EFFECT OF FOLIAR AND SOIL APPLICATION OF NUTRIENTS ON THE GROWTH AND YIELD PERFORMANCE OF BRRIdhan 28

A Thesis

By

MD. ASHRAFUL ISLAM

Student No-1305147

MASTER OF SCIENCE (MS)

IN

CROP PHYSIOLOGY AND ECOLOGY

DEPARTMENT OF CROP PHYSIOLOGY AND ECOLOGY

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY

DINAJPUR

DECEMBER 2014

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Submitted to the

Department of Crop Physiology and Ecology

Hajee Mohammad Danesh Science and Technology University, Dinajpur

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE (MS)

IN

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DEPARTMENT OF CROP PHYSIOLOGY AND ECOLOGY
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DINAJPUR

DECEMBER 2014

Dedicated to

My beloved father, mother and the poor and ultra- poor farmers of my country

ACKNOWLEDGEMENT

The author is thankful and greatly expresses his deepest sense of gratitude to the Almighty Allah who has given scope him to carry out the present research work and to complete this thesis for the degree of Master of Science (MS) in Crop Physiology and Ecology.

The author would like to express his whole heartiest respect, sincere appreciation and immense indebtedness to his respectable teacher and research supervisor Professor Dr. Md. Abu Hasan, Chairman, Department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science and Technology University, Dinajpur for his persistent and scholastic guidance, supervision, meaningful suggestions during planning and execution of the research, continuous encouragement, step by step review and criticism during the entire period of this research work and in successful preparation of this manuscript of the thesis.

He is grateful and earnest appreciation to his respectable co-supervisor Dr. Md. Maniruzzaman Bahadur, Professor, Department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science and Technology University, Dinajpur for his tenacious guidance, supervision, suggestions during planning and execution of the research, step by step review and criticism during the entire period of this research work and in successful preparation of this manuscript of the thesis.

He recognizes a profound thanks to all other teacher of Crop Physiology and Ecology, Hajee Mohammad Danesh Science and Technology University, Dinajpur for their important suggestions and all round help and kind support for successful completion of the thesis.

The author is deeply indebted to the authorities of the university and all the staffs of the Department of Crop Physiology and Ecology for their help and co-operation during the period of the study. He is very thankful and gratitude to all well-wishers for their eagerness and direct and indirect help during the period of research work.

Specially, he is deeply indebted to his wife, Most. Nazma Khatun, beloved sons Aunto and Ani whose sacrifice, encouragement in innumerable aspects made it possible to complete the requirements for the degree in a peaceful mind.

December 2014 The Author

ABSTRACT

An experiment was conducted at the research field of Hajee Mohammad Danesh Science and Technology University, Dinajpur during *Boro* season of 2013- 2014 with a view to examining the effect of foliar fertilization and nitrogen levels on performance of BRRIdhan 28 and reduce soil application of nitrogenous fertilizer. The experiment was laid out in a split plot design with three replications. Two levels of foliar fertilization- no foliar fertilization (F_0) and foliar fertilization with magic growth (F_1) were placed in the main plots as main plot treatments whereas four nitrogen fertilizer levels (0, 50, 75 and 100% of the recommended nitrogen fertilizer) were placed randomly in the sub plots as sub plot treatments.

Foliar fertilization and nitrogen levels significantly influenced most of the growth, yield and yield parameters of BRRIdhan 28. Root length, plant height, tillers hill^{-1} and dry weight hill^{-1} at 40, 55, 70 and 85 days after transplanting and SPAD value of the youngest fully expanded leaf at 55 days after transplanting were found higher due to foliar fertilization compared to no foliar fertilization treatment. The height of plant, panicle length, panicle hill^{-1}, spikelets panicle^{-1}, 1000 grain weight and grain and straw yield at harvest were also found higher due to foliar fertilization compared to no foliar fertilization of magic growth. Most of the parameter studied was increased significantly with the increment of nitrogen level applied in soil.

The overall result demonstrated that the increment of nitrogen level the grain yield was increased up to N_{100} in no foliar fertilization treatment (F_0) but in foliar fertilization treatment (F_1) grain yield was increased with the increment of nitrogen level up to N_{75} and there after decreased in $N_{100.}$ Foliar fertilization with magic growth with 50% of the recommended nitrogen fertilizer i.e F_1N_{50} provided 6.7% higher grain yield compared to recommended practice (F_0N_{100}) with a saving of 50% recommended nitrogen fertilizer whereas F_1N_{75} provided 26.6% higher grain yield compared to F_0N_{100} with a saving of 25% nitrogen fertilizer. On the other hand additional foliar fertilizer (F_1N_{100}) provided 11.3% higher grain yield compared to recommended practice (F_0N_{100}).

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CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.) being one of the richest starchy foods is consumed by about half of the world's population. It is the most important major cereal crop in Bangladesh. It is the largest crop in terms of area and production in Bangladesh. Although the rice in Bangladesh is consuming large scale but the production is still far behind the other rice producing countries. The average yield in Bangladesh is very low (3.88 t ha^{-1}) (Bangladesh Bureau of Statistics, 2013-2014) as compared to Egypt (8.4 t ha^{-1}) and USA (6.6 t ha^{-1}). All over the world, the importance of agriculture, especially rice production, is increasing. To cope with the rising population, rice production needs to increase following vertical, instead of horizontal expansion.

There are many reasons for this low yield of rice. The most important of them is the indiscriminate and improper application of nutrients with unfavorable condition. Because it may not provide adequate nutrients supply because of its poor absorption and translocation in plant system. Many factors determine the fertilizer efficiency for rice crop during cultivation such as soil, cultivar, season, environment, planting time, water management, weed control, cropping pattern, source, form, rate, time and method of application (De Datta 1978).

Rice is mainly cultivated as flooded fields. The unique properties of flooded soils make rice nutrient management different from any other crop. Submerging rice field brings a series of physical, chemical and microbial changes in the soil, which profoundly affects growth of rice plant as well as availability, loss and absorption of nutrients due to chemical reduction of soil and decrease in concentrations of water-soluble Zn and Cu (Ghildyal 1978).

Therefore, there is an imperative need to provide the required nutrients over and above the regular soil application through foliar application as well. 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). 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. Foliar feeding is an effective method for overcoming the flooded soil condition. In that 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 applied at critical times corrects deficiencies immediately. Other advantages are low application rates, uniform distribution of fertilizer, reduction in plant stress, plant's natural defense mechanisms to resist plant disease and insect infestations, improvement of plant health and yield (Finck 1982).

Foliar application can also reduce the delay time between application and uptake by the plant. The use of foliar fertilizing in rice has been a popular practice within farmers since the 1950s, when it was learned that foliar fertilization was effective in rice cultivation. Various studies have been shown that a small amount of foliar fertilization applied by foliar spraying increases significantly the yield of crops and reduced the less of nitrogenous fertilizer. Foliar application of nitrogen fertilizer may be the most effective means for maximizing yield of rice.

