE GROWTH AND YIELD OF TRANSPLANTED AMAN RICE

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CERTIFICATE

This is to certify that the thesis entitled **'Effect of Plant Growth Regulator-Flora on the Growth and Yield of Transplanted Aman Rice'** 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 **Nahid Hossain,** Registration No. **09-03506** 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:
Dhaka, Bangladesh

Prof. Dr. Alok Kumar Paul
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Supervisor


DEDICATED
TO
MY BELOVED PARENTS

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The Author

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ABSTRACT

The experiment was conducted in the farm area of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period of July to November, 2015 to find out the effect of plant growth regulator-flora on the growth and yield of transplanted aman rice. BR 11 (Mukta) was used as the test crop for this experiment. The experiment comprised of 8 treatments as- T_0: Control condition (No chemical fertilizer, no Flora), T_1: Recommended Fertilizer Doses-RFD (120, 20, 80, 16 and 2 kg ha^{-1} of N, P, K, S and Zn, respectively), T_2: RFD + 1 time spray of Flora, T_3: RFD + 2 times spray of Flora, T_4: ½ RFD + 1 time spray of Flora, T_5: ½ RFD + 2 times spray of Flora, T_6: No chemical fertilizer + 1 time spray of Flora and T_7: No chemical fertilizer + 2 times spray of Flora. Data on different yield contributing characters, yield, nutrient content in grain and straw, nutrient uptake by grain and straw and characteristics of post harvest soil was recorded and significant variation was observed for different treatments. At harvest, the tallest plant (117.60 cm), the highest number of filled grains $panicle^{-1}$ (86.27), the highest grain yield (5.13 t ha^{-1}) and the highest total nitrogen (0.063%) was recorded from T_3 treatment, whereas the shortest plant (88.85 cm), the lowest number of filled grains $panicle^{-1}$ (68.53), the lowest grain yield (2.78 t ha^{-1}) and the lowest total nitrogen (0.037%) was found in T_0 treatment. Applications of RFD + 2 times spray of Flora was the superior among the other treatments in consideration of yield contributing characters and yield of BR 11 in transplanted aman season.

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CHAPTER I

INTRODUCTION

Rice belongs to the Poeaceae family with the genus *Oryza* which contains about 22 different species (Wopereis *et al*., 2009). It is also the most important food crop for more than one third of the world population (Zhao *et al*., 2011). It is the vital food for 2.4 billion people in Asia, nearly 90% of the world's rice is produced and consumed in this region and more than four hundred millions of people in Africa and Latin America (IRRI, 2011). In worldwide, 474.86 million metric tons of rice was produced from 159.64 million hectares of land during the year of 2014-15 (USDA, 2015). About 84.67% of cropped area of Bangladesh is used for rice production, with annual production of 30.42 million tons from 10.4 million hectare of land (BBS, 2014). Among different rice growing seasons, transplant aman cover about 49.11% and it contributes to 38.11% of the total rice production in the country (BBS, 2014).

The population of Bangladesh is growing by two million every year and may increase by another 30 million over the next 20 years. Thus, Bangladesh will require about 27.26 million tons of rice for the year 2020 (BRRI, 2011). During this time total rice area will also shrink to 10.28 million hectares. Population growth demands a continuous increase in rice production in Bangladesh and it needs to be increased by 53.3% (Mahamud *et al*., 2013). But the cultivable land is reducing each year due to urbanization, industrialization, housing and road construction purposes. Rice yields are decelerating/stagnating/declining in post green revolution era mainly due to imbalance in fertilizer use, soil degradation, irrigation and weeding schedule, type of cropping system practiced, lack of suitable rice variety for low moisture adaptability and disease resistance (Prakash, 2010). In Bangladesh, the average yield of rice is about 2.92 t ha^{-1} (BBS, 2014) 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}) (FAO, 2009).

The growth process of rice plants under a given agro-climatic condition differs with variety (Alam *et al*., 2012). The genetic potentiality of a rice variety is almost fixed, but grain yield can be increased by the manipulation of management practices (BRRI, 1999). Now day's different high yielding and hybrid rice varieties are available in Bangladesh which has more yield potentiality (Bhuiyan *et al*., 2014). At present there is a very little scope for horizontal expansion of rice production in Bangladesh. So the farmers and agricultural scientists are diverting their attention towards vertical expansion for increased crop production. Therefore, attempts should be taken to increase the yield per unit area through the use of modern production technologies that included, use of quality seeds, high yielding and hybrid varieties, optimum age of seedling, optimum number of seedling $hill^{-1}$, adopting proper plant protection measures, seedling raising techniques and fertilizer management.

In Bangladesh, 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. The farmers of our country have a tendency to use indiscriminate amount of macro nutrients and very limited amount of other micro nutrients (Rahman *et al*., 2008). In Bangladesh, 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 decreases of returns and risk of environmental and soil pollution (Sharma *et al.* 2003). On the other hand, under use of non-judicious level 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). So, application of inadequate and imbalanced fertilization to crops is the results of low crop yields.

Flora is a plant growth regulator containing 20% Nitro Benzene and acts as a plant energizer, flowering stimulant and yield booster. The use of plant growth regulator (PGR) in rice in Bangladesh is very little so the requirement is to properly understand the PGR to enhance high yield and quality. Suitable PGR are necessary for sustainable agriculture that will provide maximum rice production with good quality (Aziz and Miah, 2009). PGR has 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). It regulates cell elongation, tissue swelling, cell division and formation of adventitious roots, among others (Woodward and Bartel, 2005; Abel and Theologis, 2010) and also participates in the regulation of growth and development processes (Sakamoto *et al*., 2004; Mohammed and Tarpley, 2011; Fahad *et al*., 2015). Application of PGR partially alleviates the detrimental effects of rice senescence by modulating the activity of enzymatic antioxidants, and improving antioxidant system, which helps in sustaining plant growth (Pan *et al*., 2013).

Based on above proposition, this research work was designed to evaluate the growth and yield of transplanted aman rice as affected by plant growth regulators-flora with the following objectives:

- To observe the effect of foliar application of flora on the growth and yield of transplanted aman rice;
- To observe the combined effect of recommended dose of fertilizer (RDF) and flora on the growth and yield of transplanted aman rice.

CHAPTER II

REVIEW OF LITERATURE

Rice is the main food crop of the people of Bangladesh and the World. Yield and yield contributing characteristics of rice are considerably depended on manipulation of basic ingredients of agriculture. The basic ingredients include varieties of rice, environment and agronomic practices (planting time, number of seedlings $hill^{-1}$, plant density, fertilizer, irrigation etc.). Research on this crop is going on various aspects in increase its potential yield including use of recommended dose of fertilizer and plant growth regulators which are responsible for the growth and yield of rice. Different researcher reported the effect of recommended dose of fertilizer and plant growth regulators on yield attributes and grain yield but in Bangladesh condition it is not adequate and conclusive. An attempt was taken to review the available important and informative works and research findings that are related to the recommended dose of fertilizer and plant growth regulators on the yield and yield attributes of rice as below under the following headings-

2.1 Chemical fertilizers on yield attributes and yield of rice

Asif *et al.* (2000) carried out an experiment and found that NPK levels significantly increased the panicle length, number of primary and secondary branches $panicle^{-1}$ when NPK fertilizer applied in 180-90-90 kg ha^{-1} this might be attributed to the adequate supply of NPK for the plant and produced the highest yield compared to other.

Haq *et al.* (2002) carried out a field experiment with twelve treatments combination of N, P, K, S, Zn and Diazinon with objectives to find out the optimum doses of N, P, K, S, Zn for rice cultivation. They found that all the treatments significantly increased the grain and straw yields of BRRI dhan30 rice over control. 90 kg N + 50 kg P_2O_5 + 40 kg K_2O + 10 kg S + 4 kg Zn ha^{-1} + diazinon gave the highest grain and straw yields.

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

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

Phaev *et al*. (2003) found that freshly applied P increased rice grain yield by 95%. In the first and second crops using residual P fertilizer, yields increased by 62 and 33% relative to the P-control plot. Cumulative removal of P in four successive rice crops accounted for 30 and 55% of the 16.5 kg ha^{-1} in the form of harvested grain and whole plants.

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

Saleque *et al*. (2004) studied with six treatments viz. absolute control (T_1), 1/3 of RFD (T_2), 2/3 of RD (T_3), full doses of RF (T_4), T_2 + 5 t cowdung and 2.5 t ash ha^{-1} (T_5) and T_3 + 5 t cowdung ha^{-1} + 2.5 t ash ha^{-1} (T6) were compared. The results showed that application of cowdung and ash (T_5 and T_6) increased rice yield by about 1 t ha^{-1} $year^{-1}$ over that obtained with chemical fertilizer alone.

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

Saleque *et al*. (2005) carried out an experiment and reported a linear relationship between P uptake and total system productivity which supports the concept that TSP depends to some extent on P availability. Phosphorus application increased rice yield in different seasons where the highest response in P was in Aus and Boro than T. Aman.

