EFFECT OF FOLIAR FERTILIZER APPLICATION ON THE PERFORMANCE OF TRANSPLANTED AMAN RICE (BINA dhan7)

A Thesis
By

ABDULLAH MD. TAREQ
Student No. 1705217

MASTER OF SCIENCE
IN
CROP PHYSIOLOGY AND ECOLOGY

DEPARTMENT OF CROP PHYSIOLOGY AND ECOLOGY
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY
DINAJPUR-5200, BANGLADESH

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DECEMBER 2018

DEDICATED

TO

MY BELOVED PARENTS

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ABSTRACT

A field experiment was conducted at the Crop Physiology and Ecology research field of Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during the period from July to November 2018 with a view to evaluated the effect of foliar fertilizer application on the growth and yield of aman rice (BINA Dhan-7). The experiment was laid out in a randomized complete block design (RCBD) with six treatments and four replications. The treatments were, T_0= Without fertilizer, T_1=Recommended fertilizer doses (RDF), T_2= Half of RDF and American NPKS, T_3= RDF and American NPKS, T_4= Half of RDF and foliar NK application, and T_5= RDF and foliar NK application. Data were collected on plant height, number of leaves per hill at different days after transplanting, leaf area, SPAD value, number of tillers per hill at variety days after transplanting, number of filled and unfilled grains per panicle, panicle length, 1000-grain weight, grain yield per hill, grain and straw yields. Different fertilizer management treatments had significant effects on most of the parameters. Significantly higher plant height, leaf number, tillers per hill, leaf area, number of tillers per hill, filled grains per panicle, panicle length and grain yield per hill due to additional foliar spray of T_3 (RDF and American NPKS) and T_5 (RDF and foliar NK application) were contributed to higher yield of rice.

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CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.) is the most extensively cultivated cereal crop in Bangladesh. It plays an absolutely dominant role over all other crops in respect of economic and social significance. In Bangladesh agriculture it covers 75.8% of the total cropped area (BBS 2007). Thus, it ranks the top position among the cereal crops grown in Bangladesh. Bangladesh is the fourth highest rice (*Oryza sativa* L.) producing country in the world (FAO 2013). Rice is the staple dietary item for the people and per capita rice consumption is about 166 kg/year (BBS 2010). Rice alone provides 76% of the calorie intake and 66% of total protein requirement (Bhuiyan *et al.* 2002). It employs about 43.6% of total labor forces (BBS 2010, HIES 2009). Rice covers about 81% of the total cropped area (BBS 2010). Rice alone shares about 96% of the total cereal food supply. Rice is grown in three seasons namely Aus (mid March to mid August), Aman (mid June to November) and Boro (Mid December to mid June). The largest part of the total production of rice comes from Aman rice. T. aman (Transplanted Aman) rice covers about 50.92% of the rice areas of Bangladesh of which modern T. aman varieties covers 60% (BBS 2005). Variety itself is a genetic factor which contributes a lot in producing yield and yield components of a particular crop. Yield components of rice are directly related to the variety and neighboring environments in which it grows.

Rice plant cannot produce higher grain yield without addition of fertilizer in the crop field (BRRI 2011). It is necessary to find out the suitable rate of fertilizers for efficient management and better yield of rice. Among the nutrients, nitrogen is the kingpin in rice farming (Alam *et al.* 2012) for crop growth and development (Ahsan 1996). However, only optimum dose of N applied can play a vital role on the growth and development of rice plant (Hasanuzzaman *et al*. 2009). N use efficiency in the wetland rice culture is very low, rarely exceeding 30-40 % (Alam *at al*. 2000) and more than 50 % of the applied nitrogen is lost through denitrification, volatilization, leaching and runoff (Khan *et al*. 2009) and ultimately affect on cash loss of farmers and sometimes causes environmental as well as ground water pollution (De Datta 1991, IRRI 1991). High price of urea fertilizer and its availability at the right time jeopardize rice production occasionally (BRRI 2009). So, it is necessary to improve the efficiency of applied nitrogenous fertilizer utilization by rice plant (Miah and Panaullah 1999). All the factors provide an indication of searching an effective alternate N application method for rice cultivation (BRRI 2012). However, foliar application can improve nutrient utilization and lower environment pollution through reducing amount of fertilizers added to soil (Abou El-Nour 2002). In many cases aerial spray of nutrients is preferred and gives quicker and better results than the soil application (Jamal *et al*. 2006) which minimizes N losses to the environment without affecting rice yield (Millard and Robinson, 1990). Recently foliar application of nutrients has become an important practice in the production of crops while application of fertilizers to the soil remains the basic method of feeding the majority of the crop plants (Alam *at al*. 2012). Foliar application is well recognized and is being practiced in agriculturally advanced countries. In many cases aerial spray of nutrients is preferred and gives quicker and better results than the soil application (Jamal *et al*. 2006). Foliar feeding is an effective method for overcoming the flooded soil special condition. In case of foliar feeding, nutrients are absorbed directly where they are needed, the rate of the photosynthesis in the leaves is increased, nutrient absorption by plant roots is stimulated and foliar nutrition application rates, uniform distribution of fertilizer, reduction in plant stress, plant's natural defense improvement of plant health and yield (Finck 1982). Liquid fertilization might reduce the use of chemical fertilizer specially the nitrogenous fertilizer in soil. In this aspect, the present study was therefore undertaken with the following objectives-

- To find out the effect of foliar fertilizer application on the growth and yield of Aman rice (BINA Dhan 7)
- To evaluate whether foliar application could replace the soil application of fertilizer in Aman rice cultivation.

CHAPTER II

REVIEW OF LITERATURE

A number of research works on the response of rice to different methods of fertilizers application have been carried out in the rice growing countries of the world including Bangladesh. A better understanding of the effects of different methods of foliar application on rice in this country's soils would facilitate the development of suitable soil management practices for better production of this crop. In this chapter, an attempt has been made to review the research done in Bangladesh and elsewhere related to the effect of different methods of foliar application.

2.1. Effects of foliar application of fertilizers

Islam *et al.* (2015) did an investigation during T. Aus 2012 through Boro 2013-14 at BRRI farm, Gazipur evaluated the effect of magic growth (MG) solution on rice. The experiment compared variable doses of N with or without MG along with N control in a randomized complete block design with three replications. Basal application of N with its top dress was also compared with only top dress of N (no basal). All the plots (except control) received a blanket application of phosphorus, potassium, sulfur and zinc. The application of MG spraying produced no yield advantage on rice grain yield in Aus, Aman and Boro seasons. Basal application of N with top dress produced higher yield over N top dressing only in Boro season at lower rate of N.

Pramanik *et al.* (2015) conducted an experiment to find out the effects of foliar fertilization (Magic growth) on performance of BRRI dhan28 and to calculate how much urea can be saved by foliar fertilization of magic growth without any yield reduction following split plot design with three replications. Two levels of foliar fertilization (No foliar fertilization and foliar fertilization with magic growth) were placed in the main plots and four nitrogen fertilizer levels (0, 50, 75 and 100% of the recommended nitrogen fertilizer) were placed randomly in the sub plots. Foliar fertilization with magic growth showed higher plant height, tillers hill^{-1}, SPAD value of the youngest fully expanded leaf and above ground biomass at 40, 55, and 70 DAT compared to no foliar fertilization treatment. All the parameters studied were also increased with the increment of nitrogen level. Foliar fertilization and increasing nitrogen fertilizer levels significantly influenced effective tillers hill^{-1}, spikelets panicle^{-}1, grains pnicle^{-1}, thousand grains weight, grain yield and straw yield of BRRI dhan 28. In general, foliar fertilization (F1) treatments provided greater grain yield compared to no foliar fertilization treatment (F0) in all nitrogen levels. On the other hand, with the increment of nitrogen level the grain yield was increased up to N100 in no foliar fertilization treatment (F0) but in foliar fertilization treatment (F1), grain yield was increased with the increment of nitrogen level up to N75 and there after decreased in N100. Foliar fertilization with magic growth along with 50% of the recommended nitrogen fertilizer saved 50% of the recommended nitrogen fertilizer without any yield reduction. Foliar fertilization with magic growth along with 75% of the recommended nitrogen fertilizer increased 16.9% grain yield with a saving of

25% of the recommended nitrogen fertilizer whereas foliar fertilization along with 100% recommended nitrogen fertilizer increased 9.33% grain yield compared to recommended practice alone.

Shaygany *et al.* (2012) showed that foliar application of fertilizers can guarantee the availability of nutrients to rice for obtaining higher yield. Rice responds favorably to macro- and micronutrients and the tolerance to salinity hazards improves by decreasing the N/S ratio. In this study, results showed that nutrient concentrations (g L^{-1}) for rice are: nitrogen (N) 108.0, phosphorous (P_2O_5) 6, potassium (K_2O) 81.0, calcium (CaO) 15.0, and magnesium (MgO) 6 g L^{-1}; and for iron (Fe), manganese (Mn), zinc (Zn), cupper (Cu), boron (B), molybdenum (Mo) and silicon (Si) the recommended concentrations are 0.6, 0.45, 0.21, 0.06, 0.09, 0.0002 and 0.004 g L^{-1}, respectively. A significant increase was recorded in number of panicles m^{-2}, 1000 grain weight, biological yield and grain yield with foliar application of nutrients. Five foliar applications of nutrients resulted in maximum number of panicles m^{-2}, grains panicle^{-1}, 1000 grain weight and biological yield. It is concluded that five foliar applications of balanced amounts of fertilizers at the seedling stage (two sprays), tillering (single spray) and at panicle initiation and panicle differentiation (two sprays) helped in enhancing yield and yield components of rice. In this research, five foliar applications produced the smallest damaging effects of blast (*Pyricularia oryzae*) in rice.