Nitrogen fertilizer is more urgent for rice production. Many investigators studied the importance of nitrogen fertilizer. Some of them (Chopra 2004, Sharief *et al.* 2006, Shivay and Singh 2003, Singh and Singh 2000) found that increasing nitrogen fertilizer levels had significant effect on yield and yield attributes of rice. Foliar fertilization might reduce the use of chemical fertilizer specially the nitrogenous fertilizer in soil. However, foliar fertilization is supplementary to and cannot replace the basal fertilization. In this aspect, the present study was undertaken-

1. To find out the effect of soil and foliar application of nutrients in BRRIdhan 28

2. To estimate the amount of urea savings during foliar application of nutrients.

CHAPTER II

REVIEW OF LITERATURE

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. In this regards many researchers throughout the world have made several observations on the effect of foliar fertilization on rice. But there is a little information available in Bangladesh. However, some of the information on the effect of foliar fertilization on rice has been reviewed below-

Alam *et al.* (2010) conducted an experiment at the Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh during Boro season of 2008 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 experiment was laid out in a randomized complete block design (RCBD) with eight treatments, each treatment replicated thrice. The treatments were: T_1 (control), T_2 (94 kg urea ha^{-1} SA), T_3 (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), T_7 (94 kg urea ha^{-1} SA + 2% urea solution FA) and T_8 (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 T_6 (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 T_1 (control). Economic analysis showed that treatment T_2 gave the highest marginal benefit cost ratio (7.65) while the lowest value (2.71) was observed with T_5 treatment. The overall results demonstrated that soil application of 94 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.

Ali *et al.* (2005) conducted a field experiment at Jatri Kohna, district Sheikhupura to evaluate the effects of foliar spray (1.5 % of K solution) of KCI, K_2SO_4 and KNO_3 on the yield of rice cv. 385. Foliar application of K_2SO_4 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 kg^{-1} of fertilizer applied) were also better in case of K_2SO_4 than other two sources: KNO_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).

Ali *et al.* (2007) conducted a field experiment at village Jatri Kohna, district Sheikhupura during the growing season of 2003 to compare foliar application of K_2SO_4 at various concentrations (0.5, 1.0, 2.0, 4.0 and 6.0 %) with soil application of K_2SO_4 at the rate of 50 kg K_2O ha^{-1} on yield of rice crop. Number of fertile tillers, straw and paddy yield of fine grain rice (Basmati-385) were recorded. Foliar application of K_2SO_4 at different concentrations significantly influenced the yield components. Among all the foliar application treatments, foliar application with 6.0% K_2SO_4 significantly out yielded than rest of the treatments that was application of K_2SO_4 @ 50 kg K_2O ha^{-1}. Maximum paddy yield (3837 kg ha^{-1}) was obtained with this treatment. Paddy yield in different treatments followed the order: 50 kg ha^{-1} K_2O soil application = 6.0% > 4.0% > 2.0% > 1.0% > 0.5% K_2SO_4 > control. Plant samples analyzed for K concentration showed significant increase in K uptake by rice paddy and straw with foliar application of different K_2SO_4 concentrations. Interestingly, foliar application at 6.0 % K_2SO_4 (24.12 kg ha^{-1} K uptake) showed statistically equal performance as that of K_2SO_4 soil application at the rate of 50 kg K_2O ha^{-1} (24.70 kg ha^{-1} K uptake). However, in case of K uptake by straw, foliar application of K_2SO_4 at 2.0, 4.0 and 6.0 % concentration showed similar results but were statistically comparable to soil application of K_2O @ 50 kg ha^{-1}. Their results suggested that foliar application of K_2SO_4 at 6.0 % concentration was safe and appropriate and could produce yield of rice equal to the yield obtained with soil application of K_2O at the rate of 50 kg ha^{-1}.

Ahmad *et al.* (2013) conducted a field experiment at University of Agriculture, Faisalabad, Pakistan, to investigate the effect of foliar application of silicon on yield and quality of fine rice (*Oryza sativa* L.). The research was designed as randomized complete block design (RCBD) having three replications and 6m x 4.5m net plot size was maintained. Foliar applications of silicon's aqueous solution were used as treatments comprised of control, 0.25%, 0.50%, 1.00% silicon solutions. Nursery of 30 days old seedling nursery was transplanted to the plots under aerobic condition and 22.5cm hill to hill distance was maintained. Sodium silicate (20.35% Si) as the source of silicon (soluble in warm water) was used. Fertilizer inputs as nitrogen, phosphorus and potassium were uniformly applied at the rate of 100, 67, 67 kg ha^{-1} while all other agronomic practices were kept constant for all the treatments. Silicon showed no significant effect on plant height, harvest index, number of kernels and opaque kernels percentage. Silicon (0.50% silicon solution) produced maximum grain diameter and grain protein while silicon @ 1.00% silicon solution resulted maximum in number of productive tillers, straw yield, spike per panicle, 1000 grain weight, paddy yield and grain starch. All others parameters have overlapping results of different silicon levels.

Bhuyan *et al.* (2012) conducted a field experiment at the farmer's field in Chuadanga, Bangladesh, during *Aman* season. Results found 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.

Chopra and Chopra (2000) reported that nitrogen had significantly effects on yield attributes such as plant height, panicle plant^{-1} and 1000-seed weight with increasing levels of N up to 120 kg N ha^{-1} in rice. It has been reported that application of either 80 or 120 kg N ha^{-1} improved the entire yield attributes compared with control.

Mirza *et al.* (2009) conducted an experiment at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, during boro season (November, 2008 to May, 2009) to find out the economic and effective method of urea application in rice crop. The treatments were T_1 (200 kg ha^{-1} at urea two equal splits, ½ during final land preparation + ½ at 30 DAT), T_2 (200 kg ha^{-1} urea at three equal splits, $^1/_3$ during final land preparation + $^1/_3$ at 30 DAT + $^1/_3$ at 55 DAT), T_3 = Urea supergranules (USG) @ 50 kg ha^{-1}, T_4 = Urea supergranules @ 75 kg ha^{-1}, T_5 = 0.5% foliar spray @ 20 kg ha^{-1}, T_6 = 1% foliar spray @ 40 kg ha^{-1}. Both the growth and yield was significantly affected by different methods of urea application. In all of the case except plant height and straw yield T_4 gave the highest result. Application of USG @ 75 kg ha^{-1} produced 22.03% 5.88% more yield than granular urea application an equal splits.

Mahmoodi *et al.* (2011) conducted a study on effect of nitrogen foliar application on grain filling rate and period in 3 cultivars of corn (*Zea mays* L.), In order to study the effect of nitrogen foliar application on seed rate and filing period in three cultivars of corn during 2009 at Agricultural Research Station, Islamic Azad University, Tabriz branch, Iran. Cultivars were arranged in three levels: early maturing (KSC_{307}), average maturing (Jeta), and late maturing (KSC_{704}). Urea foliar application arranged in seven levels, control (lack of foliar application), tassel appearance, ear appearance, beginning of grain filling, end of grain filling, concurrent foliar application in tassel appearance and beginning of grain filling stages and concurrent in tassel appearance, ear appearance, beginning of grain filling and end of grain filling. The results showed that foliar application of urea had a significant effect on grain yield. Yield increase with foliar application of urea took place in concurrent foliar application of urea in tassel appearance, ear appearance, beginning of grain filling and end of grain filling stage. Foliar application had a significant effect on leaf area duration and on grain filling rate and period consequently. According to the findings of this study, it is possible to use foliar application of urea for increasing grain yield per plant and leaf area duration.