Hossain *et al.* (2005) carried out a study to assess the effects of nitrogen (30, 60, 90 and 120 kg ha^{-1} N) and phosphorus (20, 40 and 60 kg ha^{-1} P_2O_5) on the growth and yield of rice/sorghum inter-crop. Application of nitrogen up to 90 kg ha^{-1} enhanced the growth and yield of rice crop and application of phosphorus @ 40 kg ha^{-1} P_2O_5 resulted in higher growth and yield of rice crop.

Jumei *et al*. (2005) conducted a field experiment in Qiyang, Hunan province, a typical red soil region of southern China, to study the effects of organic and inorganic N fertilizers on ammonia volatilization and rice yield in paddy soil. Four treatments were PK treatment as control, NPK treatment (urea as N), NPKM treatment (half chemical fertilizers + half manure), M treatment (pig manure as N), same amount of N, P, K either organic or inorganic forms (N 150 kg m^{-2}, P_2O_5 100.5 kg m^{-2} and K_2O 109.5 kg m^{-2}) were applied in each plot. All fertilizers were applied once as base fertilizers before one day of rice transplanted. The rice yields of NPKM, NPK, M treatments were increased by 68.6%, 68.1% and 60.0% respectively for early rice, and increased by 72.0%, 69.6% and 34.2% for late rice compared with control treatment. Not only the

yield of rice with NPKM treatment increased by 70 % averagely compared with PK treatment, but also the nitrogen loss was less compared with NPK treatment. N use efficiency of NPKM treatment was 34.9%, higher than that of NPK treatment (33.2%) and M treatment (28.0%).

Mashkar and Thorat (2005) conducted a field experiment to study the effects of different nitrogen levels (0, 40, 80 and 120 kg ha^{-1} N, respectively) on N, P and K uptake and grain yield of scented rice cultivars (Pula Basmati 1, Kasturi, Indrayani and Sugandha). The different levels of N had significant effect in augmenting the uptake of N, P and K nutrients and grains as well as straw yield of rice. Application of 120 kg ha^{-1} N recorded significantly higher N, P and K uptake in rice compared to the rest of the N levels. Every increment of 40 kg ha^{-1} N from 0 to120 kg ha^{-1} N increased the nutrient content and uptakes.

A field experiment was conducted by Rahman *et al.* (2007) a using rice (cv. BRRI dhan29) as a test crop and found that application of S had a significant positive effect on tillers ha^{-1}, plant height, panicle length and grains $panicle^{-1}$. They also indicated that application of S fertilizer at a recommended rate (20 kg S/ha) might be necessary for obtaining higher grain yield as well as straw yield of Boro rice (cv BRRI dhan29).

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

An experiment was conducted by Islam *et al.* (2008) to determine the response and the optimum rate of nutrients (NPK) for Chilli- Fallow-T. *aman* cropping

pattern. They found that grain yield influenced significantly due to application of different rates of nutrients and 60-19-36 kg ha^{-1} NPK maximized the yield of T. Aman rice varieties in respect of yield and economics.

Naing *et al*. (2010) investigated the effect of organic and inorganic fertilizers on growth and yield of five upland black glutinous rice varieties and soil property. Experiments were laid out in a split–plot design with four replications. Four fertilizer treatments (control, FYM or cattle manure @ 10 t ha^{-1}, NPK at the rate of 50–22–42 kg N–P–K ha^{-1}, the combination of the FYM and NPK were randomized in the main plots and five black glutinous rice varieties were randomized in the sub plots. Number of tillers and panicles per hill and grains per panicle, thousand grain weight, number of filled and unfilled grains and grain yield were recorded at harvest time. The results from both years indicated that using the combination of FYM cattle manure and inorganic fertilizers increased tiller and panicle number per hill, grain number per panicle and grain yield.

Hossaen *et al*. (2011) studied on the yield and yield attributes of Boro Rice due different organic manure and inorganic fertilizer. At 30, 50, 70, 90 DAT and at harvest stage the tallest plant (24.18, 31.34, 44.67, 67.05 and 89.00 cm) and the greatest number of total tillers $hill^{-1}$ (5.43, 11.64, 21.01 and 17.90) at same DAT was recorded from T_5 (70% NPKS +2.4 t PM ha^{-1}) and the lowest was observed from T0 (control) in every aspect. The maximum number of effective tillers $hill^{-1}$ (13.52), the longest panicle (24.59 cm), maximum number of total grains $plant^{-1}$ (97.45), the highest weight of 1000 seed (21.80 g), the maximum grain yield (7.30 t ha^{-1}) and straw yield (7.64 t ha^{-1}) was recorded from T_5 treatment whereas the lowest number of effective tillers $hill^{-1}$ (6.07), the shortest panicle (16.45 cm), the minimum total grains $plant^{-1}$ (69.13) , the lowest weight of 1000 seed (16.73 g), the lowest grain yield (2.06 t ha^{-1}) and straw yield (4.63 t ha^{-1}) was observed from T_0. Treatment T_5 also showed the highest biological yield and harvest index.

Dey (2012) found that the highest grain (6.20 t ha^{-1}) and straw yields (7.75 t ha^{-1}) were produced by the T_7 (USG at transplanting + 50% PKS at transplanting + 50% PKS at maximum tillering) treatment. The P, K and S uptake by BRRI dhan29 significantly increased due to split fertilization. So, split application of P, K and S fertilizers along with USG exerted a beneficial effect on yield contributing characters, resulting in higher grain and straw yields for BRRI dhan29 as compared to their single application.

Basu *et al*. (2012) conducted a field experiment to study the quality aspect of rice (cv. BRRI dhan28) as response to chemical fertilizers and organic manure (cowdung) treatments comprised of four doses of chemical fertilizers (0, 0.5, 0.75 and full recommended dose) and four cowdung doses (0, 1.0, 1.5, two times of full recommended dose). The grain yield ranged from 1.92 to 4.58 t ha^{-1}. The highest grain yield was observed in treatment containing the full recommended dose of chemical fertilizers along with the double dose of cowdung (F1M3) and it was the lowest in without chemical fertilizers and recommended dose of cowdung (F_0M_1). Application of cowdung and chemical fertilizers had significant effect on the content of N, P, K, S, Ca, Mg, B, Zn, protein, starch and amylose in rice grain. Grain yield of rice was increased by application of half the recommended dose of chemical fertilizers along with recommended dose of cowdung.

Vetayasuporn (2012) conducted an experiment to determine the effects of organic–chemical fertilizer and chemical fertilizer (NPK 16:16:8) on the growth and yield of rice in acidic soil of Roi-Et province, Northeast Thailand. Five treatments were compared consisting of: T_1 (control without fertilizer); T_2 (312.5 kg ha^{-1} organic-chemical fertilizer); T3 (625 kg ha^{-1} organic–chemical fertilizer); T_4 (937.5 kg ha^{-1} organic–chemical fertilizer) and T_5 (chemical fertilizer; 312.5 kg ha^{-1} NPK 16:16:8). Yield of rice grains under all treatments increased between 2-4 times when compared to the control (1.37 t ha^{-1}). Application of organic-chemical fertilizer alone showed 2-2.5 times (2.66-3.43 t ha^{-1}) increased

yield of grains over the control. However, maximum grain yield (5.57 t ha^{-1}) was obtained from T_5 (chemical fertilizer) which also gave the highest all yield parameters such as number of grain per panicle (108.20), total number panicle per hill (14.82), plant height (62.48 cm) and percentage of filled grain (82.17%).

Tasnin (2012) observed that the height of rice plant, number of leaves, number of tillers and dry matter accumulation per hill was significantly higher with application of 50% recommended NPK through fertilizers + 50% N through gliricidia, which was closely followed by 50% recommended NPK through fertilizers + 50% N through FYM. Rice supplied with 50% recommended NPK through fertilizers + 50% N through gliricidia produced higher number of panicles per hill, length of panicles, number of grains and weight of grains per panicle. They also observed that Application of 50% recommended NPK through fertilizers + 50% N through gliricidia, 50% recommended NPK through fertilizers + 50% N through FYM to rice recorded 105.41 and 103.33% higher grain yield compared to that of 100% recommended NPK, respectively, while 50% recommended NPK through fertilizers + 50% N through gliricidia produced higher straw yield of rice followed by 50% FYM substitution.

Hossain (2013) conducted an experiment to investigate the effects of inorganic fertilizers alone and in combination with different organic fertilizers in order to achieve high yield and sustainable soil chemical and organic matter balance. The experiment was conducted at the field laboratory of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. The treatment combinations were T_1 (NPK), T_2 (NPK+ FYM), T_3 (NPK+ Vermicompost), T_4 (NPK+ Rotten Rice Straw) and T_5 (NPK+ Poultry Manure). The results showed that grain and straw yields of wheat were significantly influenced by the treatments. The highest grain yield was obtained in T_2 followed by T_3 and T_5. The grain yield of wheat due to different treatment followed the order of: $T_2>T_3>T_5>T_4>T_1$ with the record of 2.48, 2.28, 1.83, 1.82 and 1.59 t ha^{-1}, respectively.