Bhuyan *et al.* (2012) conducted an experiment to find out the influence of foliar application of nitrogen fertilizer on growth and yield of transplanted aman rice and evaluation of water and fertilizer application efficiency of rice-fallow-rice cropping system were investigated under raised bed cultivation method. Results showed that foliar spray in bed planting method increased grain yield of transplanted aman rice up to 9.33% over conventional method. Foliar nitrogen fertilizer application in bed planting method increased the number of panicle m^{-2}, number of grains $panicle^{-1}$, and 1000-grain weight of rice than the conventional method. Sterility percentage and weed infestation were lower at foliar nitrogen fertilizer application in bed planting method than the conventional method. Thirty-nine percent of irrigation water and time for application could be saved through foliar nitrogen spray in bed planting than conventional method. Water use efficiency for grain and biomass production was higher by foliar nitrogen fertilizer application in bed planting than conventional method. Likewise, agronomic efficiency of foliar nitrogen fertilizer application in bed planting method was higher than the conventional method. This study concluded that foliar nitrogen spray in bed planting method is a new approach to get fertilizer and water use efficiency as well as higher yield compared to existing agronomic practice in Bangladesh.

An experiment was undertaken by Rabin *et al*. (2016) to find out the effect of foliar application of urea along with magic growth spray on the yield and nutrient content of two Aman rice cultivars. Two rice varieties *viz.,* Bina-sail (V_1), BRRI dhan46 (V_2) and eight different nitrogen doses and application methods *i.e.* T_0=N0 (No nitrogen applied), T1=N00+10% (Urea was applied only 10% of the recommended dose (RD) with magic growth as foliar spray), T_2=N50+5% (50% Urea was applied as top dressing and 5% Urea was applied with magic growth as foliar spray), T_3=N50+10% (50% Urea was applied as top dressing and 10% Urea was applied with magic growth as foliar spray), T_4=N75+5% (75% Urea was applied as top dressing and 5% Urea was applied with magic growth as foliar spray), T_5=N75+10% (75% Urea was applied as top dressing and 10% Urea was applied with magic growth as foliar spray), T_6=N100 (100% of RD of Urea was applied as topdressing), T_7=N100+10% (100% Urea was applied as top dressing and 10% Urea was applied with magic growth as foliar spray) were used in this experiment. BRRI dhan46 and 75% Urea top dressing and 10% Urea with magic growth as foliar spray gave the highest number of effective tillers hill^{-1}, longer panicle, number of total grains panicle^{-1}, 1000-grain weight, grain yield, straw yield and N, P, K content in rice grain. Moreover, 75% Urea top dressing and 10% Urea of the recommended dose with magic growth as foliar spray increased 8.27% grain yield with a saving of 15% of the recommended nitrogen fertilizer compared to recommended practice.

Sultana *et al* (2010) laid out an experiment to find out the effects of sea water salinity and foliar application of nutrient solutions on rice in the early tillering stage and early reproductive phase of growth were investigated in a glasshouse. During early tillering stage, from 10 to 35 days after transplanting (DAT) and the early reproductive phase, from 75 to 100 DAT, potted rice plants were irrigated with Japan seawater of 0, 8.8, 17.5 and 35% (equivalent to an EC of 0.9, 5.7, 11.5 and 21.5 ms cm^{-1}, respectively). The nutrient solution of 1 mM $Ca(NO_3)_2$, $MnSO_4$ or K_2HPO_4 was sprayed twice a week until the solution ran off the leaves. Photosynthesis and its related parameters were measured at 30 and 95 DAT in the early tillering stage and in the reproductive growth phase, respectively. Seawater salinity diminished photosynthesis rate and photosynthesis-related parameters, such as stomatal conductance, intercellular CO_2 concentration, leaf water and osmotic potential and relative leaf water content in both growth stages and have reduced tiller number, leaf area and top dry matter content in tillering stage. We have also studied the effect of salt-stress on the mineral content at 35 DAT. Na^+ concentration increased, whereas Ca^{2+}, Mn^{2+} and K^+ concentration were decreased with increasing stress. Seawater decreased fertile spikelets in the panicle, decreased accumulation of dry matter in the grain and concomitantly decreased grain yield. Foliar spray of $Ca(NO_3)_2$, $MnSO_4$ or K_2HPO_4 partially minimized the salt-induced nutrient deficiency, increased photosynthesis, dry matter accumulation, number of fertile spikelet in the panicle and grain yield. Among the nutrient solutions, Ca $(NO_3)_2$ seemed to be the most effective, followed by $MnSO_4$ and K_2HPO_4. These results suggested that foliar application of nutrient solutions partially alleviates the adverse effects of salinity on photosynthesis and photosynthesis-related parameters, yield and yield components through mitigating the nutrient demands of salt-stressed plants.

Swaroopa and Lakshmi (2015) showed the effect of nitrogen (N) fertilizer levels and foliar feeding on yield and yield components of machine transplanted rice. In this experiment, four treatments including: 75 % RDN, 100% RDN, 150% RDN and 200% RDN are laid in main plots and 2% KNO_3, 2% DAP and 1% 19-19-19 in sub plots. The results revealed that application of 150% RDN (135 kg/ha) recorded maximum plant height, tillers m^{-2}, dry matter production, panicle length, No of grains panicle^{-1}, grain yield, and straw yield. Foliar feeding at panicle initiation stage did not influence the yield attributes, grain yield, straw yield and quality parameters significantly. The interaction between nitrogen levels and foliar feeding treatments was found to be non-significant.

Salim *et al* (2005) coducted an experiment to evaluate the effects of foliar spray (1.5 % of K solution) of KCI, K_2S0_4 and $KN0_3$ on the yield of rice cv. 385. Foliar application of K2S04 gave better paddy and straw yields, number of tillers, potassium content of paddy and straw than the other two sources of K. Potassium recovery (72.87 %) and agronomic efficiency (13.12 kg of paddy kg1 of fertilizer applied) were also better in case of K2S04 than other two sources: $KN0_3$ (44.87% and 8.69 kg of paddy kg-1 of fertilizer applied) and KCI (22.40% and 5.66 kg of paddy kg-1 of fertilizer applied).

Alam *et al.* 2010 conducted an experiment with a view to examining the effect of soil and foliar application of urea on the yield and nutrient uptake of BRRIdhan 29 and to evaluate whether urea foliar application (FA) could replace its soil application (SA) in the rice cultivation. The treatments were: T_1 (control), T2 (282 kg urea ha^{-1} SA), T3 (1% urea solution FA), T_4 (2% urea solution FA), T_5 (3% urea solution FA), T_6 (94 kg urea ha^{-1} SA + 1% urea solution FA), T7 (94 kg urea ha^{-1} SA + 2% urea solution FA) and T8 (94 kg urea ha^{-1} SA + 3% urea solution FA). The results showed that soil and foliar application of nitrogen significantly influenced the growth and yield of crop. The treatment T_2 (282 kg urea ha^{-1}) produced the highest grain yield (5.34 t ha-1). The T6 (94 kg urea ha^{-1} + 1% urea solution FA) produced the highest straw yield (6.58 t ha-1) of the crop. The lowest grain yield (3.20 t ha-1) and the lowest straw yield (4.19 t ha-1) were recorded with T1 (control). Economic analysis showed that treatment T2 gave the highest marginal benefit cost ratio (7.65) while the lowest value (2.71) was observed with T5 treatment. The overall results demonstrated that soil application of 282 kg urea ha-1 was the best treatment for obtaining higher grain yield, higher nitrogen content of rice and higher marginal benefit cost ratio, and soil application is better than foliar application of urea.

Field experiments were conducted by Ravi *et al.* (2007) at Annamalai University Experimental Farm (Tamil Nadu, India) during Navarai and Kuruvai season to study the effect of foliar spray of phytohorrnones and nutrients on the yield and nutrient uptake of transplanted rice cv. ADT 36. The results revealed that foliar application of miraculan at 1000 ppm recorded an added beneficial effect over other treatments.

Singaravel *et al.* (2007) conducted an experiment to study the effects of recommended NPK rates (120:38:38 kg/ha) with or without Kiecite (a foliar micronutrient mixture containing 1.0% Fe, 0.5% Mn, 5.0% Zn, 0.35% Cu and 0.05% B) at 0.50, 1.0, 1.5 or 2.0% on the performance of rice (cv. ADT 43) were studied in Annamalai, Tamil Nadu, India, from July to October 2003.They reported that NPK + 1.0% Kiecite significantly enhanced the growth and yield of rice.

An experiment was conducted by Seilsepour (2007) to study wheat grain protein increasing through foliar application of nitrogen after flowering. The RCBD design was analysed with three replications and four N-treatments as foliar application as (N0=0, N_1=4 kg /ha Urea. N_2=8 kg/ ha Urea. N_3=4 kg / ha Ammonium Sulfate). Results showed that seed protein content increased significantly by foliar application of nitrogen.

Moeini *et al*. (2006) conducted a 3-year trial from 1999 to 2001 in Karaj, Iran. Treatments included herbicide combination at nine levels and urea application in two methods (foliar application and top dressing). The results indicated that foliar application of urea had a significant effect on yield. Tank mixing urea with herbicide had no effect on herbicide use efficiency. Among combinations, urea + tribenuron-methyl + clodinafop-propargyl were the best for controlling weeds and increasing grain and biological wheat yield.

Krishnaveni and Balasubramanian (2003) conducted a field experiments at Madurai, Tamil Nadu. India, during 1997-98 and 1998-99, to investigate the influence of nutrient management, foliar application of growth regulators and plant product on productivity of rabi rice and reported that among the light management practices, foliar spray of triacontanol at 2 ppm given at 35 and 65 days after transplanting significantly recorded the highest grain yield of 6328 kg ha^{-1}.