Osman *et al*. (2013) conducted a field experiment at Soils, Water and Environ. Res. Inst., Agric. Res. Centre, Giza, Egypt to study the effect of nitrogen fertilizer sources and foliar spray of organic acids on rice crop, In this regard, this test was performed in 2010 and 2011 years at El- Gemmeiza Agricultural Research Station, El-Gharbia Governorate located at 30.47, 31.00 and 14.80 m above the mean sea; the used design was split plot randomized complete block with 3 replications. Main plots, two nitrogen fertilizer sources: anhydrous ammonia and urea while subplots, were treated with foliar application of humic and /or fulvic acid resulting 4 treatments including: controls (without foliar spray), humic, fulvic and humic + fulvic acids were considered.

Shafiee *et al.* (2013) conducted large scale 12 ha multi-locations trial in the main- and off-seasons of 2007 through 2009 in Sungai Besar, Selangor's North West Project, Malaysia to assess the enhancing effect of SBAJATM (formerly known as BIPOMIXTM) on the growth and yields of rice (*Oryza sativa* L. var. MR 220). The clonal growth of SBAJATM -treated rice crop based on plant height and tiller numbers plant^{-1}, albeit temporal inconsistencies, did not register any significant difference from each other at $p<0.05$, save for those in the control plots at 45, 75 DAT, and at harvest with measurably lower tiller numbers plant^{-1}. The mean panicle length plant^{-1} and mean number of panicles m^{-2} were significantly ($p<0.05$) longer and higher, respectively in plots treated with SBAJATM *vis-à-vis* the control. While no significant differences were recorded in the 1000 grain weight, the percentage of filled grains panicle^{-1} and the number of grains panicle^{-1} were higher among rice plants in plots receiving the SBAJATM treatments. Invariably, the Crop Cutting Tests (CCT) in plots subjected to foliar applications of SBAJATM registered measurable increase in rice yields from 15 to 29% *vis-à-vis* the equivalent foliar-applied fertilizer subsidy from the government, and the conventional NPK fertilizer applications of 100:30:20 (here served as the control), respectively. The SBAJATM treated plots registered a mean yield of 9.66 tons ha^{-1} compared with 7.49 tons ha^{-1} in the control plots. The parallel average yield from the equivalent foliar-applied fertilizer subsidy from the government was 8.38 tons ha^{-1}.

Sultana *et al.* (2001) reported that foliar application nutrient solution increased the net photosynthesis of salt stressed rice plants. Invariably, supplementation of Ca^{2+},

Mn^{2+} and K^+ through the foliar fertilization increased the rate of photosynthesis. Soylu *et al.* (2005) and Kenbaev and Sade (2002) reported that foliar application of different micronutrients individually or in combination significantly increased in number of panicles m^{-2}.

Sharief et al. (2006) during 2003 and 2004 seasons at El-Manzala district in Egypt to study the effect of four nitrogen fertilizer rates i. e. 15, 30, 45 and 60 kg N/fed and times of foliar nutrients spraying i.e. 15, 25, 35 and 45 days after transplanting on growth, yield and yield components of rice cultivar Sakha 104. Increasing nitrogen fertilizer rates from 15, 30, 45 and 60 kg N/fed significantly affected growth, yield and yield components in both seasons. Highest grain yield and yield components were produced from increasing nitrogen fertilizer rates up to 45 or 60 kg N/fed without significant differences between them in both seasons. Grain yield increased by 28% and 31%, respectively compared with fertilization rate of 15 kg N/fed over both seasons. In both seasons, times of nutrients foliar application had significant effect on flag leaf area, plant height, number of tillers m^{-2}, number of panicles m^{-2}, panicle height, number of filled grains /panicle, grain weight/panicle, 1000-grain weight, biological, straw and grain yield/fed. Maximum yield and yield components were produced from foliar spraying after 45 days after from transplanting in both seasons. Grain yield increased by 10.2% and 11.5% when foliar spraying after 35 and 45 days transplanting, respectively compared with those spraying after 15 days after transplanting over both season.

Soylu *et al*. (2005) and Guenis *et al.* (2003) reported a significant increase in 1000 grain weight with the foliar application of micronutrients. Fang *et al.* (2008)

reported that foliar application of zinc, selenium and iron fertilizers increased grain yield. 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.

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. Sultana *et al*. (2001) stated that foliar application of nutrient solutions partially alleviates the adverse effects of salinity on photosynthesis and photosynthesis-related parameters. Such applications were observed to increase yield and yield components through mitigating the nutrient demands of salt-stressed plants. The photosynthetic rates of leaves are dependent on their stomatal and non- stomatal components (Bethke and Drew, 1991), and each of the components has a unique response to an environmental variable. Stomatal conductance is related to turgor pressure of cells. The turgor pressure is controlled by solute regulation within the guard cell protoplast and the relative water content of epidermal tissues. Accumulation of K^+ and other organic ion increased the osmotic activity, causing a reduction in water potential and an influx of water from the surrounding cells. In addition, phytohormones and Ca^{2+} play important signaling role on the regulation of stomata (Sage and Reid, 1994) and Mn^{2+} bind firmly to the lamellae of chloroplasts, possibly to the outer surface of thylakoid membranes, affecting the chloroplast structure and photosynthesis (Lidon and Teixerira, 2000). The optimal balance of these physicochemical components in the cells is directly or indirectly related to photosynthesis. The minerals Na^+, Ca^{2+}, K^+ and Mn^{2+} are not only involved in the regulation of photosynthesis but have other cellular regulatory function, which are directly or indirectly involved in growth and physiology of the plant.

Recently, it has been reported that a small amount of nutrients (nitrogen, potash or phosphate) applied by foliar spraying increases significantly the yield of crops (Asenjo *et al.*, 2000; Haq and Mallarino, 2000). Many researchers have reported the positive response of K_2SO_4 foliar application to rice and wheat crops as well as higher plants (Ali *et al.*, 2005).