A field trial was conducted by Wu *et al*. (2013) with Fuyou 33, a new rice variety derived from the cross Yanfeng 47 × H1024in Liaoning with 5 treatments [N application 135 (E_1), 187.5 (E_2), 240 (E_3), 242.5 (E_4), and 345 kg/ha (E_5)] to investigate the effect of nitrogen application on growth characters and yield of Fuyou 33. It was found that increasing nitrogen amounts could increase harvested panicles, leaf area index in the full heading stage, photosynthetic rates of flag leaf, and dry weight accumulation in the maturity stage, but had a negative effect on productive panicle rates, the rate of dry matter accumulation in the grain yield after heading, and harvest index and the highest yield was marked in E3 at 9.22 ton ha^{-1}.

Sukristiyonubowo *et al*. (2013) reported that the application of 2 ton ha–1 year–1 dolomite, 2 ton ha^{-1} $season^{-1}$ rice straw compost and mineral fertilizers (200 kg urea, 100 kg SP–36 and 100 kg KCl ha^{-1} $season^{-1}$) improve the rice yield by combined addition of organic matter (straw compost), lime and mineral fertilizer. With these applications the rice yield was observed about 3.5 – 4.2 tons ha^{-1} $season^{-1}$ can be reached under weathered soils, especially ultisols and oxisols.

An experiment was conducted by Rattanapichai *et al*. (2013) to study the effects of various soil conditioners, MK doses (0, 1.56, 3.12 and 6.25 tons ha^{-1}) and NPK fertilizers (16-8-8 and 16-16-8) on growth and yield of rice grown in acid sulfate soil in Thailand, a Rangsit (Rs) soil series. The result showed that application of MK caused an increase in tillers per plants, biomass and grain yield as well as silicon uptake. However, there was no effect on native phosphorus in soil and phosphorus uptake. The 16-16-8 fertilizer application increased the number of tillers per plants; shoots dry matter and grain yield were higher than in 16-8-8 fertilizer model. Grain yields showed highest response when 1.56 $kgha^{-1}$ of MK (0.63 kg grain kg^{-1} MK) was applied, and the harvest index was highest as well.

Islam *et al*. (2013) studied to evaluate the effect of nitrogen supplied from organic sources and inorganic source (urea) on the yield and nitrogen use efficiency of BRRI dhan28. The treatments were T_0 (Control), T_1 (100% N from RFD), T_2 (70% N from RFD, RFD + 30% N from CD), T_3 (70% N from RFD + 30% N from PM), T_4 (70% N from RFD + 30% N from CoM), T_5 [70% N from RFD + 30% N from (CD + PM + CoM)], T_6 [100% N from (CD + PM + CoM), T_7 [100% N from RFD + 30% N from (CD + PM + CoM)]. The highest grain yield of 5847 kg ha^{-1} was observed in the treatment T_7 and the lowest grain yield of 2426 kg ha^{-1} was found in T_0. The highest N uptake (138.9 kg ha^{-1}) was found in T_7 followed by T_1 (119.8 kg ha^{-1}).

Sarkar (2014) found that the application of 75% RD of inorganic fertilizers + 50% cowdung showed superiority in terms of plant height (123.3 cm) and total tillers $hill^{-1}$ (13.87) where those were also highest in combination of BRRI dhan34 × 75% RD of inorganic fertilizers + 50% cowdung. Nutrient management of 75% RD of inorganic fertilizers + 50% cowdung (5 t ha^{-1}) gave the highest grain yield (3.97 t ha^{-1}) and the lowest grain yield (2.87 t ha^{-1}) was found in control. The highest grain yield (4.18 t ha^{-1}) was found in BRRI dhan34 coupled with 75% RD of inorganic fertilizers + 50% cowdung and the lowest grain yield (2.7 t ha^{-1}) was found in BRRI dhan37 in control.

Islam *et al*. (2014) found that the yield contributing characters like plant height, effective tillers $hill^{-1}$, panicle length and grains $panicle^{-1}$ of BRRI dhan49 were significantly influenced by the application of manures and fertilizers. The highest grain yield of 4.87 t ha^{-1} was observed in the treatment T_3 [PM + STB–CF (HYG)] and the lowest value of 3.61 t ha^{-1} was found in T_0 i.e. control condition. The straw yield also ranged from 4.10 to 5.51 t ha^{-1} due to the different treatments. The NPKS uptake by BRRI dhan49 was markedly influenced by manures and fertilizers under this field conditions. Based on overall experimental results, the treatment T_3 [PM + STB–CF (HYG)] was found

to be the best combination of manures and fertilizers for obtaining the maximum yield and quality of BRRI dhan49 rice variety.

The experiment was carried out by Pandey *et al*. (2014) at research farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh India. Experiment was comprised of different levels of inorganic fertilizer (NPK) and its conjunction with different organic fertilizers. Yield and yield attributing characters was significantly increased with increasing fertilizer levels from 50:30:20 kg, NPK ha^{-1} to 150:80:60 kg, NPK ha^{-1} during both the year of experiment. Grain yield and yield attributes were significant among different treatments. Application of 100:60:40 kg NPK ha^{-1} + blending of N with cow–dung urine (T_9) or poultry manure (T_{10}) resulted higher effective tillers, panicle length, and test weight which is statistically at par to that of inorganic level 150:80:60 kg NPK ha^{-1} (T_1). Almost similar trend was noticed when said organic fertilizer was combined with lower level of inorganic fertilizer (50:30:20 kg NPK ha^{-1}), which tended to produced above yield components comparable to that of inorganic fertilizer level of 100:60:40 kg NPK ha^{-1}. Thus it was concluded that use of inorganic fertilizer with different organic fertilizers sources are better for sustaining growth, yield and nutrient uptake by hybrid rice.

A long term (33 years) experiments were conducted by China *et al*. (2014) experimental site locates at the experimental farm of the Research Institute of Red Soil of Jiangxi province, Jinxian county, China ($28^0 21^/$N, $116^0 10^/$E). From the different experiment they concluded that the impact of fertilizers on grain yields was 2NPK > NPK > NP > NK > N, and application of P fertilizer not only increased the rice yield, but improved yield stability.

2.2 Plant growth regulators-PGR on yield attributes and yield of rice

Gurmani *et al*. (2006) carried out a pot experiment 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). Seeds of each cultivar were soaked prior to sowing with ABA and BA each at 10^{-5} M and CCC 10^{-6} M for 24 hour. 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. 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 and the findings of the study revealed that traits are augmented by ABA more effectively than BA.

An experiment was conducted by Aziz and Miah (2009) at Bangladesh Rice Research Institute farm and another experiment at farmer's field, Samantopur, Gazipur during the T. aman season, in order to determine the performance of flora on the growth and yield of wetland rice. The following four treatment combinations were tested in both site as T_1= Control (No-fertilizer), T_2= Flora @ 3 ml/L of water, T_3= Soil Test Based (STB) dose and T_4= T_3 + Flora @ 3 ml/L of water. BRRI dhan31 was used as test crop. The treatment T_4 where chemical fertilizer was applied on STB in combination with flora produced the maximum yield but in terms of economic point of view the treatment T_3 (STB) was found superior to other treatments.

An experiment was conducted by Bakhsh *et al*. (2011) to find out the growth behaviour of transplanted coarse rice (IR-6) as influenced by plant growth regulator (NAA) at 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, growth stages of paddy rice and their interactions 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.

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 (Pan *et al*., 2013). 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/panicle, seed setting rate and grain yields in Peizataifeng and Huayou86. 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.

An experiment was conducted by Fahad *et al*. (2016) with the objectives 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. 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) carried out an 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 GA_3 at 60 ml/ha. Comparing the ATONIK rates with the GA_3, 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 GA_3 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.

Above cited literature revealed that the effect of recommended dose of fertilizers-RDF (nitrogen, phosphorus, potassium, sulphur and zinc) and plant growth regulators-PGR significant in terms of yield attributes and yield of rice and suggests that RDF and PGR significantly increased the grain yield of rice in different growing seasons.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to find out the effect of plant growth regulator-flora on the growth and yield of transplanted aman rice. The details of the materials and methods i.e. experimental period, location, soil and climatic condition of the experimental area, materials used, treatment and design of the experiment, growing of crops, data collection and data analysis procedure that followed in this experiment has been presented under the following headings:

3.1 Description of the experimental site

3.1.1 Experimental period

The experiment was conducted during the period of July to November, 2015.

3.1.2 Experimental location

The present research work was conducted in the farm area of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is $23^0 74^/$N latitude and $90^0 35^/$E longitude with an elevation of 8.4 meter above from sea level. Experimental location presented in Appendix I.