Satheesh *et al.* (2003) conducted an experiment during the 1999 rabi and 2000 kharif seasons in Hyderabad, Andhra Pradesh, India, to determine the effect of foliar applied NPK fertilizers on the growth and yield of rice cultivars Pro Agro 6201 (hybrid) and Ajaya (high yielding). The treatments comprised 100 and 75%

NPK fertilizers, alone or in combination with 2% Polyfeed (19:19:19), 2% Polyrice (15:15:30) and 2% multi-K (13:0:46). Pro Agro 6201 had the highest panicle per m2, panicle weight, and 1000-grain weight with NPK at 75% + 3 sprays of Polyrice (at panicle initiation. one week before and after flowering) had the highest panicle per m2, which was at par with 100% NPK + 3 sprays of Polyrice during both seasons. Pro Agro 6201 had the highest mean grain yield (5.85 t/ha), straw yield (8.15 t/ha) and harvest index (41.61%).

Vaiyapuri *et al*. (2003) were studied to study the effect of foliar application of phytohormones (triacontanol and salicylic acid) and nutrients (diammonium phosphate (DAP) and $inSO_4$ on lowland rice at various concentrations along with the recommended dose of NPK on the growth. yield and nutrient uptake revealed that triacontanol sprayed at 0.1% registered the highest plant height (81 cm), number of tillers/hill (8.02). grain yield (4.71 t/ha), straw yield (7.25 tlha) and uptake of nutrients (106.7, 29.0, 51.8 kg NPK/ha) and significantly superior to 7nSO4, DAP. salicylic acid and water spray. Foliar spray of higher concentrations of either growth hormones or nutrients caused reduction in growth and rice yield.

Duraisami *et al.* (2002) had conducted field experiments during the winter of 1994-95 and 1996-97 to determine the suitable nutrient management for rice. the treatments comprised soil application of 100% recommended NPK rate (TO, Ti 20% additional N (T2), 50% recommended N + 100% recommended P and K rates + 2.5 urea foliar spray at the active tittering and panicle initiation stages (T3), 100% P and K rates + 2.5% urea foliar spray at active tillering, panicle initiation, mid-heading. first flowering and 50% flowering stages (T4). T_0 + 2 kg phosphor bacterium/ ha (T_5), T_1+ 25 kg ZnSO4 (T_6). T_2 + 2% urea foliar spray application at active tillering and panicle initiation stages (T_7) and T_2 + 1% ZnSO4 spraying at active tillering and panicle initiation stages (Ts). 12 resulted in the tallest plants (101.9 cm) and highest number of productive tillers (10), grain yield (6713 kg hal) and straw yield (9183 kg hal), whereas T_3, T_4 and T_7 gave the highest chaff per panicle (12.4), harvest index (43.64%) and number of grains per panicle, respectively.

Hard red winter wheat (*Triticum aestivum*) studies were conducted at two locations in Oklahoma. USA during 1997-2000 to evaluate the effects of late-season foliar N applications on grain yield, total grain N, straw yield, and total straw N (Woolfolk *et al*. 2002). Foliar applications of N were made at two different times (pm and post flowering) using urea ammonium nitrate (UAN) at 0, 11, 22, 34, and 45 kg N/ha. A significant linear increase in total grain N was observed for post flowering applications using UAN in five of six site-years. No consistent increases or decreases from foliar N applications were observed for grain yield, straw yield, or straw N.

Pot experiments were conducted by Andreevska *et. a/.* (2001) to determine the effect of nitrogen fertilizers on the dry matter yield and the total nitrogen content in the roots, stems, leaves and panicles of rice. The complex fertilizer was applied as a basic treatment, while the nitrogen fertilizer was applied as a double foliar split application at the start of the heading stage. The result reported that the method and time of nitrogen application showed a significant positive effect on the yield increase of raw and dry matter of the roots and aboveground organs, and on their total nitrogen content.

Borjian and Emam (2001) conducted a field experiment in Shiraz, Iran, during 1998-99, the effect of rate and time of foliar urea application on protein content and quality in two cultivars of winter wheat, 'Falat' and 'Marvdasht', was studied. A split-plot arrangement of treatments in a randomized complete block design was used with cultivars as the main plots and factorial levels of five urea foliar application rates (0, 8, 16, 24 and 32 kg N ha-1) and three stages of application (booting, anthesis and early-milk), as subplots. The results showed that each 8 kg/ha increment in N applied as urea was associated with a 0.6% increase in grain protein in both cultivars. Both grain yield and protein percentage increased, resulting in higher protein yield.

In a study conducted during 1996-98 in Kalyani, West Bengal, India, crude extract of a compound having growth promoting activity, obtained from Lantana camaro leaves, when used as foliar spray on rice cultivar 1R-36 resulted in appreciable increase in growth of the plants (Sukul and Chaudhuri. 2001). The flowering date was considerably advanced and accompanied with increase in the length of the particle and grain yield. A field experiment was conducted by Badole and Narkhede in (1999) Maharashtra, India during 1995-98 to study the effect of foliar spray of 2% urea for 6 times at 10-day intervals (27.5 kg N/ha) and 3 times at the tillering, panicle initiation and grain-filling stages, with and without basal application of NPK on transplanted rice (*Orvza sativa* cv. Sye-75). the growth and yield of rice increased significantly with the application of 50, 50 and

50 kg/ha (N: P: K) as a basal rate and foliar spray of urea at the 3 growth stages. This same treatment also recorded the highest values for the yield attributing characters.

Aguilar and Grau (1995) had studied that the alluvian soil was given 0-210 lb N/acre as urea before sowing 3 Joponica and 2 Indica type rice cultivars. Foliar analysis at 46, 59 and 67 day after sowing showed that N content decrease during tittering. For each phonological stage and cultivar the critical N scontent was established at which 90% of maximum grain yield was achieved. This should reduce excessive N application and harmful effects on the environment. Japonica type and Indicia type cultivar gave highest grain yields following application of 120 lb and 120-150 lb Nacre"' respectively

Stefan and Stefan (1990) conducted an experiment during 1987-1989.They used 0- 120kg N/ ha applied to soil and 0-90 kg N applied to leaves of rice at 4-5 leaves, 7- 8 leaves or shoot elongation , grain yields ranged from 3.52 and 3.08 ton /ha without N to 7.77 ton and 6.60 ton with 60kg N applied to soil . 60 kg N as urea applied 4-5 and 5-7 to 8 leaf stages in CV polizesti 28 and cristal respectively nutrition co-efficient and rice yield and quality increased with increase in use of liquid N fertilizer.

2.2. Effects of soil application of fertilizers

Singh *el al.* (2008) conducted field experiments in Patna, Bihar, India, from 2001-02 to 2003-04, to study the effect of irrigation and nitrogen (N) fertilizers on yield, water use efficiency and nutrient balance in a rice-based cropping system.

Application of optimum levels of irrigation and N fertilizer increased the rice equivalent yield by 8.40. 6.38 and 6.90% over the sub-optimum level in the both cropping systems.

A field experiment was done to determine the effect of different levels of N on N uptake, yield components and dry matter yield of japonica (1-latsuboshi) and indica (1R-13) rice varieties (Prudente *el al.* 2008). The results showed an increasing trend in N uptake, rice yield, panicle number, tiller number and dry matter production, with increasing the amount of applied N fertilizer. There was a 30 kg/ ha increase in the yield of brown rice and about 1.4% increase in the total N uptake for every additional kilogram of applied N ha The increase in yield could be attributed to the increase in N uptake with increasing N application.

Bamwal *et al*. (2007) conducted an experiment to evaluate the effect of different levels of nitrogen and karanj cake in relation to occurrence of diseases and yield of rice. Applied with 80 kg nitrogen as urea +20 kg karanj oil cake per ha recorded higher mean grain and straw yields of 44.9 q ha-1 and 98.2 q ha-1, respectively.

A field experiment was conducted by Ghosh (2007) during the 2002 and 2003 wet seasons in Curtack, Orissa, India, to study the effect of stand density (high at 150 cm^2 hill- at 15 x 10 cm spacing: medium or normal 300 cm^2 hill- at 15 x 20 cm spacing: and low at 450 cm^2 hill- at 15 x 30 cm spacing) and N fertilizer rates (0, 40, 60 and 80 kg/ha) on the yield and N utilization of rice cv. Sarala. The result reported that N at 60 kg/ha combined with low density stand produced the highest grain yield (3.40 t/ha).

Jia *et al.* (2007) conducted field experiments in China to determine the effect of the application of different nitrogen (N) fertilizer ratios on the vegetative and reproductive stages of rice. Results showed that the suitable N fertilizer ratio applied during the vegetative and reproductive stages in rice was 7:3 and this application decreased production of non-productive tillers, increased production of effective tillers, enhanced kernel set and 1000-grain weight and increased yield.

Li *et al*. (2007) evaluated the effects of nitrogen levels on grain yield and quality of rice under field grown conditions with a typical indica hybrid Shanyou 63 and a japonica cultivar Wuyujing 3 as materials and six N levels, 0, 8, 16, 24, 32 and 40 g/m2, as treatment factors. N at 160 and 240 kg/ha could be the optimum rate for Shanyou 63 and Wuyujing 3, respectively, in the production for the high yield and good quality of rice.

Malik and Kaleem (2007) conducted a field study in Allahabad, Uttar Pradesh, India to evaluate the effect of N rates (100, 150 and 200 kg/ha) and application date on the performance of hybrid rice. N increased grain yield, straw yield, harvest index, test weight up to 200 kg/ha. Split application of N produced higher values of yield components in both cultivars PAC-832 and PAC-801: when N was applied as basal, maximum tillering + panicle initiation.