Yosuf *et al.* (2012) conducted a study on effect of nitrogen (N) fertilizer and foliar-applied iron (Fe) fertilizer at various reproductive stages on yield, yield component and chemical composition of soybean (*Glycine max* L. Merr.) seed found that Nutritional management is an important factor in the success of crop production. However, research on the effects of nitrogen (N) and iron (Fe) application on soybean yield is limited. In order to study the effects of N and Fe application at various reproductive stages on grain yield and quality of soybean seed, an experiment was conducted using a factorial arrangement based on randomized complete block design with three replications at the research farm of Kurdistan University in 2009. The experimental treatments consisted of three different levels of N fertilizer application as follows: 0, 50 and 100 kg N ha^{-1}, and two levels of Fe fertilizer (spray with iron and non-sprayed). Results indicate that the maximum seeds yield was obtained at N_1 (303 g m^{-2}) and N2 (328 g m^{-2}) treatments and the highest number of seed per plant was obtained at N_2 (128)

treatment. Potassium concentration in seed and SPAD chlorophyll value responded to fertilizer treatments and the maximum protein percentage (32.5%) was obtained at N_1F_1 treatment. This treatment had no significant difference with N_1F_0, N_2F_0 and N_0F_1 treatments. The Fe and N fertilization treatments had no significant effect on Fe, Zn, Ca, Na, Cu and P concentration of soybean seed.

CHAPTER III

MATERIALS AND METHODS

The materials used and methods followed in present study have been presented in this chapter.

3.1. Experimental location and duration

The experiment was conducted at the research farm and laboratory of Crop Physiology and Ecology Department, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during Boro season of December 2013 to May 2014. The experimental site is situated under the Dinajpur Sadar Upazila and located at 25°39′ N latitude and 88°41′ E longitude with an elevation of 37.58 meter above the sea level.

3.2. Soil and climate

The experimental field was a medium high land belonging to the non-calcarious dark gray floodplain soil under the agro-echological zone (AEZ-1) of Old Himalayan Piedmont Plain. The soil was sandy loam under the Order Inceptisol. The experimental field was a medium high land belonging to the non-calcareous dark gray floodplain soil. Electrical conductivity and pH value of the initial soil were 0.38 dS/m and 7.1, respectively. The initial soil contained 1.28% organic matters, 0.064% Nitrogen, 18.56μg /g Phosphorous and 0.18 m/100g Potassium. The experimental site is situated in the sub-tropical region characterized by heavy rainfall during the months from June to September and scantly rainfall in the rest of the year.

3.3. Variety

The Boro rice variety BRRIdhan 28 was used as experimental crop, because this variety is widely cultivating by the farmers in the experimental areas.

3.4. Experimental design

The experiment was conducted in a split plot design (RCBD) with three replications. Two levels of foliar fertilization of magic growth were applied in the main plots as main plot treatments, whereas four levels of nitrogen fertilizer levels were applied randomly in the sub plots as sub plot treatments. The unit plot size was 20 m^2 (4m X 5m).

3.5. Experimental treatments

Main plot treatments: Foliar fertilization

F_0 – No foliar fertilization

F_1 – Foliar fertilization with magic growth at 40, 55, 70 and 85 days after transplanting

Sub-plot treatments: Nitrogen levels

N_0 – Nitrogen fertilizer was not applied

N_{50} – 50% of the recommended nitrogen fertilizer was applied

N_{75} – 75% of the recommended nitrogen fertilizer was applied

N_{100} – 100% of the recommended nitrogen fertilizer was applied

3.6. Seedbed preparation and raising of seedlings

The field was ploughed and crossed ploughed by a power tiller then level the land. Nursery beds of 3m x 1m size were prepared for seedling raising. Clean and mature seeds of BRRIdhan 28 were soaked in tube-well water in a container for 24 hours and incubated for 48 hours for sprouting. Then the seeds were sown in the seedbed on 15/12/2013 to obtain 53 days old seedling at transplanting date. Adequate water was applied to the growing seedling in the seedbed as and when required until the day of uprooting the seedlings. Magic growth (2 ml magic growth in 2 liter of water + 10 g urea + 5 g MoP) was sprayed at 7 days interval.

3.7. Land preparation and experimental layout

The land was ploughed by a tractor drawn disc plough and was leveled by harrowing and laddering carefully. The weeds and stubble were removed and plots were prepared. Ridges were made around each plot to restrict the lateral run off of irrigation water.

3.8. Fertilizer application

Fertilizer was applied at a rate of 150-20-65-18-2.6 kg ha^{-1} nitrogen (N), phosphorus (P), potassium (K), sulpher (S), and zinc (Z) respectively as recommended dose for Boro rice, (BARC 2012). After land preparation, full doses of triple supper phosphate (TSP), murate of potash (MP), gypsum and zinc sulphate were incorporated thoroughly into the soil as basal dose. For foliar fertilization, 32 ml Magic growth + 200 g urea + 100 g murate of potash was dissolved in 16 liter clean water to spray 445.4 m^2 of land at sprayed 15 days interval. Urea and Magic growth were applied in different plots as follows-

Treatment	At 7 DAT	At 30 DAT	At 45 DAT	At 60 DAT
F_0N_0	-	-	-	-
F_0N_{50}	$^1/_3$ urea	$^1/_6$ urea	-	-
F_0N_{75}	$^1/_4$ urea	$^1/_4$ urea	$^1/_4$ urea	-
F_0N_{100}	$^1/_3$ urea	$^1/_3$ urea	$^1/_3$ urea	-
F_1 N_0	-	FF	FF	FF
F_1 N_{50}	$^1/_3$ urea	$^1/_6$ urea+ FF	FF	FF
F_1 N_{75}	25.00% urea	25.00% urea + FF	25.00% urea + FF	FF
F_1 N_{100}	33.33% urea	33.33% urea + FF	33.33% urea + FF	FF

FF indicates foliar fertilization

% urea indicates percent of recommended dose of urea

Magic growth is a liquid fertilizer formulated by Md. Arif Hassain Khan, Joint Director (Seed Marketing), Bangladesh Agricultural Development Corporation (BADC). The pH value of magic growth is 1.0 and it contains 10.51% total Nitrogen, 5.58% Phosphorous, 6.33% Potassium, 0.10% Sulphur, 0.16% Zinc, 0.04% Copper, 0.0006% Iron, 0.006% Manganese, 0.25% Boron, 0.07% Calcium and 0.007% Magnesium.

3.9. Transplanting

53 days old seedlings of rice (Variety- BRRIdhan 28) were uprooted from the seed bed without making any injury and transplanted them on the main field in the

same day. The seedling was transplanted on 08/02/2014 as per treatment. Three seedlings $hill^{-1}$ were transplanted maintaining a line to line distance 20 cm and hill to hill distance 20 cm.

3.10. Intercultural operations

Manual weeding was done twice in transplant to keep the crop field free from weed and using the weedy side of pyrazosulfuran Ethanole was sprayed after 7 DAT @ 75g $acre^{-1}$ with 10 litter of water for free from weed. The crop was kept insects and diseases free. Rat and other pests were controlled by applying recommended practices. The rice was infested by stem borer at tillering stage; Furadan 5G at the rate of 10 kg ha^{-1} was applied at 40 DAT to control stem borer respectively. Other intercultural operations were done accordingly. 3 to 5 cm water was kept throughout the growing period by checking depth of water every 24 h.

3.11. Data collection

1. Root length, plant height, number of tillers $hill^{-1}$, biomass dry weight (g $hill^{-1}$) at 40, 55, 70 and 85 days after transplanting was recorded. For recoding these data 3 hills were used per treatment.