3.1.3 Soil characteristics

The soil belonged to Tejgaon series under “Modhupur Tract”, AEZ-28 (FAO, 1988). Top soil was Silty Clay Loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 6.2 and had organic carbon 0.43%. The study area was flat having available irrigation and drainage system and above flood level. The details have been presented in Table 1 and 2.

3.1.4 Climatic condition

The geographical location of the experimental site was under the subtropical climate and its climatic conditions is characterized by three distinct seasons, namely winter season from the month of November to February, the pre-monsoon period or hot season from the month of March to April and monsoon period from the month of May to October (Edris *et al*., 1979). Details of the meteorological data of the experimental period are presented in Appendix II.

Table 1. Morphological characteristics of the experimental field

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

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)	6.2
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

Source: SRDI, Khamarbari, Farmgate, Dhaka

3.2 Experimental details

3.2.1 Planting material

In this experiment BR 11 (Mukta) was used as the test crop which 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).

3.2.2 Treatment of the experiment

The experiment comprised of the following 8 treatment:

T_0: Control condition (No chemical fertilizer, no Flora)

T_1: Recommended Fertilizer Doses-RFD (120, 20, 80, 16 and 2 kg ha^{-1} of N, P, K, S and Zn, respectively)

T_2: RFD + 1 time spray of Flora

T_3: RFD + 2 times spray of Flora

T_4: ½ RFD + 1 time spray of Flora

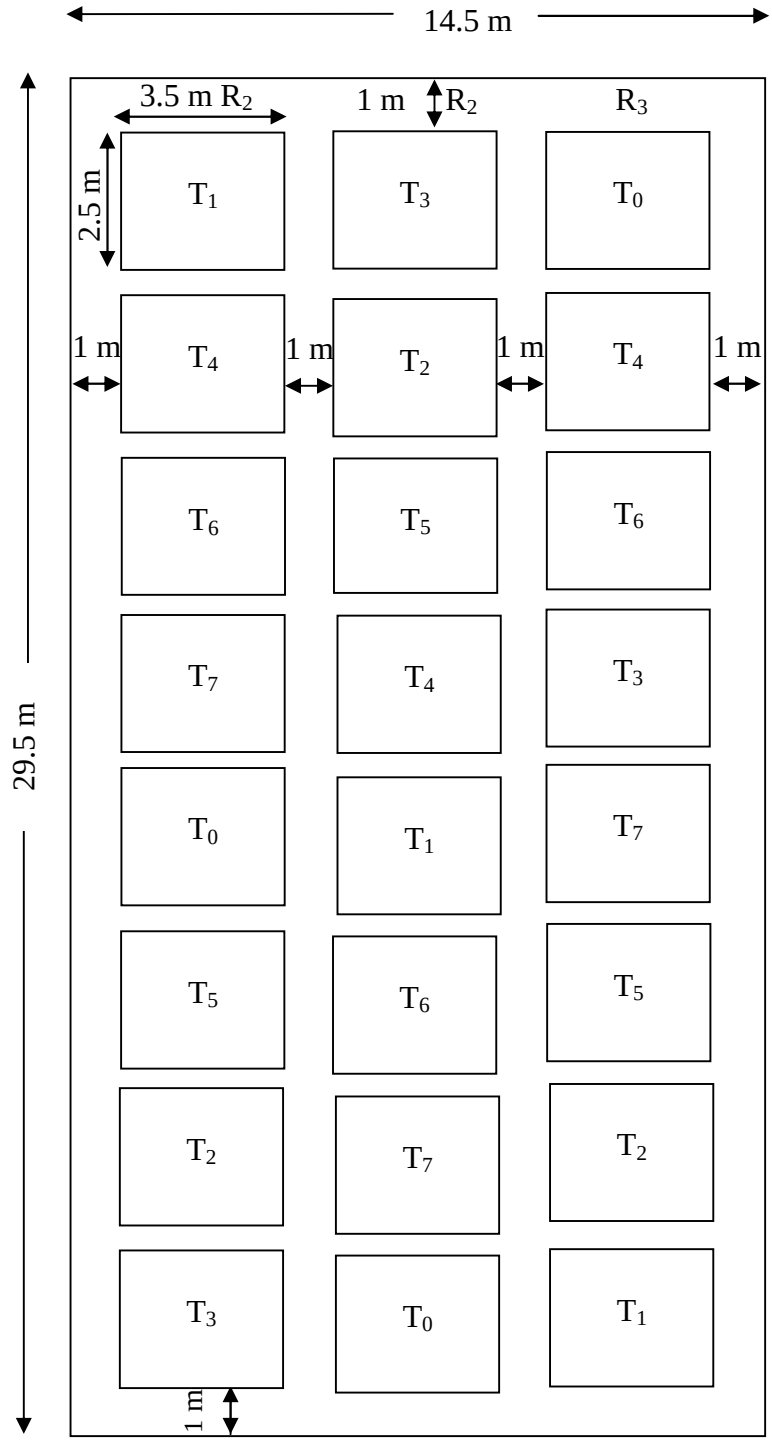
T_5: ½ RFD + 2 times spray of Flora

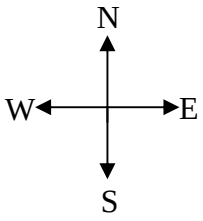
T_6: No chemical fertilizer + 1 time spray of Flora

T_7: No chemical fertilizer + 2 times spray of Flora

3.2.3 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. An area of 29.5 m × 14.5 m was divided into 3 blocks. The size of the each unit plot was 3.5 m × 2.5 m. The space between two blocks and two plots were 0.75 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.





Plot size: 3.5 m × 2.5 m

Plot spacing: 50 cm

Between replication: 1.0 m

Treatment

T_0: Control condition (No chemical fertilizer, no Flora)

T_1: Recommended Fertilizer Doses-RFD (120, 20, 80, 16 and 2 kg ha^{-1} N, P, K, S and Zn, respectively)

T_2: RFD + 1 time spray of Flora

T_3: RFD + 2 times spray of Flora

T_4: ½ RFD + 1 time spray of Flora

T_5: ½ RFD + 2 times spray of Flora

T_6: No chemical fertilizer + 1 time spray of Flora

T_7: No chemical fertilizer + 2 times spray of Flora

Figure 1. Layout of the experimental plot

3.3 Growing of crops

3.3.1 Seed collection and sprouting

Seeds were collected from BRRI (Bangladesh Rice Research Institute), Gazipur and local market just 20 days ahead of the sowing of seeds in seed bed. For seedling raising clean seeds were immersed in water in a bucket for 24 hours. The imbibed seeds were then taken out of water and kept in gunny bags. The seeds started sprouting after 48 hours which were suitable for sowing in 72 hours.

3.3.2 Raising of seedlings

The nursery bed was prepared by puddling with repeated ploughing followed by laddering. The sprouted seeds were sown on beds on 1st July, 2015 as uniformly as possible. Irrigation was gently provided to the bed as and when needed. No fertilizer was used in the nursery bed.

3.3.3 Land preparation

The plot selected for conducting the experiment was opened in the 20th July 2015 with a power tiller, and left exposed to the sun for 4 days. After o4 days the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good puddle condition. Weeds and stubbles were removed. The experimental plot was partitioned into unit plots in accordance with the experimental design. Organic and inorganic manures as indicated below were mixed with the soil of each unit plot.

3.3.4 Fertilizers and manure application

The fertilizers N, P, K, S and Zn in the form of urea, TSP, MoP, Gypsum and zinc sulphate, respectively were applied @ 120 kg, 20 kg, 80 kg, 16 kg and 2.0 kg ha^{-1} (BRRI, 2013). The entire amounts of TSP, MoP, gypsum and zinc sulphate were applied during the final preparation of experimental plot. Urea was applied in two equal installments as top dressing at tillering and panicle initiation stages.

3.3.5 Transplanting of seedling

Twenty five days old seedlings were carefully uprooted from the seedling nursery and transplanted on 25 July, 2015 in well puddled plot. 2/3 number of seedlings $hill^{-1}$ was transplanted in each hill. After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings of the same source whenever required followed by the treatment of number of seedlings $hill^{-1}$.

3.3.6 Application of PGR-Flora

PGR-Flora was collected from Siddique Bazaar, Dhaka and applied as per treatment with mixing 2.0 ml Flora with 500 ml water for per plot. 1^{st} spray was done at 5 September at late tillering stage and 2^{nd} spray at 20 September, 2015 at early panicle initiation stage in the specific plot as per treatment.

3.3.7 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:

3.3.7.1 Irrigation and drainage

In the early stages to establishment of the seedlings irrigation was provided to maintain a constant level of standing water upto 6 cm and then maintained the amount drying and wetting system throughout the entire vegetative phase. No water stress was encountered in reproductive and ripening phase. The plot was finally dried out at 15 days before harvesting.

3.3.7.2 Weeding

Weedings were done to keep the plots free from weeds, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully at 25 DAT and 45 DAT by sickles.