Majumdar *et al.* (2007) Conducted a field experiment during 2001-03 to study the effects of N (0, 30 and 60 kg/ha), farmyard manure (0 and 5 tonnes/ha) and seed inoculation with diazotrophs (Azotobacter chroococcum and Azospirillum brasilense) on the yield, nutrient uptake by upland rice (*Oryza saliva*) and the residual buildup of various forms of N in an acidic Alfisol. The result revealed that a combined dose of 60 kg N/ha, 5 tonnes farmyard manure and seed inoculation with Azotobacter was the most suitable treatment for upland paddy production (3.9 tonnes/ha), with adequate nitrogen buildup in the Alfisol.

Oo *et al.* (2007) conducted a field experiment during the rainy season of 2003 at the research farm of the Indian Agricultural Research Institute, New Delhi to study the effect of N and S levels on the productivity and nutrient uptake of aromatic rice. Treatments comprised 4 N levels (0, 50, 100 and 150 kg hal). The growth and yield attributes, grain, straw and biological yields increased significantly with increasing N levels. The increase in grain yield due to application of 100 and 150 kg N/ ha over the control was 1.99 and 1.95 t/ha (or 49.5 and 48.5%), respectively. Various N levels had a significant effect on grain, straw and total N. P, K and S uptake. Based on the total N uptake (grain 4- straw) there was 49.9, 63.9 and 70.4% increase in the N uptake over the control with 50, 100 and 150 kg N/ ha, respectively.

Poshtmasari *et al.* (2007) from the Rice Research Institute of Iran-Deputy of Mazandaran (Amol) reported that nitrogen fertilizer rates and split application had significant effect on dry matter remobilization in shoot, stem and leave (except flag leaf). This amount was obtained at the 100 kg ha-' nitrogen fertilizer and the first split application treatment. The highest rate of dry matter remobilization in leaves (except flag leaf) was obtained in 200 kg hal nitrogen fertilizer level. Also, flag leaf had the highest dry matter remobilization, although it was not affected by nitrogen fertilizer rates and split application.

Rahman *et al.* (2007) conducted on experiment in Agricultural University, Mymensingh during T. Aman season of 2002 to study the effect of different level of nitrogen on growth and yield of transplant aman rice. The experiment included four treatments viz. 0, 60, 80 and 100 kg N hal. Nitrogen level significantly influenced growth and yield components. The highest number of effective tillers hill', maximum grains panicle" and highest grain yield and the highest harvest index i.e., maximum yield were obtained with 80 kg N .

A field experiment was conducted by Sharma *et al*. (2007) during the rainy season of 2002 and 2003 at Sabour study the effect of nitrogen and weed management in direct-seeded upland rice (*Oryza saliva* L). Grain and straw yields of rice and N, P and K uptake by rice crop and weeds increased significantly with successive increase in nitrogen up to 120 kg/ha.

A field experiment was conducted in India during kharif seasons at the Rajendra Agricultural University Farm, Pusa, Samastipur (Bihar) to assess the optimum nitrogen level and time of its application on growth, yield, yield attributes and quality of Basmati rice var. 'Kasturi' (Singh and Thakur, 2007). Results showed that the N fertilization influenced the quality traits of Basmati rice (Var. Kasturi).

Tari *el al.* (2007) carried out a field experiment in Iran to study the effects of transplanting date (2, 12 and 22 May), planting space (16 x3 0, 20 x 20 and 25 x 25) cm and N application rates (92,115 and 135 kg ha-I) on morphological characters of a promising rice line (IR6874-2). The N levels had significant effect on panicle length. 1000-grain weight and grain yield of rice. The 1000-grain weight, harvest index and filled grain percentage had the highest correlation with grain yield.

A field experiment was conducted by Gobi *et al.* (2006) during the late pishanam season of 2001-02, in Killikulam, Tamil Nadu, India, to evaluate the effect of plant population (40 and 50 hills/m2), establishment method (line planting and seedling broadcasting), and split application of N and K (three splits of N + two splits of K; four splits of N + three splits of K; and five splits of N and four splits of K) on the growth and yield of hybrid rice (CORN-2). The result revealed that maximum values of growth and yield attributes as well as net returns and benefit: cost ratio were obtained with seedling broadcasting with 40 hills/m2 under five splits of N and four splits of K.

Field experiments were conducted by Mehla *et al.* (2006) at the Rice Research Station, in Kaul, Haryana, India, during kharif 2000, 2001 and 2002 to study the effect of N (at 0, 90. 120. 150 and 180 kg ha-I) and water management practices (continuous submergence, irrigation one day after disappearance of standing water and irrigation three days after disappearance of standing water) on the yield and nutrient uptake by rice cv. HKR-120. The yield and nutrient uptake by rice increased with the increase in N levels during all the years.

Manzoor *et al.* (2006) conducted a study during kharif season of three successive years from 2001 to 2003 at Rice Research Institute, Kala Shah Kaku, Lahore, Pakistan. Nine nitrogen levels (0, 50. 75, 100, 125, 150, 175, 200 and 225 kg ha-') were studied to see their effect on paddy yield. According to the results plant height, number of productive tillers per hill, panicle length, number of grains per panicle, 1000 grain weight and paddy yield showed increasing trend from up to 175 kg N per hectare. The yield parameters including paddy yield, number of grains per panicle and 1000-grain weight started declining at 200 kg N per hectare level and above. The maximum paddy yield (5.34 t ha-') was obtained from 175 kg N application which also produced higher number of grains per panicle (142.27 cm) along with maximum 1000-grain weight (24.96 g). The plant height (145.56 cm), productive tillers per hill (19.67) and panicle length (36.62 cm) were the maximum at 225 kg N level.

Masud (2006) reported that application of nitrogen exerted positive effect on all crop characteristics. The rice genotypes differ significantly in yield contributing characters and grain yield growth and yield of hybrid rice (CORN-2). The result revealed that maximum values of growth and yield attributes as well as net returns and benefit: cost ratio were obtained with seedling broadcasting with 40 hills/m2 under five splits of N and four splits of K.

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Masud (2006) reported that application of nitrogen exerted positive effect on all crop characteristics. The rice genotypes differ significantly in yield contributing characters and grain yield. The effects of nitrogen levels (0, 30 and 60 kg/ha) on rice (cv. MW-10) intercropped with greengram (cv. B-105) under different spatial arrangements (4R:26 and 2R:2G) were studied during the wet seasons of 2000 and 2001, on sandy loam soil, in Nadia, West Bengal, India (Patra *et al.* 2006) Intel-cropping of gm-engrain with rice grown without nitrogen was the most efficient intercropping system, producing the highest yield advantage. The advantages in intercroppings were through higher yield components, land equivalent ratio (1.62), area time equivalent ratio (1.28), monetary advantages (Rs 10318/ha), net return (Rs 19 981) and benefit-cost ratio (2.73). An economy of at least 30 kg N/ha in intercropping with greengram could be possible when component crop of rice was grown without or at 30 kg N

Field experiments were conducted by Pragya and Abha (2006) in the Taraj region, near Bareilly, Uttar Pradesh, India, to evaluate the effects of different levels of N fertilizer (0, 60, 90, 120 and 150 kg/ha) on the grain yield, harvest index and chlorophyll content of rice cultivars Pant-4 and Manhar. All parameters increased with increasing levels of N up to 120 kg/ha.

Singh *et al.* (2006) from a field experiment in Ludhiana. Punjab, India, during kharif 2003 reported that N application significantly increased plant height, number of grains panicle', 1000-grain weight and LAI but it did not influence the number of effective tillers plant", panicle length and branches panicle'. A progressive and significant increase in grain and straw yield was observed with each increment of nitrogen up to 40 kg ha'. Overall acceptability score with respect to aroma, colour, flavour, tenderness and cohesiveness was increased with early transplanting, less plant population and application of different levels of nitrogen compared to the control.

Sharma and Agarwal (2006) conducted a field experiment in the Taraj region, near Bareilly. Uttar Pradesh, India, to evaluate the effects of different levels of N (0, 60, 90, 120 and 150 kg /h) on the grain yield, harvest index and chlorophyll content of rice cultivars Pant-4 and Manhar. All parameters increased with increasing levels of N up to 120 kg ha". Pant-4 produced higher yield than Manhar did.

A field experiment conducted by Thakur *et al.* (2006) in Ludhiana, Punjab, India. during kharif 2003 to evaluate the effect of date of transplanting, plant population and nitrogen level on yield and quality of Basmati rice (*Oryza saliva*). The result showed that date of transplanting did not influence plant height, leaf area index (LAI), straw yield and other yield attributing characters and produced statistically similar grain yield for Basmati rice. Plant population of 25 and 33 hills m-2 produced taller plant, whereas population of 44 hills fri-2 recorded significantl) higher LAI. The number of effective tillers plant" decreased significantly with increase in population. Nitrogen application significantly increased plant height, number of grains per panicle, 1000-grain weight and LAI but it did not influence the number of effective tillers per plant, panicle length and branches per panicle.

CHAPTER III

MATERIALS AND METHODS

Details of the methodology of the study followed during the research period are presented in this chapter.

3.1. Location and duration

The experiment was conducted at Crop Physiology and Ecology Research Field, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during the period from July to November 2018.

3.2. Soil and Climate

The experimental field was a medium high land belonging to the non-calcareous dark gray floodplain soil under the agro-ecological zone (AEZ-1) of Old Himalayan Piedmont Plain. The soil is sandy loam under the Order Inceptisol. The experimental site is situated in the sub-tropical region characterized by heavy rainfall during the months from May to September and scantly rainfall in the rest of the year. Details of the soil characteristics of the experimental site is presented in Appendix I and details of the meteorological data in respect to temperature, rainfall and relative humidity during the growing period of the experimental site are presented in the Appendix II.

3.3. Land preparation

Land preparation was started on 12 July 2018. The land was prepared thoroughly by ploughing and cross ploughing with a power tiller. Weeds and stubbles of the previous crop were collected and removed from the plot. After uniform labelling, the plots were laid out as per as treatment and design of the experiment.