2. SPAD value of youngest leaf at 55 days after transplanting was recorded and for recoding these data 10 leaves were used per treatment

3. Plant height, panicle length, tillers $hill^{-1}$, panicle $hill^{-1}$ at harvest was recorded and for recoding these data 10 hills were used per plot.

4. Spikelet panicle^{-1} and 1000 grain weight at harvest was recorded and for recoding these data 10 panicles were used per plot.

5. Grain and straw yield t ha^{-1}was recorded using an electrical balance (Model-AND EK- 300 i).

6. Thousand grains weight was recorded using an electrical balance (Model-AND EK- 300 i).

7. Grain and straw yield were recorded by collecting samples from an area of 4 m^2 of each plot. Grain yield was adjusted at 14% moisture level and was expressed as t ha^{-1}. Straw was dried in sun and straw yield was expressed as t ha^{-1}.

3.12. Statistical analysis of data

The data were analyzed by partitioning the total variance with the help of computer using STAR program. The treatment means were compared by DMRT at $P \leq 5\%$ level of significance. t test was also done for to test significance of difference between means.

CHAPTER IV

RESULTS AND DISCUSSION

The results of the present study have been presented in several tables and figures and adequate discussion and possible interpretations whenever suitable have been provided in this chapter.

4.1. Effect of foliar fertilization on Seedling characteristics at transplanting date

Seedling a characteristic of BRRIdhan 28 was influenced by foliar fertilization at presented in Table 1. Results showed that root length of seedling at transplanting date was increased (8.28 cm) due to foliar fertilization compared to that obtained from no foliar fertilization treatment (7.08 cm) and the difference was found significant in t test. Seedling height at transplanting date was increased (17.02 cm) due to foliar fertilization compared to that obtained from no foliar fertilization (16.32 cm) and the difference was found significant in t test. Seedling dry weight at transplanting date were increased (0.4 g) due to foliar fertilization compared to that obtained from no foliar fertilization (0.33 g) but the difference was not significant.

Table. 1. Effect of foliar fertilization on seedling characteristics of BRRIdhan 28

Variable	F_0	F_1	Difference
Root length (cm)	7.08	8.28	1.20 *
Seedling height (cm)	16.32	17.02	0.70 *
Seedling dry weight (g)	0.33	0.4	0.07 ^{NS}

4.2. Growth characters

4.2.1. Root length at different days after transplanting

Root length of BRRIdhan 28 at different days after transplanting as influenced by foliar fertilization, nitrogen levels and interaction effect is presented in Figure 1. Figure 1 showed that the root length of the plant was increased with the advancement of time after transplanting.

At 40 days after transplanting, root length was significantly influenced by foliar fertilization and nitrogen levels but the interaction of foliar fertilization and nitrogen levels did not influence the root length significantly. Foliar fertilization with magic growth provided significantly higher root length (14.12 cm) than that provided by no foliar fertilization treatment (11.99 cm). With the increment of nitrogen level applied in soil the root length was increased significantly. The longest root (14.30 cm) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was followed by that (13.28 cm) obtained from N_{75}. The smallest root length (11.95 cm) was obtained when no nitrogen fertilizer was applied in soil (N_0) which was followed by that (12.70 cm) obtained from N_{50} treatment. Among the treatment combinations F_1N_{100} provided the longest root (15.56 cm) but F_0N_0 provided the smallest root (10.61 cm).

At 55 days after transplanting, the foliar fertilization and nitrogen levels influenced the root length significantly but their interaction did not influence root length significantly. The higher root length (15.29 cm) was obtained due to foliar fertilization with magic growth (F_1) compared to that (13.23 cm) provided by no foliar fertilization treatment (F_0).

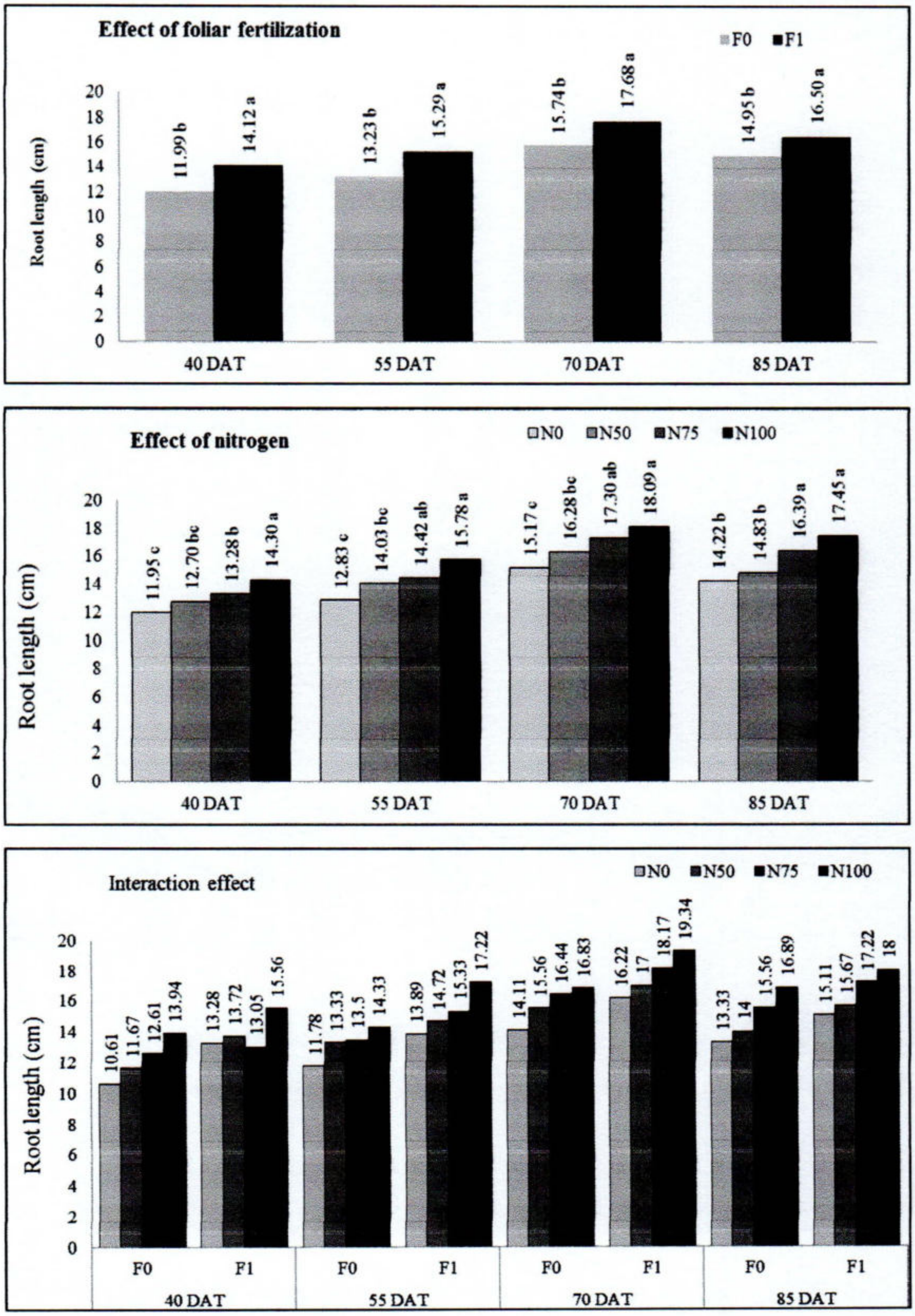

Fig. 1. Effect of foliar fertilization and nitrogen levels on root length of BRRIdhan 28 at different days after transplanting. (Means followed by different letter(s) at specific days after transplanting within main effects and interaction effect differed significantly by DMRT at $P \leq 5\%$).