3.3.7.3 Insect and pest control

There was no infection of diseases in the field but leaf roller (*Chaphalocrosis medinalis*) was found in the field and used Malathion @ 1.12 L ha^{-1} at 30 DAT with using a hand sprayer.

3.4 Harvesting, threshing and cleaning

The crop was harvested at full maturity at 05th November, 2015 when 80-90% of the grains were turned into straw colored. The harvested crop was bundled separately, properly tagged and brought to threshing floor. Enough care was taken during threshing and cleaning period of rice grain. Fresh weight of rice grain and straw were recorded plot wise from 1 m^2 area. The grains were dried up to moisture content 14%, then cleaned and weighed for individual plot. Yields of rice grain and straw 1 m^{-2} were recorded from each plot and converted to hectare yield and expressed in t ha^{-1}.

3.5 Data recording

3.5.1 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.

3.5.2 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.

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

The total number of in-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.

3.5.4 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.

3.5.5 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.

3.5.6 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.

3.5.7 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.

3.5.8 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.

3.5.9 Weight of 1000 seeds

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

3.5.10 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 and five sample plants were added to the respective unit plot yield to record the final grain yield plot^{-1} and finally converted to t ha^{-1}.

3.5.11 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 and five sample plants were added to the respective unit plot yield to record the final straw yield $plot^{-1}$ and finally converted to t ha^{-1}.

3.5.12 Biological yield

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

Biological yield = Grain yield + Straw yield.

3.5.13 Harvest index

Harvest index was calculated from the grain and straw yield of rice for each plot and expressed in percentage.

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

3.6 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.

3.7 Soil analysis

Soil samples were analyzed for both physical and chemical characteristics viz. pH, organic matter, total N, available P and Exchangeable K contents. The soil samples were analyzed by the following standard methods as follows:

3.7.1 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 as described by Page *et al.*, 1982.

3.7.2 Organic matter

Organic carbon in soil sample was determined by wet oxidation method (Page *et al.*, 1982). 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.

3.7.3 Total nitrogen

Total N content of soil were determined followed by the Micro Kjeldahl method. One gram of oven dry ground 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 added. 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 clear and colorless. After cooling, the content was taken into 100 ml volumetric flask and the volume was made up to the mark with distilled water. A reagent blank was prepared in a similar manner. These digests were used for nitrogen determination (Page *et al.*, 1982).

Then 20 ml digest solution was transferred 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 flask under the condenser outlet of the distillation apparatus so that the delivery end dipped in the acid. Add sufficient amount of 10N-NaOH solutions in the container connecting with distillation apparatus. Water runs through the condenser of distillation apparatus was checked. Operating switch of the distillation apparatus collected the distillate. The conical flask was removed by washing the delivery outlet of the distillation apparatus with distilled water. Finally the distillates were 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:

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

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

W = Sample weight in gram

3.7.4 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).

3.7.5 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).

3.8 Statistical Analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference of different treatments. The mean values of all the characters were calculated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the differences among the treatment means were estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to find out the effect of plant growth regulator-flora on the growth and yield of transplanted aman rice. Data on different yield contributing characters, 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 III-VI. The finding of the study have been presented and discussed with the help of Table and Graphs under the following headings:

4.1 Yield attributes and yield of rice

4.1.1 Plant height

Statistically significant variation was recorded in terms of plant height due to the effect of different treatments at 40, 50, 60, 70 DAT (days after transplanting) and harvest (Appendix III). At 40 DAT, the tallest plant (25.76 cm) was observed in T_3 (RFD + 2 times spray of Flora) which was statistically similar (25.33 cm, 24.32 cm, 23.29 cm, 22.27 cm, 22.00 cm and 21.44 cm, respectively) to T_2 (RFD + 1 time spray of Flora), T_1 (Recommended Fertilizer Doses-RFD: 120, 20, 80, 16 and 2 kg ha^{-1} of N, P, K, S and Zn, respectively), T_5 (½ RFD + 2 times spray of Flora), T_4 (½ RFD + 1 time spray of Flora), T_7 (No chemical fertilizer + 2 times spray of Flora) and T_6 (No chemical fertilizer + 1 time spray of Flora), whereas the shortest plant (18.60 cm) was observed in T_0 (Control condition i.e. no chemical fertilizer, no flora) treatment (Table 3). Similar tends of results also recorded at 50, 60 and 70 DAT. At harvest, the tallest plant (117.60 cm) was recorded from T_3 treatment, which was statistically similar with other treatment except T_0, while the shortest plant (88.85 cm) was found in T_0 treatment. 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 but management practices also influenced it. Ndaeyo *et al.* (2008) reported that NPK (15:15:15) fertilizer rate significantly increased plant height.

Table 3. Effect of Plant Growth Regulator-Flora on plant height at different days after transplanting (DAT) and harvest of transplanted aman rice

Treatments	Plant height (cm) at				
	40 DAT	50 DAT	60 DAT	70 DAT	Harvest
T_0	18.60 b	41.90 d	62.96 c	73.27 d	88.85 b
T_1	24.32 a	51.76 a-c	79.97 ab	91.96 a-c	112.80 a
T_2	25.33 a	52.73 ab	81.61 ab	93.51 ab	115.00 a
T_3	25.76 a	54.24 a	83.42 a	97.81 a	117.60 a
T_4	22.27 ab	48.24 bc	74.37 a-c	85.59 bc	108.56 a
T_5	23.29 a	49.33 a-c	76.55 ab	88.91 a-c	110.56 a
T_6	21.44 ab	46.73 cd	70.51 bc	82.03 cd	107.19 a
T_7	22.00 ab	47.62 bc	73.83 a-c	83.70 bc	109.25 a
$LSD_{(0.05)}$	3.906	5.047	10.66	9.435	10.07
Significance level	0.05	0.01	0.05	0.01	0.01
CV(%)	9.75	5.87	8.07	6.19	5.29

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_0: Control condition (No chemical fertilizer, no Flora)

T_1: Recommended Fertilizer Doses-RFD (120, 20, 80, 16 and 2 kg ha^{-1} of N, P, K, S and Zn, respectively)

T_2: RFD + 1 time spray of Flora

T_3: RFD + 2 times spray of Flora

T_4: ½ RFD + 1 time spray of Flora

T_5: ½ RFD + 2 times spray of Flora

T_6: No chemical fertilizer + 1 time spray of Flora

T_7: No chemical fertilizer + 2 times spray of Flora

4.1.2 Number of effective tillers hill^{-1}

Number of effective tillers hill^{-1} showed statistically significant differences due to the effect of different treatments (Appendix IV). The highest number of effective tillers hill^{-1} (16.13) was found in T_3 which was statistically similar (15.80, 15.33, 14.73, 14.60 and 14.20, respectively) to T_2, T_1, T_5, T_7 and T_4, and closely followed (13.87) by T_6, while the lowest number of effective tillers hill^{-1} (10.27) was recorded in T_0 treatment (Table 4). 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 ineffective tillers hill^{-1}

Statistically significant variation was recorded in terms of number of ineffective tillers hill^{-1} due to the effect of different treatments (Appendix IV). The lowest number of ineffective tillers hill^{-1} (2.27) was observed in T_3 which was statistically similar (2.40) to T_2 and closely followed (2.67) by T_1. On the other hand, the highest number (4.33) was found in T_0 treatment (Table 4).

4.1.4 Total tillers hill^{-1}

Number of total tillers hill^{-1} showed statistically significant differences due to the effect of different treatments (Appendix IV). The highest number of total tillers hill^{-1} (18.40) was found in T_3 which was statistically similar with other treatment except T_0, while the lowest number of total tillers hill^{-1} (14.60) was observed in T_0 treatment (Table 4). Ndaeyo *et al.* (2008) reported that NPK (15:15:15) fertilizer rate significantly increased tillers per plant.

4.1.5 Number of filled grains panicle^{-1}

Statistically significant variation was recorded in terms of number of filled grains panicle^{-1} due to the effect of different treatments (Appendix IV). The highest number of filled grains panicle^{-1} (86.27) was recorded in T_3 which was statistically similar (84.27, 81.73, 81.67, 80.20 and 79.40, respectively) to T_2, T_5, T_1, T_4 and T_7, and closely followed (77.60) by T_6, whereas the lowest number of filled grains panicle^{-1} (68.53) was found in T_0 treatment (Table 4).