3.4. Experimental design and treatments

The experiment was laid out in a single factor Randomized Complete Block Design (RCBD) with five treatments and four replications. The total number of unit plots was 24 and the size of unit plot was 2 m x 2 m. Plots were separated from one another by ails of 0.25 m. Unit blocks were separated d from one another by 1 m drains. Treatments were randomly distributed within the blocks. The treatments were:

T_0 = Without fertilizer

T_1 = Recommended Fertilizer Doses (RDF)

T_2 = Half of RDF and American NPKS

T_3 = RDF and American NPKS

T_4 = Half of RDF and foliar NK application

T_5 = RDF and foliar NK application

American NPKS is a foliar-applied mixed fertilizer providing four major nutrient elements of nitrogen, phosphorus, potassium and sulphur with a grade mixing ratio of 8:20:14:5. American NPKS is also a complete fertilizer as it contains all three principle elements extremely essential for overall plants growth and development. A fertilizer dose of 116-16.1-70.2-13.34-1.04-0.502 kg ha^{-1} N, P, K, S, Zn and B was applied in the form of Urea, Triple Supper phosphate (TSP), Murate of potash (MP), Gypsum and Boric acid respectively for Recommended Fertilizer Doses (RDF). Full amount and half amount of RDF was applied during final land preparation except urea. Urea was splited into equal amount in three times i.e. basal application, 25 and 50 days after transplanting. 1% American NPKS, 2 % Urea and 1% Murate of potash (MP) solution were prepared and applied in the respective plot for three times at 15 days interval starting from 30 days up to 60 days after transplanting.

3.5. Transplanting of seedling

Twenty four days old seedlings were carefully uprooted from a seedling nursery and planted on well puddled unit plots. Three healthy seedlings were transplanted in each hill.

3.6. Intercultural operations

Following intercultural operations were done for ensuring proper growth and development of the crop.

3.6.1. Irrigation and drainage

Necessary irrigations were provided to the plots as and when required and water level was maintained at 5 cm on soil surface in each unit plot during the growing period of rice crop.

3.6.2. Weeding

The experiment plots were infested with some common weeds, which were removed by uprooting from the field three times during the crop growth.

3.6.3 Disease and pest control

There was no infestation of insect pest and disease in the field and no control measures were adapted.

3.7. Data collection from plant samples

3.7.1 Plant height

The plant height in cm at 45, 55, 65, 75 days after transplanting and at harvest was measured from the ground level to the top of the panicle for each plot. Plants of 5 hills were measured and averaged.

3.7.2. Number of leaves per hill

Number of leaves per hill at 45, 55, 65, 75 days after transplanting and at harvest was counted and the data were recorded from 5 hills and mean value was counted and recorded.

3.7.3. Leaf area

Leaf area at 65 days after sowing and at harvest was measured from leaf length and leaf breadth from 5 selected plants and then averaged as leaf area/plant in cm^2. Actual leaf area was calculated by multiplying leaf length × leaf breath× 0.75.

3.7.4. SPAD value

SPAD value was taken from middle portion of the flag leaf of five main shoot at 50, 60 days after transplanting and at harvest using SPAD meter (Model:

MINOLTA, CHLOROPHYLL METER, SPAD-502, JAPAN).

3.7.5. Number of tillers per hill

Five hills were taken randomly from each plot and total number of tillers per hill, total number of effective tillers per hill were recorded.

3.7.6. Number of filled and unfilled grains per panicle

Five panicles were taken at random hill^{-1} and the filled and unfilled spikelet panicle^{-1} were counted and averaged.

3.7.7. Panicle length

The measurement of panicle length in cm was taken from basal node of the rachis to apex of each panicle. Each observation was an average of 5 hills.

3.7.8. 1000-grain weight

The weight of 1000 grains from each plot was weighed after sun drying by an electrical balance.

3.7.9. Grain yield per hill (g)

Grain yield was recorded for five hill after sun drying. The grain yields per hill was expressed as gm on 14% moisture basis.

3.7.10. Grain and straw yields (t/ha)

Grain and straw yields were recorded for each plot after sun drying. The grain yields were expressed as t/ha on 14% moisture basis.

3.8. Data Analysis

The data were analyzed by partitioning the total variance with the help of computer by using MSTAT program. The treatment means were compared using DMRT at $P \leq 1\%$ level.

CHAPTER IV

RESULT AND DISCUSSION

4.1. Pant height

Plant height at different days after transplanting was not significantly influenced by different treatments at different days after transplanting (Fig. 1). Figure shows that plant height was increased with the advancement of time. The highest plant height was observed in treatment T_4 (Half of RDF and foliar NK application) and lowest plant height was observed in T_0 (Without fertilizer). Plant height at harvest where the highest plant height was observed in treatment T_1 (Recommended Fertilizer Doses) and the lowest plant height was observed in T_5 (RDF and foliar NK application). The results of the present study revealed that plant height at different days after transplanting was increased due to foliar fertilization compared to control. The results were supported by Khang (2011) and Shafiee *et al.* (2013) who reported that foliar fertilization significantly increased the plant height of rice at different days after transplanting. The results also indicated that increasing nitrogen levels increased the plant height because of improving the rate of photosynthesis and translocation of assimilates which was reflected by increase in plant height (Sharief *et al*. 2006).

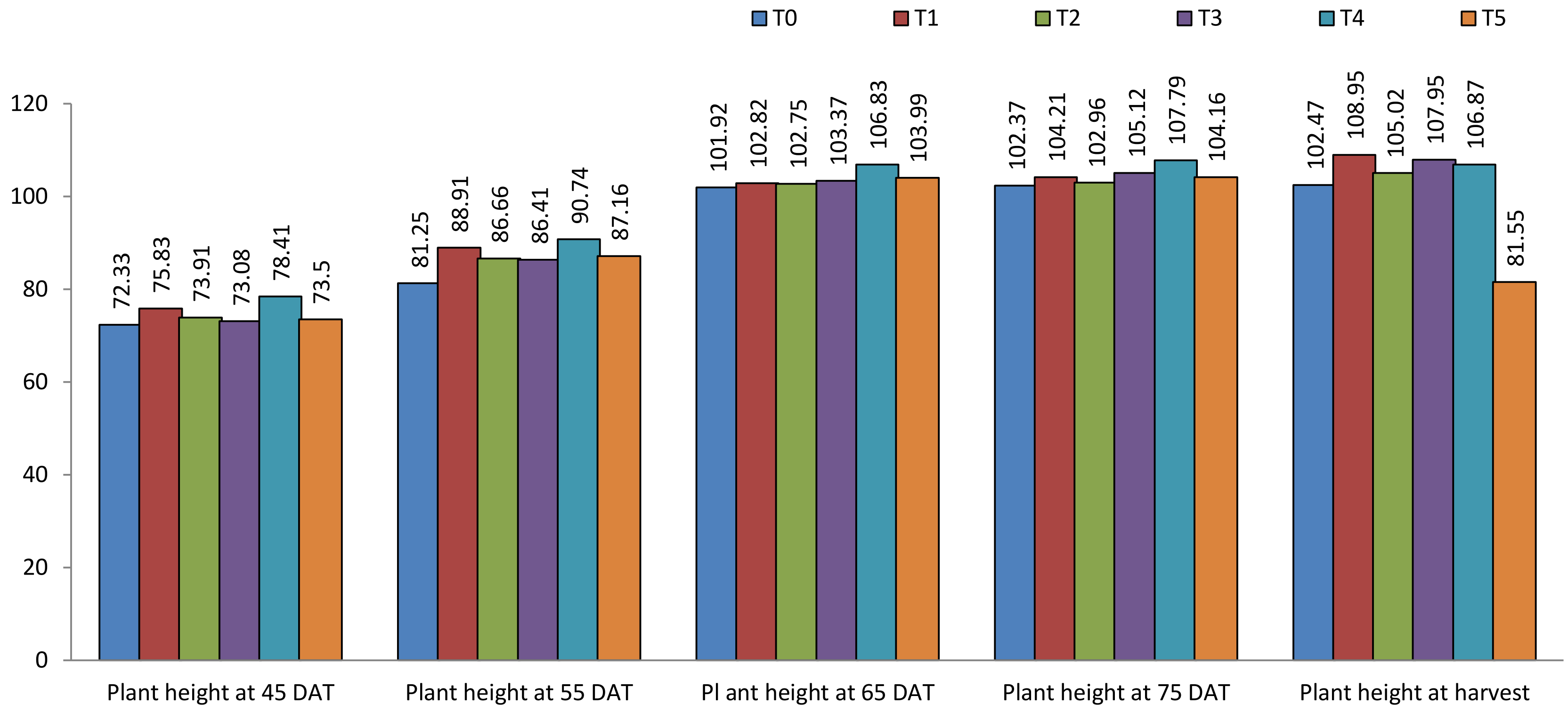

Fig. 1. Plant height at different days after transplanting as influenced by different foliar fertilizer applications.

In a column, values followed by similar letter(s) did not differ significantly by Tukey'stest at P ≤ 5%.