The root length was increased with the increment of nitrogen level applied in soil. Recommended nitrogen fertilizer (N_{100}) provided the longest root (15.78 cm) which was statistically equal to that (14.42 cm) obtained when recommended nitrogen fertilizer was applied in soil as urea (N_{75}). No nitrogen fertilizer treatment provided the shortest root (12.83 cm) which was statistically equal to that (114.03 cm) recorded in N_{50} treatment. Among the treatment combinations F_1N_{100} provided the tallest root (17.22 cm) but F_0N_0 provided the smallest root (11.78 cm).

At 70 days after transplanting, foliar fertilization with magic growth and nitrogen levels influenced the root length significantly but the interaction effect did not influenced significantly. The higher root length (17.68 cm) was obtained due to foliar fertilization with magic growth (F_1) compared to that (15.74 cm) provided by no foliar fertilization treatment (F_0). Root length was also influenced by different levels of nitrogen fertilizer applied in soil; with the increment of nitrogen level the root length was increased. The higher root (18.09 cm) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was followed by that that (17.30 cm) obtained from N_{75}. The shortest root (15.17 cm) was obtained when no nitrogen fertilizer was applied in soil (N_0) which was statistically equal to that (16.28 cm) obtained from N_{50} treatment. The combined effect of foliar fertilization and nitrogen levels did not influence the root length significantly and it ranged from (14.11 cm) in F_0N_0 to (19.34 cm) in F_1N_{100}.

At 85 days after transplanting, the foliar fertilization did not influence significantly the root length. Higher root length (16.50 cm) was obtained due to foliar fertilization with magic growth (F_1) compared to that (14.95 cm) provided by no foliar fertilization treatment (F_0). Root length was also influenced by different levels of nitrogen fertilizer applied in soil. With the increment of nitrogen level the root length was increased significantly. The highest root length (17.45 cm) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was statistically equal to that (16.39 cm) obtained from N_{75}. The smallest root length (14.22 cm) was obtained when no nitrogen fertilizer was applied in soil (N_0) which was statistically equal to that (14.83 cm) obtained from N_{50} treatment. The combined effect of foliar fertilization and nitrogen levels did not influence the root length significantly and it ranged from (13.33 cm) in F_0N_0 to (18.00 cm) in F_1N_{100}.

The present study provided the results that the root length at different days after transplanting was increased due to foliar fertilization compared to control. The results also indicated that increasing nitrogen levels increased the root length at different days after transplanting. Increasing nitrogen dose might improve the rate of root initiation which was reflected by increase in root length in the present study.

4.2.2. Plant height at different days after transplanting

Plant height of BRRIdhan 28 as influenced by foliar fertilization and nitrogen levels at different days after transplanting is presented in Figure 2. Results showed that the plant height was increased with the advancement of time after transplanting.

At 40 days after transplanting, plant height was significantly influenced by foliar fertilization and nitrogen levels but the interaction of foliar fertilization and nitrogen levels did not influence the height of plant significantly. Foliar fertilization with magic growth provided significantly higher plant height (54.88 cm) in F_1 than that provided by no foliar fertilization treatment (47.61 cm) in F_0. With the increment of nitrogen level applied in soil the plant height was increased significantly. The tallest plant (55.53 cm) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was statistically equal to that (53.81 cm) obtained from N_{75}. The shortest plant (45.55 cm) was obtained when no nitrogen fertilizer was applied in soil (N_0) which was followed by that (50.08 cm) obtained from N_{50} treatment. Among the interaction effect of F_1N_{100} provided the tallest plant (59.28 cm) but F_0N_0 provided the shortest plant (41.67 cm).

At 55 days after transplanting, foliar fertilization, nitrogen levels and combination treatment influenced the plant height significantly. Foliar fertilization with magic growth provided significant higher plant height (68.70 cm) than that provided by no foliar fertilization treatment (60.53 cm). With the increment of nitrogen level applied in soil the plant height was increased. The longer plant (71.70 cm) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was followed by that (69.84 cm) obtained from (N_{75}). The shortest plant (54.95 cm) was obtained when no nitrogen fertilizer was applied in soil (N_0) which was followed by that (62.97 cm) obtained from N_{50} treatment.