Table 4. Effect of Plant Growth Regulator-Flora on yield contributing characters of transplanted aman rice

Treatments	Number of effective tillers hill^{-1}	Number of in-effective tillers hill^{-1}	Total tillers hill^{-1}	Number of filled grains panicle^{-1}	Number of unfilled grains panicle^{-1}
T_0	10.27 c	4.33 a	14.60 b	68.53 c	9.67 a
T_1	15.33 ab	2.67 d	18.00 a	81.67 ab	7.13 b-d
T_2	15.80 ab	2.40 de	18.20 a	84.27 ab	6.60 cd
T_3	16.13 a	2.27 e	18.40 a	86.27 a	6.13 d
T_4	14.20 ab	3.20 c	17.40 a	80.20 ab	7.27 b-d
T_5	14.73 ab	3.07 c	17.80 a	81.73 ab	7.00 b-d
T_6	13.87 b	3.67 b	17.53 a	77.60 b	8.20 b
T_7	14.60 ab	3.33 c	17.93 a	79.40 ab	7.60 bc
$LSD_{(0.05)}$	1.963	0.271	2.130	7.367	1.150
Significance level	0.01	0.01	0.05	0.01	0.01
CV(%)	7.80	4.98	6.96	5.26	8.81

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_0: Control condition (No chemical fertilizer, no Flora)

T_1: Recommended Fertilizer Doses-RFD (120, 20, 80, 16 and 2 kg ha^{-1} of N, P, K, S and Zn, respectively)

T_2: RFD + 1 time spray of Flora

T_3: RFD + 2 times spray of Flora

T_4: ½ RFD + 1 time spray of Flora

T_5: ½ RFD + 2 times spray of Flora

T_6: No chemical fertilizer + 1 time spray of Flora

T_7: No chemical fertilizer + 2 times spray of Flora

4.1.6 Number of unfilled grains panicle^{-1}

Number of unfilled grains panicle^{-1} showed statistically significant differences due to the effect of different treatments (Appendix IV). The lowest number of unfilled grains panicle^{-1} (6.13) was observed in T_3 which was statistically similar (6.60, 7.13 and 7.27, respectively) to T_2, T_1 and T_4, whereas the highest number of unfilled grains panicle^{-1} (9.67) was found in T_0 treatment (Table 4).

4.1.7 Number of total grains panicle^{-1}

Number of total grains panicle^{-1} showed statistically significant differences due to the effect of different treatments (Appendix IV). The highest number of total grains panicle^{-1} (92.40) was found in T_3 which was statistically similar with other treatments except T_0, while the lowest number of total grains panicle^{-1} (78.20) was recorded in T_0 treatment (Figure 2). Vetayasuporn (2012) reported that chemical fertilizer) which gave the highest total number panicle per hill (14.82).

4.1.8 Length of panicle

Statistically significant variation was recorded in terms of length of panicle due to the effect of different treatments (Appendix V). The longest panicle (25.78 cm) was observed in T_3 which was statistically similar (25.05 cm, 24.37 cm and 23.95, respectively) to T_2, T_1 and T_5, and closely followed (22.61) by T_4, whereas the shortest panicle (18.79 cm) was observed in T_0 treatment which was statistically similar (20.16 cm and 21.16 cm) to T_6 and T_7 and they were statistically similar (Table 5).

4.1.9 Weight of 1000 grains

Weight of 1000 grains showed statistically significant differences due to the effect of different treatments (Appendix V). The highest weight of 1000 grains (20.92 g) was recorded in T_3 which was statistically similar with other treatment except T_0, while the lowest weight of 1000 grains (18.03 g) was observed in T_0 treatment (Table 5). Sarkar and Singh (2002) observed that the 1000-grain weight significantly increased with the application recommended doses of fertilizer.

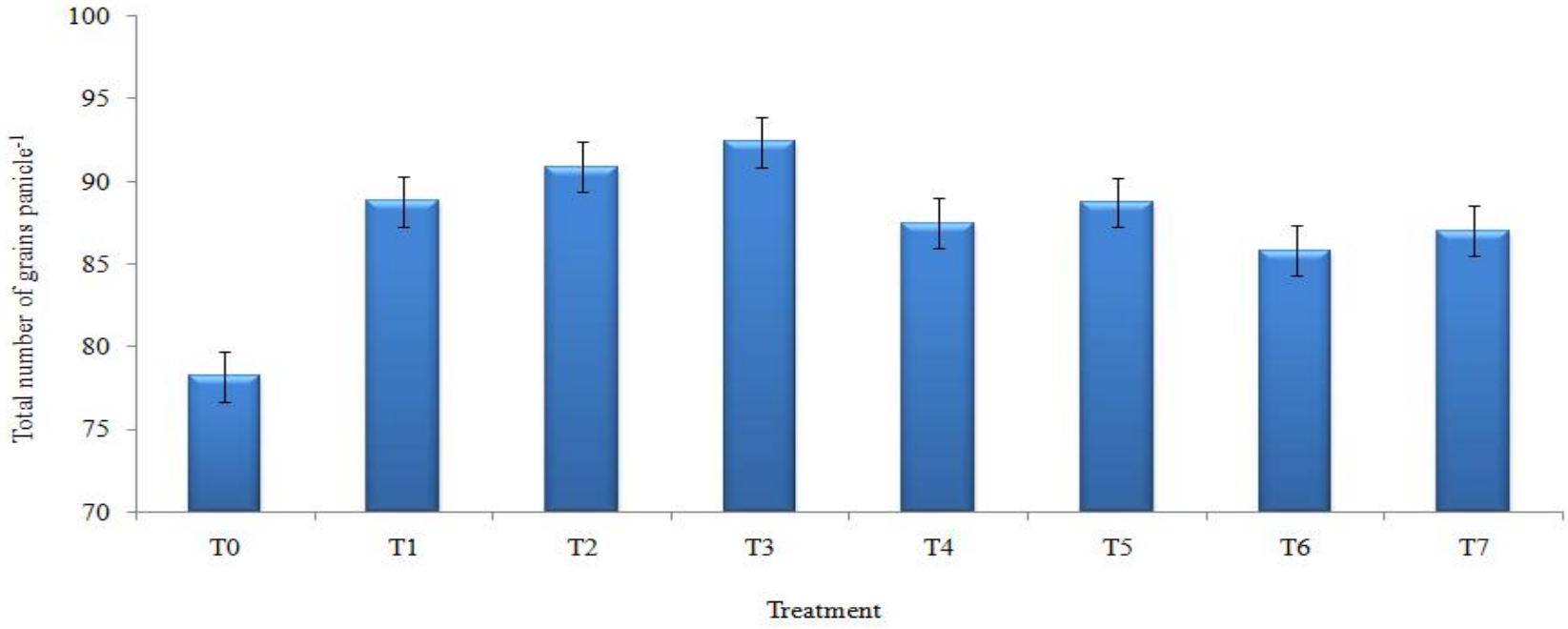


Figure 2. Effect of Plant Growth Regulator-Flora on total number of grains panicle^{-1} of transplanted aman rice. (Vertical bars represent LSD value at 5% level of probability)

Table 5. Effect of Plant Growth Regulator-Flora on yield contributing characters and yield of transplanted aman rice

Treatments	Length of panicle (cm)	Weight of 1000 grains (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
T_0	18.79 d	18.03 b	2.78 e	4.32 d	39.18 c
T_1	24.37 ab	20.44 a	4.24 bc	5.06 a-c	45.46 ab
T_2	25.05 ab	20.65 a	4.41 b	5.15 ab	46.15 a
T_3	25.78 a	20.92 a	5.13 a	5.31 a	46.31 a
T_4	22.61 bc	19.68 ab	3.77 cd	4.53 cd	45.37 ab
T_5	23.95 ab	20.16 a	4.05 bc	4.82 a-d	45.68 ab
T_6	20.16 cd	19.21 ab	3.33 d	4.39 d	43.11 ab
T_7	21.16 cd	19.38 ab	3.41 d	4.56 b-d	42.78 b
$LSD_{(0.05)}$	2.605	1.679	0.508	0.543	2.950
Significance level	0.01	0.05	0.01	0.01	0.01
CV(%)	6.54	4.84	7.83	6.50	3.81

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_0: Control condition (No chemical fertilizer, no Flora)

T_1: Recommended Fertilizer Doses-RFD (120, 20, 80, 16 and 2 kg ha^{-1} of N, P, K, S and Zn, respectively)

T_2: RFD + 1 time spray of Flora

T_3: RFD + 2 times spray of Flora

T_4: ½ RFD + 1 time spray of Flora

T_5: ½ RFD + 2 times spray of Flora

T_6: No chemical fertilizer + 1 time spray of Flora

T_7: No chemical fertilizer + 2 times spray of Flora

4.1.10 Grain yield

Grain yield showed statistically significant differences due to the effect of different treatments (Appendix V). The highest grain yield (5.13 t ha^{-1}) was recorded in T_3 which was followed (4.41, 4.24 and 4.05 t ha^{-1}) by T_2, T_1 and T_5, respectively, while the lowest grain yield (2.78 t ha^{-1}) was observed in T_0 treatment (Table 5). Haq *et al.* (2002) reported that 90 kg N + 50 kg P_2O_5 + 40 kg K_2O + 10 kg S + 4 kg Zn ha^{-1} + diazinon gave the highest grain yields. 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.