T_o= Without fertilizer, T_1=Recommended Fertilizer Doses (RDF), T_2= Half of RDF and American NPKS, T_3= RDF and American NPKS, T_4= Half of RDF and foliar NK application, T_5= RDF and foliar NK application

4.2. Tillers per hill

Number of tillers per hill was not significantly influenced by different treatments at 45DAT and 55 DAT but it was significant in 65, 75 and 85 DAT (Fig. 2). Figure shows that number of tillers per hill was increased with the advancement of time. At 45 DAT, the highest tiller number (25.91) was observed in treatment T_3 (RDF and American NPKS) and lowest tiller number (18.25) was observed in treatment T_0 (Without fertilizer). At 55 DAT, the highest tiller number (27.83) was observed in treatment T_3 (RDF and American NPKS) and lowest tiller number (19.83) was observed in treatment T_0 (without fertilizer). At 65 DAT, the highest tiller number (27.49) was observed in treatment T_3 (RDF and American NPKS) which was statistically similar to those observed in T_5, T_2 followed by T_1 and T_4 and lowest tiller number (18.58) was observed in treatment T_0 (Without fertilizer). At 75 DAT, the highest tiller number (26.41) was observed in treatment T_3 (RDF and American NPKS) which was statistically similar to those observed in T_5, T_2 followed by T_1 and T_4 and lowest tiller number (17.58) was observed in treatment T_0 (Without fertilizer). At 85 DAT, the highest tiller number (26.7) was observed in treatment T_3 (RDF and American NPKS) followed by T_1, which was statistically similar to those observed in T_4, T_5 and T_2 and lowest tiller number (17.58) was observed in treatment T_0 (Without fertilizer). The results of the present study were also supported by the findings of Shayganya *et al*. (2011) who reported that foliar application of different nutrients increased tiller number of rice.

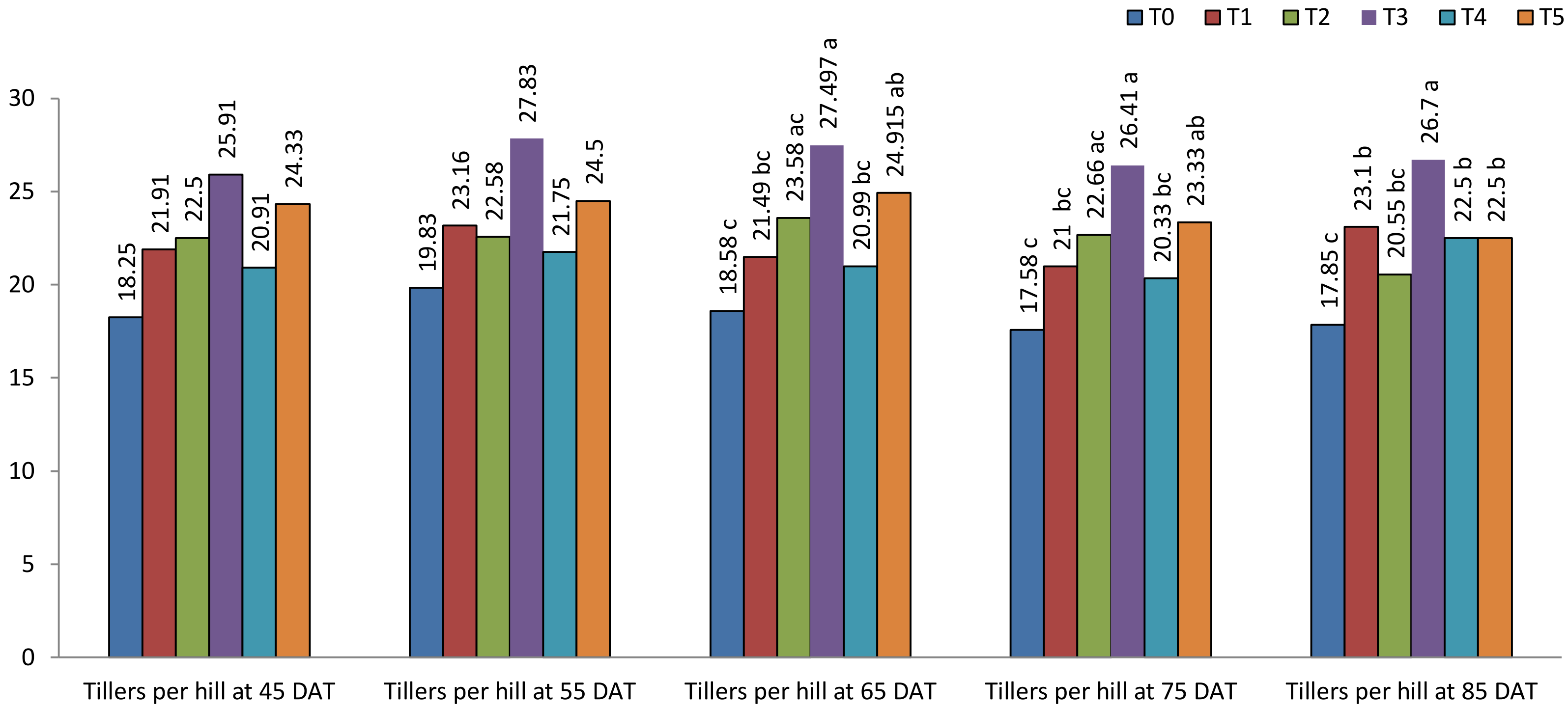

Fig. 2. Number of tiller per hill at different days after transplanting as influenced by different foliar fertilizer applications.

In a column, values followed by similar letter(s) did not differ significantly by Tukey's test at $P \leq 5\%$.

T_o= Without fertilizer, T_1=Recommended Fertilizer Doses (RDF), T_2= Half of RDF and American NPKS, T_3= RDF and American NPKS, T_4= Half of RDF and foliar NK application, T_5= RDF and foliar NK application

4.3. Leaves per hill

Number of leaves per hill at different days after transplanting was significantly influenced by different fertilizer treatments at different days after transplanting (Fig. 3). Figure shows that number of leaves per hill was increased with the advancement of time. At 45 DAT, the highest leave number (106.58) was observed in treatment T_5 (RDF and foliar NK application) followed by T_3 which was statistically similar to those observed in T_2 followed by T_1 and T_4 and lowest leaf number (84.91) was observed in treatment T_0 (without fertilizer). At 55 DAT, the highest leave number (129.25) was observed in treatment T_3 (RDF and American NPKS) followed by T_5 which was statistically similar to those observed in T_2 , T_1 and T_4 and lowest leaf number (89.5) was observed in treatment T_0 (without fertilizer). At 65 DAT, the highest leave number (136.24) was observed in treatment T_3 (RDF and American NPKS) which was statistically similar with T_5 followed by T_2, T_4 and T_1 and lowest leaf number (98.82) was observed in treatment T_0 (Without fertilizer). At 75 DAT, the highest leave number (129.5) was observed in treatment T_3 (RDF and American NPKS) followed by T_5 which was statistically similar with T_2 followed by T_4 and lowest leaf number (86.16) was observed in treatment T_0 (without fertilizer). Greater leaves per hill in additional foliar (T_3 and T_5) spray treatment might be due to greater tillers per hill in the respected treatments.

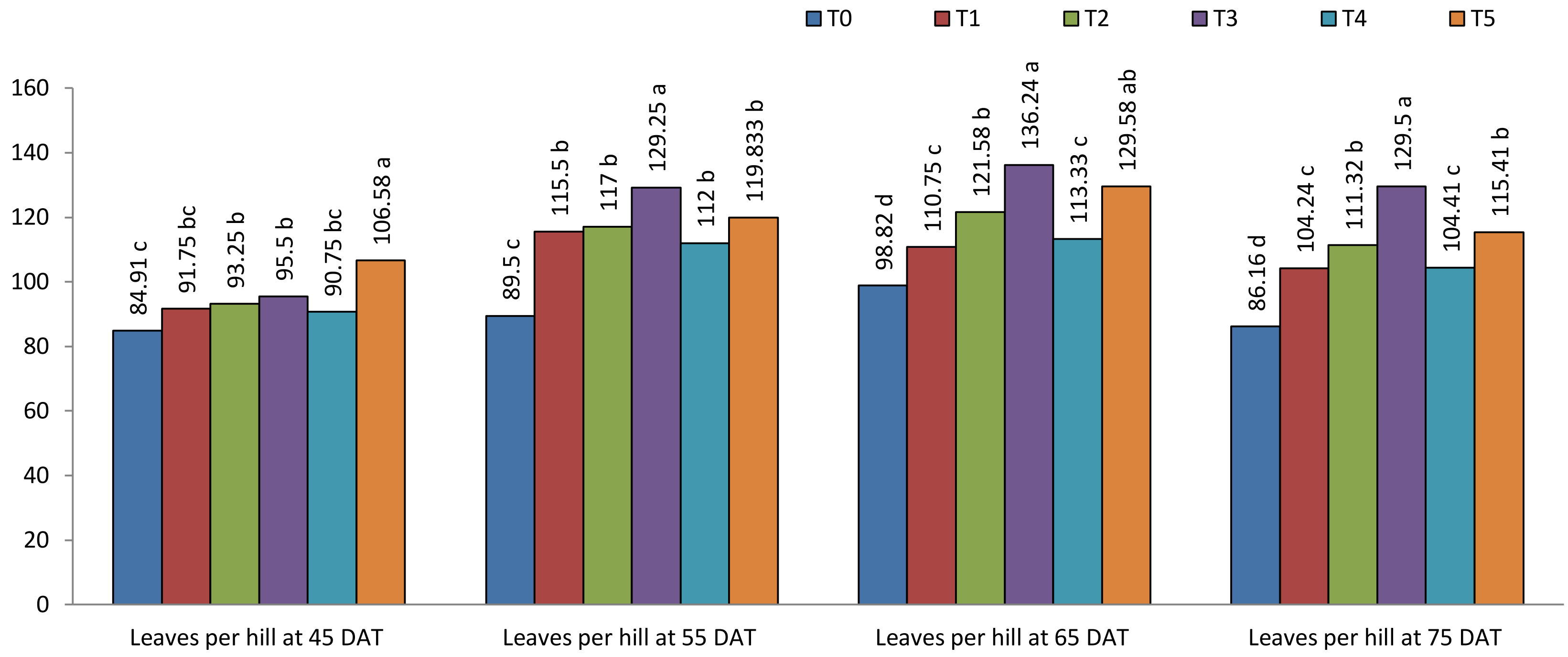

Fig. 3.Number of leaves per hill at different days after transplanting as influenced by different foliar fertilizer applications.