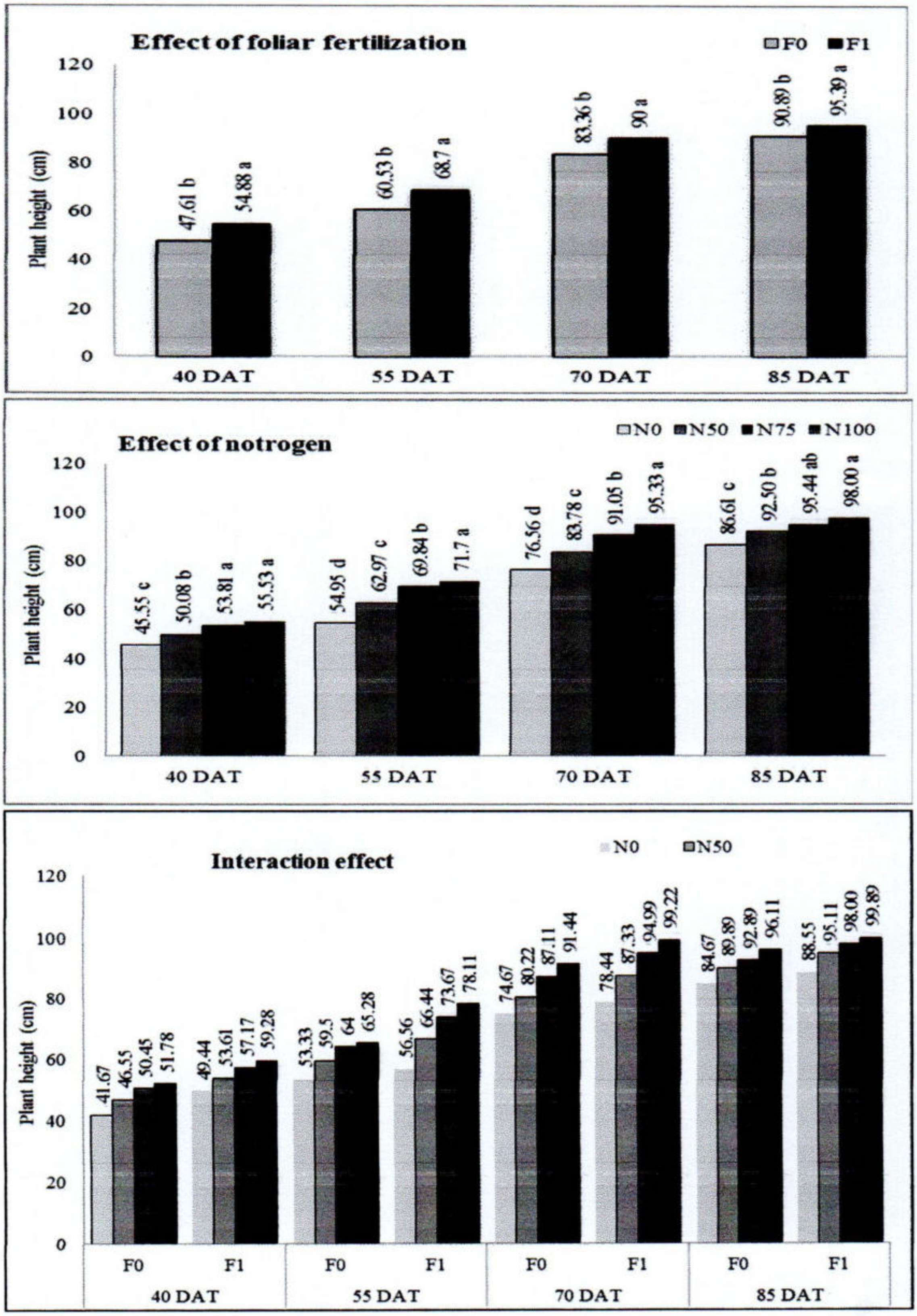

Fig. 2. Effect of foliar fertilization and nitrogen levels on plant height of BRRIdhan 28 at different days after transplanting. (Means followed by different letter(s) at specific days after transplanting within main effects and interaction effect differed significantly by DMRT at $P \leq 5\%$).

Among the treatment combinations F_1N_{100} provided the tallest plant (78.11 cm) but F_0N_0 provided the shortest plant (53.33 cm).

At 70 days after transplanting, foliar fertilization and nitrogen levels influenced the plant height significantly. Higher plant height (90.00 cm) was obtained due to foliar fertilization with magic growth (F_1) compared to that (83.36 cm) provided by no foliar fertilization treatment (F_0). Plant height was also influenced significantly by different levels of nitrogen fertilizer applied in soil. With the increment of nitrogen levels the plant height were increased. The tallest plant (95.33 cm) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was followed by that (91.05 cm) obtained from N_{75}. The smallest plant (76.56 cm) was obtained when no nitrogen fertilizer was applied in soil (N_0) which was followed by that (83.78 cm) obtained from N_{50} treatment. The interaction effect of foliar fertilization and nitrogen levels did not influence the height of plant significantly and it ranged from (74.67 cm) in F_0N_0 to (99.22 cm) in F_1N_{100}.

At 85 days after transplanting, foliar fertilization and nitrogen levels influenced the plant height significantly. Higher plant height (95.39 cm) was obtained due to foliar fertilization with magic growth (F_1) compared to that (90.89 cm) provided by no foliar fertilization treatment (F_0). The plant height was increased with the increment of nitrogen level applied in soil. The higher plant (98.00 cm) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was statistically equal to that (95.44 cm) obtained from N_{75}. The shortest plant (86.61 cm) was obtained when no nitrogen fertilizer was applied in soil (N_0)

which was followed by that (92.50 cm) obtained from N_{50} treatment. The interaction effect of foliar fertilization and nitrogen levels did not influence the height of plant significantly and it ranged from (84.67 cm) in F_0N_0 to (99.89 cm) in F_1N_{100}.

The results of the present study showed 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 the nitrogen levels increased the plant height at different days after transplanting. Increasing nitrogen dose might improve the rate of photosynthesis and translocation of assimilates which was reflected by increase in plant height (Sharief *et al.* 2006). Similar results were reported by El-Kalla *et al*. (1988) and Chopra and Chopra (2004).

4.2.3. Tillers hill^{-1} at different days after transplanting

Tillers hill^{-1} of BRRIdhan 28 at different days after transplanting as influenced by foliar fertilization, nitrogen levels and interaction effect is presented in figure 3. Figure 3 showed that the tillers hill^{-1} was increased with the advancement of time after transplanting.

At 40 days after transplanting, foliar fertilization and nitrogen level influenced significantly the number of tillers hill^{-1}. Foliar fertilization with magic growth provided significantly tillers hill^{-1} (18.81) in F_1 than that provided by no foliar fertilization treatment (13.57) in F_0. With the increment of nitrogen levels tillers hill^{-1} were increased. The highest tillers hill^{-1} (19.45) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was followed by that (17.16) obtained from N_{75}. The lowest tillers hill^{-1} (11.22) was obtained when no nitrogen fertilizer was applied in soil (N_0) which was followed by that (13.86) obtained from N_{50} treatment. The interaction effect of foliar fertilization and nitrogen levels did not influenced the number of tillers hill^{-1} significantly and it ranged from (9.78) in $F_0N_0$to (21.33) in $F_1N_{100.}$

At 55 days after transplanting, tillers hill^{-1} was not influenced significantly by foliar fertilization but it was influenced significantly by different levels of nitrogen fertilizer applied in soil. Foliar fertilization with magic growth provided significantly tillers hill^{-1} (17.28) in F_1 than that provided by no foliar fertilization treatment (11.42) in F_0. With the increment of nitrogen levels tillers hill^{-1} did not influenced significantly. The highest number of tillers hill^{-1} (21.14) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was followed by that (19.11) obtained from N_{75}. The lowest tillers hill^{-1} (11.50) was obtained when no nitrogen fertilizer was applied in soil (N_0) which was followed by that (13.95) obtained from N_{50} treatment. The combined effect of foliar fertilization and nitrogen levels did not influence the number of tillers hill^{-1} significantly and it ranged from (9.45) in F_0N_0 to 23.50 in $F_1N_{100.}$

At 70 days after transplanting, foliar fertilization with magic growth and nitrogen levels influenced the number of tillers hill^{-1} significantly. The highest tillers hill^{-1} (20.03) was observed due to foliar fertilization with magic growth (F_1) compared to that (16.21) provided by no foliar fertilization treatment (F_0).