4.1.11 Straw yield

Statistically significant variation was recorded in terms of straw yield due to the effect of different treatments (Appendix V). The highest straw yield (5.31 t ha^{-1}) was found in T_3 which was statistically similar (5.15, 5.06 and 4.82 t ha^{-1}) to T_2, T_1 and T_5, respectively, where the lowest straw yield (4.32 t ha^{-1}) was recorded in T_0 treatment which was statistically similar (4.39 t ha^{-1} and 4.53 t ha^{-1}) to T_6 and T_4 treatment (Table 5). Haq *et al.* (2002) reported that 90 kg N + 50 kg P_2O_5 + 40 kg K_2O + 10 kg S + 4 kg Zn ha^{-1} + diazinon gave the highest straw yields. 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 V). The highest biological yield (10.44 t ha^{-1}) was recorded in T_3 which was statistically similar (9.56, 9.30 and 8.88 t ha^{-1}) to T_2, T_1 and T_5, respectively and closely followed (8.29 t ha^{-1}) by T_4, while the lowest biological yield (7.10 t ha^{-1}) was observed in T_0 treatment which was statistically similar (7.71 t ha^{-1} and 7.97 t ha^{-1}) to T_6 and T_7 treatment (Figure 3).

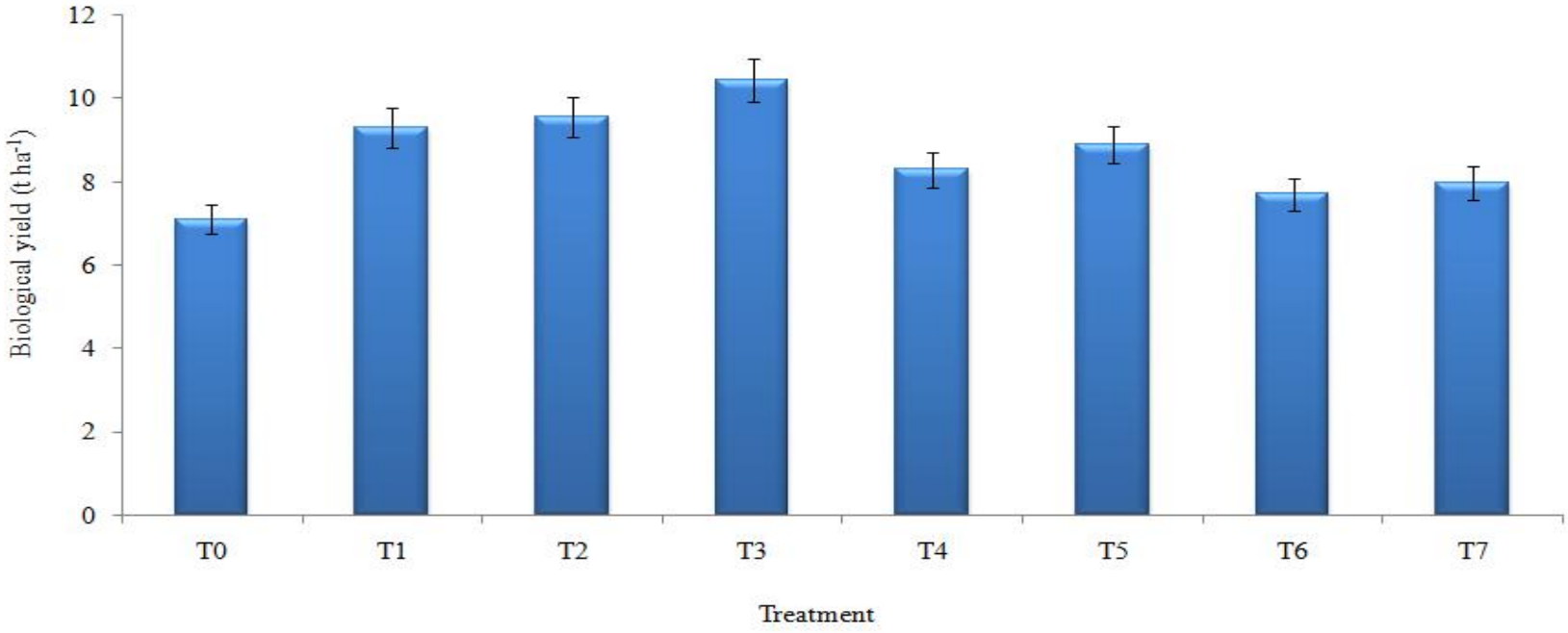


Figure 3. Effect of Plant Growth Regulator-Flora on biological yield of transplanted aman rice. (Vertical bars represent LSD value at 5% level of probability)

4.1.13 Harvest index

Statistically significant variation was recorded in terms of harvest index due to the effect of different treatments (Appendix V). The highest harvest index (46.31%) was found in T_3 which was statistically similar with other treatment except T_1 and T_7 and closely followed (42.78%) by T_7 and the lowest harvest index (39.18%) was obtained in T_0 treatment (Table 5).

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

4.2.1 Soil pH

Soil pH showed statistically non significant differences due to the effect of different treatments (Appendix X). The highest soil pH (6.15) was found from T_3 treatment, whereas the lowest soil pH (5.73) was observed from T_0 treatment (Table 6).

4.2.2 Organic matter

Organic matter showed statistically non significant differences due to the effect of different treatments (Appendix X). The highest organic matter (1.46%) was recorded from T_3 treatment and the lowest organic matter (1.33%) was found from T_0 treatment (Table 6).

4.2.3 Total Nitrogen

Statistically significant variation was recorded in terms of total nitrogen due to the effect of different treatments (Appendix X). The highest total nitrogen (0.063%) was recorded from T_3 treatment which was statistically similar with other treatmnet except T_0 and T_6, while the lowest total nitrogen (0.037%) was observed from T_0 treatment (Table 6).

Table 6. Effect of Plant Growth Regulator-Flora on nutrient content of post harvest soil of transplanted aman rice

Treatments	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me%)
T_0	5.73	1.33	0.037 c	16.54 e	0.084 c
T_1	6.05	1.44	0.062 a	30.11 ab	0.160 ab
T_2	6.13	1.45	0.063 a	31.92 a	0.165 a
T_3	6.15	1.46	0.063 a	32.59 a	0.169 a
T_4	5.89	1.41	0.060 ab	28.32 bc	0.151 ab
T_5	5.94	1.41	0.061 ab	29.19 ab	0.160 ab
T_6	5.85	1.40	0.056 b	22.75 d	0.141 b
T_7	5.89	1.43	0.058 ab	25.55 cd	0.151 ab
$LSD_{(0.05)}$	--	--	0.006	3.331	0.018
Significance level	NS	NS	0.01	0.01	0.01
CV(%)	5.24	6.23	4.74	7.01	9.55

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_0: Control condition (No chemical fertilizer, no Flora)

T_1: Recommended Fertilizer Doses-RFD (120, 20, 80, 16 and 2 kg ha^{-1} of N, P, K, S and Zn, respectively)

T_2: RFD + 1 time spray of Flora

T_3: RFD + 2 times spray of Flora

T_4: ½ RFD + 1 time spray of Flora

T_5: ½ RFD + 2 times spray of Flora

T_6: No chemical fertilizer + 1 time spray of Flora

T_7: No chemical fertilizer + 2 times spray of Flora

4.4.4 Available phosphorus

Available phosphorus showed statistically significant differences due to the effect of different treatments (Appendix X). The highest available phosphorus (32.59%) was recorded from T_3 treatment which was statistically similar (31.92%, 30.11% and 29.19%, respectively) to T_2, T_1 and T_5, whereas the lowest available phosphorus (16.54%) was obtained from T_0 treatment (Table 7).

4.4.5 Exchangeable potassium

Statistically significant variation was recorded in terms of exchangeable potassium due to the effect of different treatments (Appendix X). The highest exchangeable potassium (0.169 me%) was observed from T_3 treatment which was statistically similar with other treatment except T_0 and T_6, while the lowest exchangeable potassium (0.084 me%) was recorded from T_0 treatment (Table 7).

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the farm area of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period of July to November, 2015to find out the effect of plant growth regulator-flora on the growth and yield of transplanted aman rice. BR 11 (Mukta) was used as the test crop for this experiment. The experiment comprised of 8 treatments as- T_0: Control condition (No chemical fertilizer, no Flora), T_1: Recommended Fertilizer Doses-RFD (120, 20, 80, 16 and 2 kg ha^{-1} of N, P, K, S and Zn, respectively), T_2: RFD + 1 time spray of Flora, T_3: RFD + 2 times spray of Flora, T_4: ½ RFD + 1 time spray of Flora, T_5: ½ RFD + 2 times spray of Flora, T_6: No chemical fertilizer + 1 time spray of Flora and T_7: No chemical fertilizer + 2 times spray of Flora. Data on different yield contributing characters, yield, nutrient content in grain and straw, nutrient uptake by grain and straw and characteristics of post harvest soil was recorded and significant variation was observed for different treatments.