In a column, values followed by similar letter(s) did not differ significantly by Tukey'stest at $P \leq 5\%$.

T_o= Without fertilizer, T_1=Recommended Fertilizer Doses (RDF), T_2= Half of RDF and American NPKS, T_3= RDF and American NPKS, T_4= Half of RDF and foliar NK application, T_5= RDF and foliar NK application

4.4. SPAD value

SPAD value at different days after transplanting was significantly influenced by different treatments (Fig. 4). Figure shows that SPAD value was different for different treatments at different days after transplanting. At 50 DAT, the highest SPAD value (36.95) was observed in treatment T_1 (Recommended Fertilizer Doses) followed by T_3 which was statistically similar to those observed in T_2 and T_5 and lowest SPAD value (31.22) was observed in treatment T_0 (Without fertilizer). At 60 DAT, the highest SPAD value (37.87) was observed in treatment T_1 (Recommended Fertilizer Doses) followed by T_3 which was statistically similar to those observed in T_2 and T_1 and lowest SPAD value (33.65) was observed in treatment T_5 (RDF and foliar NK application). At 70 DAT, the highest SPAD value (41.25) was observed in treatment T_4 (Half of RDF and foliar NK application) which was statistically similar to those observed in T_1 and T_3 followed by T_1, T_5 and lowest SPAD value (37.32) was observed in treatment T_2 (Half of RDF and American NPKS). Shafiee *et al.* (2013) showed that SPAD meter readings of rice leaf were significantly influenced by different foliar fertilizer treatments. Tejada and Gonzalez (2004) reported positive effects of foliar fertilization on chlorophyll *a* and *b,* and carotenoids content of rice plant, which presumably favored photosynthesis. Lin and Zhu (2000) also reported that leaf senescence was inhibited and the leaf chlorophyll was increased by foliar application of fertilizer at heading stage, but the results of the present study indicated that foliar fertilization did not influence the chlorophyll content in rice.

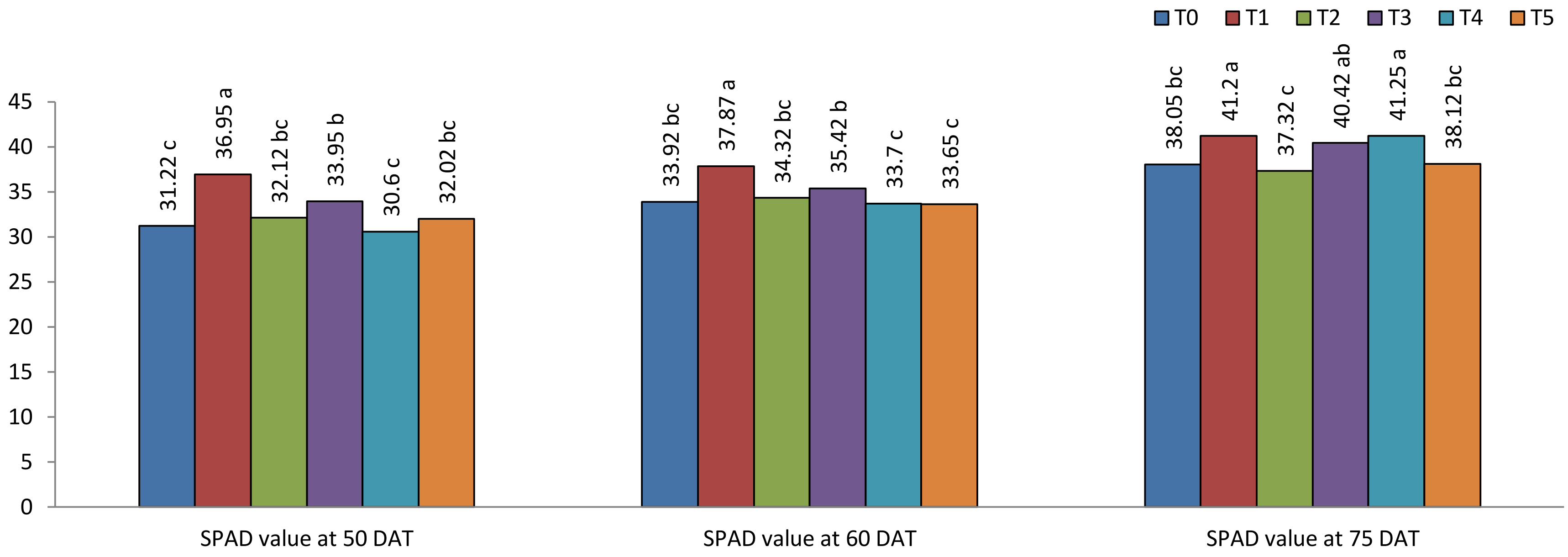

Fig. 4. SPAD value at different days after transplanting as influenced by different foliar fertilizer application

In a column, values followed by similar letter(s) did not differ significantly by Tukey's test at P ≤ 5%.

T_o= Without fertilizer, T_1=Recommended Fertilizer Doses (RDF), T_2= Half of RDF and American NPKS, T_3= RDF and American NPKS, T_4= Half of RDF and foliar NK application, T_5= RDF and foliar NK application

4.5. Leaf area per hill

Leaf area per hill at 65 DAT was significantly influenced by different treatments (Table 1). Table shows that leave area per hill was different for different treatments. The highest leaf area (3951.88 cm^2) was observed in treatment T_3 (RDF and American NPKS) which was statistically similar to those observed in T_4, T_5 and T_2 and the lowest leaf area (2674.50 cm^2) was observed in treatment T_0 (Without fertilizer) which was statistically similar with T_1. Greater leaf area per hill for greater leaf number per hill in respected treatments.

4.6. Leaf dry weight

Leaf dry weight at 65 DAT was not significantly influenced by different treatments (Table 1). Result showed that leave dry weight was different for different treatments. The highest leaf dry weight (0.114 gm) was observed in treatment T_2 (Half of RDF and American NPKS) and the lowest leaf dry weight (0.093 gm) was observed in treatment T_0 (Without fertilizer).

Table 1: Effect of fertilizer foliar spay on leaf area and leaf dry weight

Treatment	Leaf area per hill (cm^2)	Leaf dry weight (gm) at 65 DAT
T_0	2674.50 c	0.093
T_1	3194.33 bc	0.104
T_2	3488.47 ab	0.114
T_3	3951.88 a	0.110
T_4	3719.51 ab	0.110
T_5	3601.54 ab	0.109
Levels of significance	NS	NS
CV (%)	10.42	10.42

In a column, values followed by similar letter(s) did not differ significantly by Tukey'stest at $P \leq 5\%$.

T_o= Without fertilizer, T_1=Recommended Fertilizer Doses (RDF), T_2= Half of RDF and American NPKS, T_3= RDF and American NPKS, T_4= Half of RDF and foliar NK application, T_5= RDF and foliar NK application

4.7. Effective tillers per hill

Effective tiller per hill was significantly influenced by different treatments (Table 2). Table shows that effective tiller per hill was different for different treatments. The highest number of effective tiller per hill (23.30) was observed in treatment T_3 (RDF and American NPKS) which was statistically similar to those observed in T_5 followed by, T_4 and T_1, and lowest number of effective tiller per hill (15.30) was observed in treatment T_0 (Without fertilizer).

4.8. Filled spikelet per spike

Filled spikelet per spike was significantly influenced by different treatments (Table 2). Table shows that filled spikelet per spike was different for different treatments. The highest number of filled spikelet per spike (152.00) was observed in treatment T_3 (RDF and American NPKS) which was statistically similar to those observed in T_4, T_2 and T_1 and lowest number of filled spikelet per spike (122.00) was observed in treatment T_0 (Without fertilizer) which was statistically similar with T_5. Increase in level of nitrogen application will increase the number of filled grains panicle-1 as reported by Channabasavanna *et al*. (2001), which might be due to higher availability of N at panicle initiation and grain development stages.

Table 2: Effect of fertilizer foliar spay on effective tiller per hill, filled spikelet per spike and unfilled spikelet per spike

Treatment	Effective tillers per hill	Filled spikelet per panicle	Unfilled spikelet per panicle
T_0	15.30 c	122.00 b	26.80
T_1	19.55 b	138.80 a	22.70
T_2	18.25 bc	142.75 a	26.95
T_3	23.30 a	152.00 a	23.50
T_4	19.85 b	142.15 a	28.40
T_5	20.20 ab	136.35 ab	25.40
Levels of significance	**	*	NS
CV (%)	10.65	6.99	33.09

In a column, values followed by similar letter(s) did not differ significantly by Tukey'stest at $P \leq 5\%$.

T_o= Without fertilizer, T_1=Recommended Fertilizer Doses (RDF), T_2= Half of RDF and American NPKS, T_3= RDF and American NPKS, T_4= Half of RDF and foliar NK application, T_5= RDF and foliar NK application

4.9. Unfilled spikelet per spike

Unfilled spikelet per spike was not significantly influenced by different treatments (Table 2). Table shows that unfilled spikelet per spike was different for different treatments. The highest number of unfilled spikelet per spike (28.40) was observed in treatment T_3 (RDF and and lowest number of unfilled spikelet per spike (22.70) was observed in treatment T_0 (Without fertilizer).

4.10. Panicle length

Panicle length at 85 DAT was significantly influenced by different treatments (Table 3). Table shows that panicle length was different for different treatments. The highest panicle length (28.27 cm) was observed in treatment T_3 (RDF and American NPKS) which was statistically similar to those observed in T_2, $T_{1,}$ T_4 and T_5 and lowest panicle length (26.60) was observed in treatment T_0 (Without fertilizer). Ndaeyo *et al.* (2008) conducted an experiment in Nigeria with five rice varieties and found that higher N doses increased length of central panicle per plant.

4.11. Grain yield per hill

Grain yield per hill was significantly influenced by different treatments (Table 3). Table shows that grain yield per hill was different for different treatments. The highest grain yield per hill (52.31 gm) was observed in treatment T_3 (RDF and American NPKS) followed by T_5 which was statistically similar to those observed in T_1, $T_{4,}$and T_2 and lowest grain yield per hill (30.22 gm) was observed in treatment T_0 (Without fertilizer).

Table 3: Effect of foliar fertilizer spay on panicle length, grain yield per hill, thousand grain weight, grain yield and straw yield

Treatment	Panicle length (cm)	Grain yield per hill (g)	Thousand grain weight (g)	Grain yield (t/ha)	Straw yield (t/ha)
T_0	26.60 b	30.22 c	23.92	8.74 c	7.88 c
T_1	28.17 a	42.25 b	24.07	10.64 ab	10.82 ab
T_2	28.22 a	38.24 b	23.86	8.92 c	9.07 c
T_3	28.27 a	52.31 a	24.10	11.05 a	11.87 a
T_4	28.07 a	39.84 b	24.10	9.19 c	10.48 b
T_5	28.02 a	43.70 b	24.94	11.09 ab	10.51 b
Levels of significance	*	**	NS	**	**
CV (%)	2.50	10.75	3.74	5.14	8.41

In a column, values followed by similar letter(s) did not differ significantly by Tukey'stest at $P \leq 5\%$.

T_o= Without fertilizer, T_1=Recommended Fertilizer Doses (RDF), T_2= Half of RDF and American NPKS, T_3= RDF and American NPKS, T_4= Half of RDF and foliar NK application, T_5= RDF and foliar NK application

4.12. Thousand grain weight

Thousand grain weights was not significantly influenced by different treatments (Table 3). Table shows that thousand grain weight was different for different treatments. The highest thousand grain weight (24.94 gm) was observed in treatment T_5 (RDF and foliar NK application) and lowest thousand grain weights (23.86 gm) was observed in treatment T_2 (Half of RDF and American NPKS).

4.13. Grain yield

Grain yield was significantly influenced by different treatments (Table 3). Table shows that grain yield was different for different treatments. The highest grain yield (11.05 t/ha) was observed in treatment T_3 (RDF and American NPKS) which was statistically similar to those observed in T_5 followed by T_1 and lowest grain yield (8.74 t/ha) was observed in treatment T_0 (Without fertilizer) which was statistically similar to those observed in T_2 and T_4. Increase in yield attributes and yield might be due to higher availability of N at panicle initiation and grain development stages. The contribution of carbohydrates from photosynthetic activity for longer period might have resulted in efficient translocation of food material into grain. This is in line with findings of Kumar *et al*. (2008). Lin and Zhu (2000) found that foliar spray of fertilizer at heading stage increased grain yield as a result of increasing grain number per panicle. They also reported that leaf senescence was inhibited and the leaf chlorophyll and photosynthesis were increased by foliar application of fertilizer at heading stage.

4.14. Straw yield

Straw yield was significantly influenced by different treatments (Table 3). Table shows that straw yield was different for different treatments. The highest straw yield (11.87 t/ha) was observed in treatment T_3 (RDF and American NPKS) which was statistically similar to those observed in T_1 followed by $T_{5,}T_4$ and lowest grain yield (7.88 t/ha) was observed in treatment T_0 (Without fertilizer) which was statistically similar with T_2.

Improved rice growth due to foliar fertilization might be due to increase in chlorophyll content (Tejada and Gonzalez 2004), inhibition of leaf senescence (Lin and Zhu, 2000), increase in photosynthesis rate (Sultana *et al*. 2001) and improve in translocation of assimilates (Sharief *et al.* 2006) which is reflected by increase in plant height, tillers hill^{-1} and leaves hill^{-1} resulting in increased above ground biomass.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Crop Physiology and Ecology research field of Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during the period from July to November 2018 with a view to evaluating the effect of foliar fertilizar application on the growth and yield of Aman rice (BINA Dhan-7). The experiment was laid out in a randomized complete block design (RCBD) with six treatments and four replications. The total number of unit plots was 24 and the size of unit plot was 2 m x 2 m. Plots were separated from one another by ails of 0. 25 m. Unit blocks were separated from one another by 1 m drains. Treatments were randomly distributed within the blocks. The treatments were, T_o= Without fertilizer, T_1=Recommended Fertilizer Doses (RDF), T_2= Half of RDF and American NPKS, T_3= RDF and American NPKS, T_4= Half of RDF and foliar NK application, and T_5= RDF and foliar NK application. A fertilizer dose of 116-16.1-70.2-13.34-1.04-0.502 kg ha^{-1} N, P, K, S, Zn and B was applied in the form of Urea, Triple Supper phosphate (TSP), Murate of potash (MP), Gypsum and Boric acid respectively for Recommended Fertilizer Doses (RDF). Full amount and half amount of RDF was applied during final land preparation except Urea. Urea was splited into equal amount in three times i.e. basal application, 25 and 50 days after transplanting. 1% American NPKS, 2 % Urea and 1% Murate of potash (MP) solution were prepared and applied in the respective plot for three times at 15 days interval starting from 30 days after transplanting. Data were collected on plant height, number of leaves per hill at days after transplanting, leaf area, SPAD value, number of tillers per hill at days after transplanting, number of filled and unfilled grains per panicle, panicle length, 1000-grain weight, grain yield per hill, grain and straw yields.

There was a significant variation in all the parameters due to different treatment. In most cases, plant height, number of leaves per hill and tillers per hill at days after transplanting was highest in treatment T_4 (Half of RDF and foliar NK application) and lowest plant height was observed in T_0 (Without fertilizer).

SPAD value was also significantly influenced by different treatments. The highest SPAD value was observed in treatment T_1 (Recommended Fertilizer Doses) and the lowest SPAD value was observed in treatment T_0 (Without fertilizer) at different days after transplanting.

The highest leaf area was observed in treatment T_3 (RDF and American NPKS) which was statistically similar to those observed in T_4, T_5 and T_2 and lowest leaf area was observed in treatment T_0 (Without fertilizer) which was statistically similar with $T_{1.}$ The highest number of effective tiller per hill was observed in treatment T_3 (RDF and American NPKS) which was statistically similar to those observed in T_5 followed by, T_4 and $T_{1,}$ and lowest number of effective tiller per hill was observed in treatment T_0 (Without fertilizer).. The highest number of filled spikelet per spike was observed in treatment T_3 (RDF and American NPKS) which was statistically similar to those observed in T_4, T_2 and T_1 and lowest number of filled spikelet per spike was observed in treatment T_0 (Without fertilizer) which was statistically similar with $T_{5.}$

Leaf dry weight, unfilled spikelet per panicle and thousand grain weight were not significantly influenced by different treatments. The highest panicle length was observed in treatment T_3 (RDF and American NPKS) which was statistically similar to those observed in T_2, T_1, T_4 and T_5 and lowest panicle length was observed in treatment T_0 (Without fertilizer). The highest grain yield per hill was observed in treatment T_3 (RDF and American NPKS) followed by T_5 which was statistically similar to those observed in T_1, T_4, and T_2 and lowest grain yield per hill was observed in treatment T_0 (Without fertilizer). The highest grain yield as observed in treatment T_3 (RDF and American NPKS) which was statistically similar to those observed in T_5 followed by T_1 and lowest grain yield was observed in treatment T_0 (Without fertilizer) which was statistically similar to those observed in T_2 and T_4. In case of straw yield, the highest straw yield was observed in treatment T_3 (RDF and American NPKS) which was statistically similar to those observed in T_1 followed by T_5, T_4 and lowest grain yield was observed in treatment T_0 (Without fertilizer) which was statistically similar with T_2 treatment.

From the overall results it may concluded that-

- Growth and yield of Aman rice was increased due to foliar fertilizer application.
- Significantly higher plant height, leaf number, tillers per hill, leaf area, number of tillers per hill, filled grains per panicle, panicle length and grain yield per hill due to additional foliar spray T_3 (RDF and American NPKS) and T_5 (RDF and foliar NK application) were contributed to higher yield.

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APPENDICES

Appendix I. Characteristics of soil of the experimental site

General characters	Description	
Location	Crop Physiology and Ecology, HSTU, Dinajpur	
AEZ	Old Himalayan Piedmont Plain (AEZ-1)	
General Soil type	Non-Calcareous Brown Floodplain Soil	
Parent material	Piedmont alluvium	
Soil series	Ranishankail	
Drainage	Moderately well drained	
Flood level	Above flood level	
Topography	High land	
Physical characteristics	**Value**	
Bulk density (g cm-3)	0.86-1.07	
Particle size (%)		
Sand (2-0.02mm)	60.0	
Silt (0.02-0.002mm)	27.0	
Clay (< 0.002mm)	13.0	
Textural class	Sandy loam	
Chemical characteristics	**Content**	**Interpretation**
pH	5.40-5.50	Moderately acidic
Organic carbon (%)	0.69	Low
Organic matter (%)	1.19	Low
CEC (meq/100g soil)	5.60	Low
Total N (%)	0.07	Very low
Available P (ppm)	16.75	Medium
Exchangeable K (meq/100g soil)	0.17	Medium low

Source: Analysis of initial soil samples was done in SRDI, Dinajpur, Bangladesh

Appendix II: Weather data for growing season of mungbean, July to November, 2018.

Month	Relative humidity (%)	Temperature		Total rainfall (mm)
		Minimum (^{o}C)	Maximum (^{o}C)	
July	82.25	26.3	36.0	13.60
August	83.85	26.3	36.3	14.32
September	75.22	25.4	36.9	12.50
October	70.25	20.6	35.4	8.75
November	68.12	15.5	33.9	5.25

Source: Bangladesh Wheat and Maize Research Institute, Dinajpur.