At 40 DAT, the longest plant (25.76 cm) was observed in T_3, whereas the shortest plant (18.60 cm) was observed in T_0. At harvest, the tallest plant (117.60 cm) was recorded from T_3 treatment, while the shortest plant (88.85 cm) was found in T_0 treatment. The highest number of effective tillers $hill^{-1}$ (16.13) was found in T_3, while the lowest number of effective tillers $hill^{-1}$ (10.27) was recorded in T_0 treatment. The lowest number of ineffective tillers $hill^{-1}$ (2.27) was observed in T_3 and the highest number of ineffective tillers $hill^{-1}$ (4.33) was found in T_0 treatment. The highest number of total tillers $hill^{-1}$ (18.40) was found in T_3, while the lowest number of total tillers $hill^{-1}$ (14.60) was observed in T_0 treatment. The highest number of filled grains $panicle^{-1}$ (86.27) was recorded in T_3, whereas the lowest number of filled grains $panicle^{-1}$ (68.53) was found in T_0 treatment. The lowest number of unfilled grains $panicle^{-1}$ (6.13) was observed in T_3, whereas the highest number of unfilled grains $panicle^{-1}$ (9.67) was found in T_0 treatment. The highest number of total grains $panicle^{-1}$ (92.40) was found in T_3, while the lowest number of

total grains panicle^{-1} (78.20) was recorded in T_0 treatment. The longest panicle (25.78 cm) was observed in T_3, whereas the shortest panicle (18.79 cm) was observed in T_0 treatment. The highest weight of 1000 grains (20.92 g) was recorded in T_3, while the lowest weight of 1000 grains (18.03 g) was observed in T_0 treatment. The highest grain yield (5.13 t ha^{-1}) was recorded in T_3, while the lowest grain yield (2.78 t ha^{-1}) was observed in T_0 treatment. The highest straw yield (5.31 t ha^{-1}) was found in T_3, where the lowest straw yield (4.32 t ha^{-1}) was recorded in T_0 treatment. The highest biological yield (9.88 t ha^{-1}) was recorded in T_3, while the lowest biological yield (7.10 t ha^{-1}) was observed in T_0 treatment. The highest harvest index (46.31%) was found in T_3 and the lowest harvest index (39.18%) in T_0 treatment.

The highest soil pH (6.15) was found from T_3 treatment, whereas the lowest soil pH (5.73) was observed from T_0 treatment. The highest organic matter (1.46%) was recorded from T_3 treatment and the lowest organic matter (1.33%) was found from T_0 treatment. The highest total nitrogen (0.063%) was recorded from T_3 treatment, while the lowest total nitrogen (0.037%) was observed from T_0 treatment. The highest available phosphorus (32.59%) was recorded from T_3 treatment, whereas the lowest available phosphorus (16.54%) was obtained from T_0 treatment. The highest exchangeable potassium (0.169 me%) was observed from T_3 treatment, while the lowest exchangeable potassium (0.084 me%) was recorded from T_0 treatment.

Conclusion:

Applications of RFD + 2 times spray of Flora was the superior among the other treatments in consideration of yield contributing characters and yield of BRRI Dhan BR 11 in transplanted aman season.

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 combination of organic manures and chemicals fertilizer and other management practices may be used for further study to specify the specific combination.

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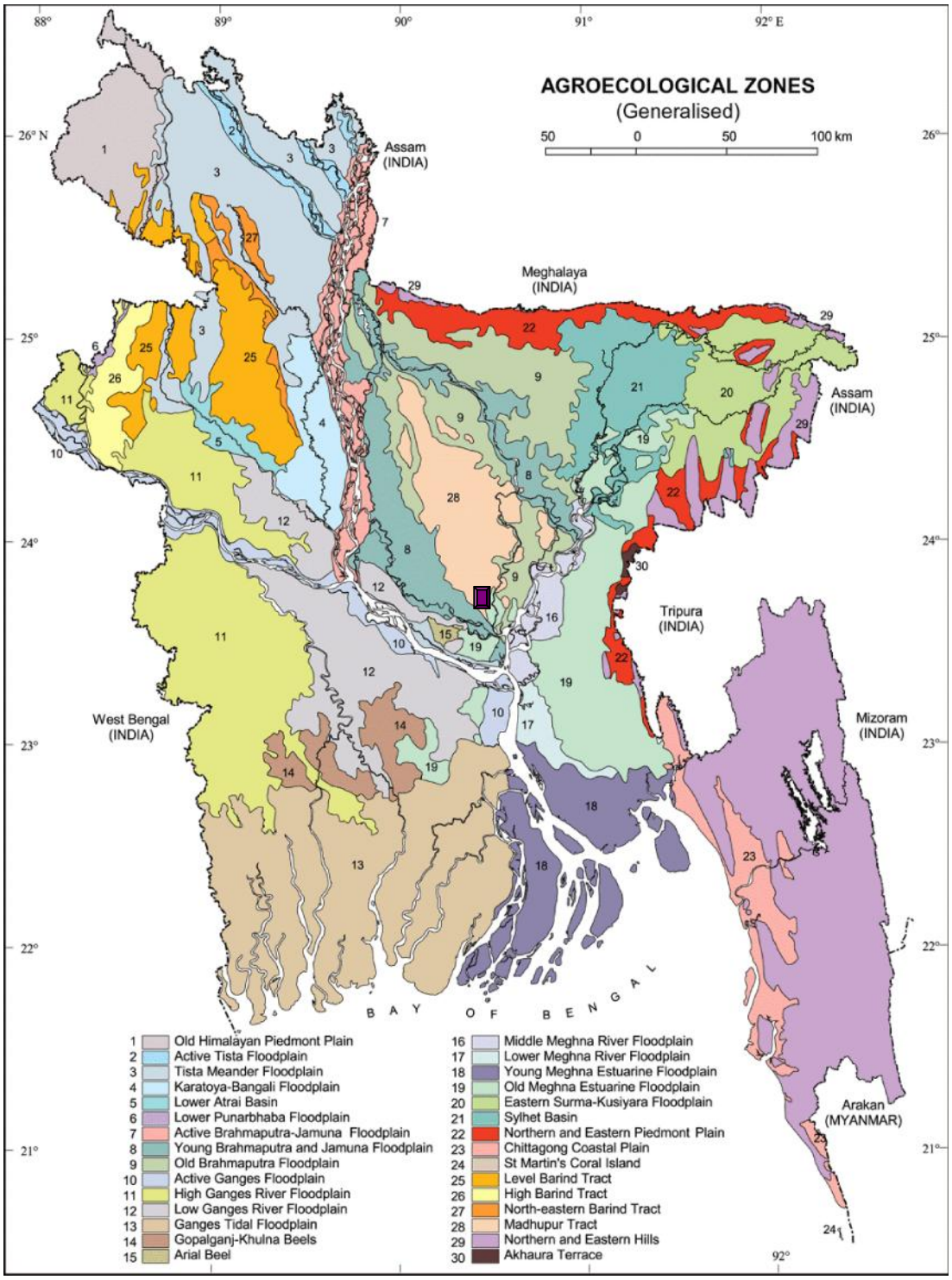
APPENDICES

Appendix I. The Map of the experimental site



Appendix II. 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 III. Analysis of variance of the data on plant height at different days after transplanting (DAT) and harvest of transplanted aman rice as influenced by Plant Growth Regulator-Flora

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at				
		40 DAT	50 DAT	60 DAT	70 DAT	Harvest
Replication	2	0.106	5.145	14.456	10.824	5.095
Treatment	7	16.301*	45.885**	131.680*	177.265**	229.672**
Error	14	4.974	8.307	37.057	29.030	33.068

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

Appendix IV. Analysis of variance of the data on yield contributing characters of transplanted aman rice as influenced by Plant Growth Regulator-Flora

Source of variation	Degrees of freedom	Mean square					
		Number of effective tillers hill^{-1}	Number of in-effective tillers hill^{-1}	Total tillers hill^{-1}	Number of filled grains panicle^{-1}	Number of unfilled grains panicle^{-}	Number of total grains panicle^{-1}

						[1]	
Replication	2	0.712	0.032	1.032	9.532	0.395	13.752
Treatment	7	10.023**	1.405**	4.391*	86.095**	3.553**	54.908*
Error	14	1.256	0.024	1.479	17.699	0.431	19.835

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

Appendix V. Analysis of variance of the data on yield contributing characters and yield of transplanted aman rice as influenced by Plant Growth Regulator-Flora

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	0.694	0.113	0.068	0.027	0.077	4.307
Treatment	7	18.649**	2.660*	1.131**	0.419**	2.855**	17.885**
Error	14	2.212	0.919	0.090	0.096	0.284	2.837

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

Appendix VI. Analysis of variance of the data on nutrient content of post harvest soil of transplanted aman rice as influenced by Plant Growth Regulator-Flora

Source of variation	Degrees of freedom	Mean square				
		pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me%)
Replication	2	0.051	0.006	0.001	1.385	0.00001
Treatment	7	0.063	0.005	0.023**	86.200**	0.002**
Error	14	0.097	0.008	0.001	3.619	0.0001

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