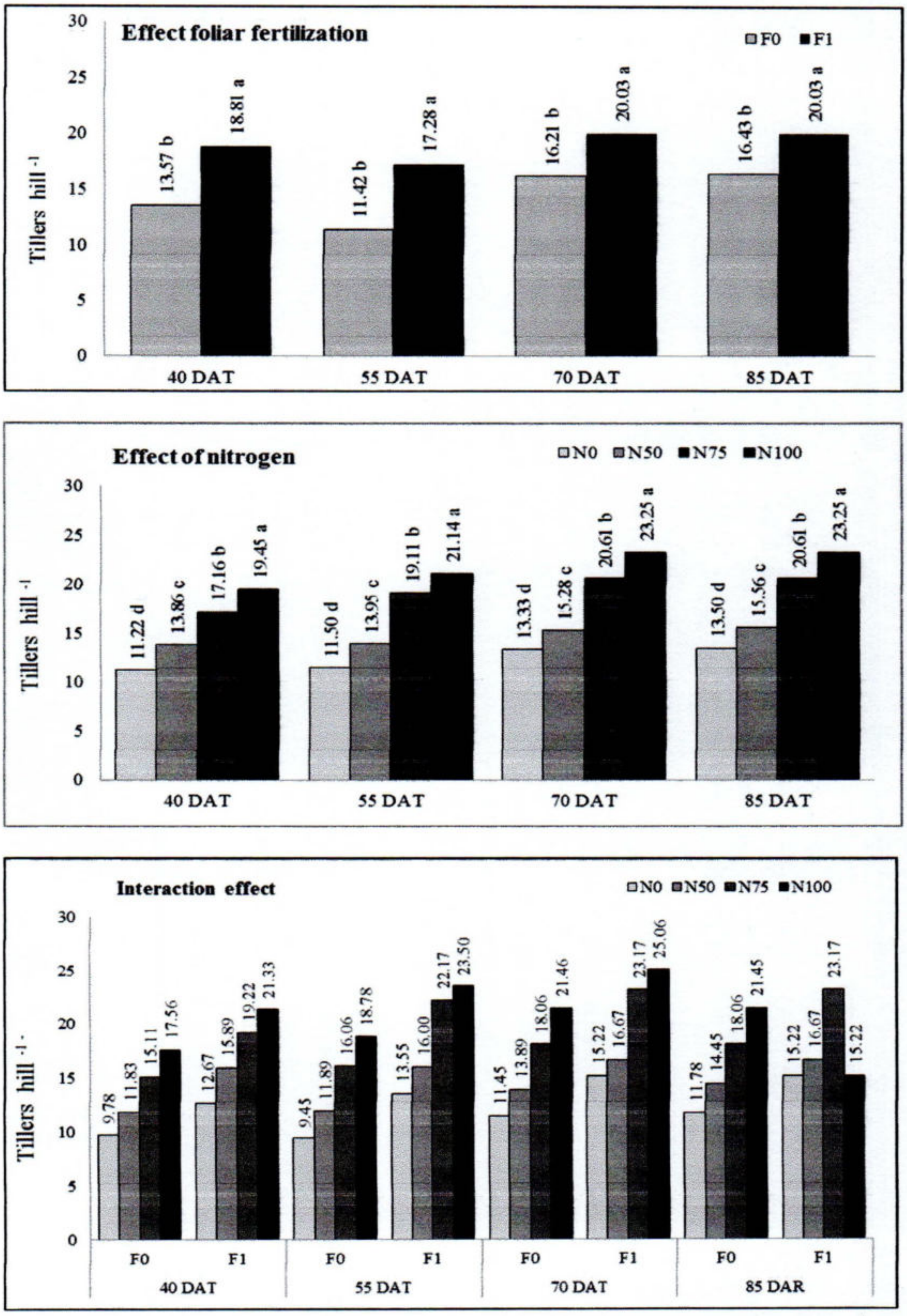

Fig. 3. Effect of foliar fertilization and nitrogen levels on tillers hill^{-1} of BRRIdhan 28 at different days after transplanting. (Means followed by different letter(s) at specific days after transplanting within main effects and interaction effect differed significantly by DMRT at $P \leq 5\%$).

With the increment of nitrogen levels applied in soil the tillers hill^{-1} was increased. The highest number of tillers hill^{-1} (23.25) was obtained when recommended nitrogen fertilizer was applied as urea N_{100} which was followed by that (20.61) obtained from N_{75} treatment.

The lowest number of tillers hill^{-1} (13.33) was obtained when no nitrogen fertilizer was applied in soil (N_0) which was followed by that (15.28) obtained from N_{50} treatment. Among the treatment combinations did not influence tillers hill^{-1} significantly and it ranged (25.06) in F_1N_{100} to (11.45) in $F_0N_{0.}$

At 85 days after transplanting, foliar fertilization with magic growth and nitrogen levels influenced the number of tillers hill^{-1} significantly. The higher tillers hill^{-1} (20.03) was observed due to foliar fertilization with magic growth (F_1) compared to that (16.43) provided by no foliar fertilization treatment (F_0). Among different nitrogen levels, N_{100} provided the highest number of tillers hill^{-1} (23.25) whereas N_o provided the lowest number of tillers hill^{-1} (13.50). The combined effect of foliar fertilization and nitrogen levels did not influenced the number of tillers hill^{-1} significantly. Among the treatment combinations F_1N_{75} was provided the highest number of tillers hill^{-1} (23.17) which was followed by that (16.67) obtained from $F_1N_{50.}$ F_0N_0 provided the lowest number of tillers hill^{-1} (11.78) which was followed by that (14.45) obtained from F_0N_{50}.

The findings of the present study shown that the tillers hill^{-1} was influenced significantly at 40 and 70 DAT under foliar fertilization with magic growth and nitrogen levels but it was not influenced significantly at 55 and 85 DAT. On the other hand the combined effect of foliar fertilization and nitrogen levels was not influenced the number of tillers $hill^{-1}$ significantly. Shafiee *et al.* (2013) did not found significant differences in tillers $hill^{-1}$ at 25 DAT among foliar fertilization treatments and control but it was increased considerably at 45 and 75 DAT due to foliar fertilization. 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. El-Kalla *et al.* (1988), Chopra and Chopra (2004) and Sharief *et al.* (2006) in their studies reported that increasing nitrogen dose increased number of tillers $hill^{-1}$ through improving the photosynthesis rate and translocation of assimilates.

4.2.4. Biomass dry weight (g $hill^{-1}$) at different days after transplanting

Biomass dry weight of BRRIdhan 28 at different days after transplanting as influenced by foliar fertilization and nitrogen levels is presented in figure 4. Figure 4 demonstrate that the biomass dry weight of BRRIdhan 28 was increased with the advancement of time after transplanting.

Biomass dry weight after 40 days of transplanting, the foliar fertilization and nitrogen levels influenced the biomass production significantly but interaction effect of foliar fertilization and nitrogen levels did not influence significantly. Statistically better biomass produced (10.97 g $hill^{-1}$) was recorded when magic growth was applied on leaf (F_1) compared to that (8.39 g $hill^{-1}$) recorded in no foliar fertilization treatment (F_0). With the increase of nitrogen level the biomass weight was increased significantly. The highest biomass produced (12.00 g $hill^{-1}$) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was statistically equal to that (11.62 g $hill^{-1}$) obtained from N_{75}.

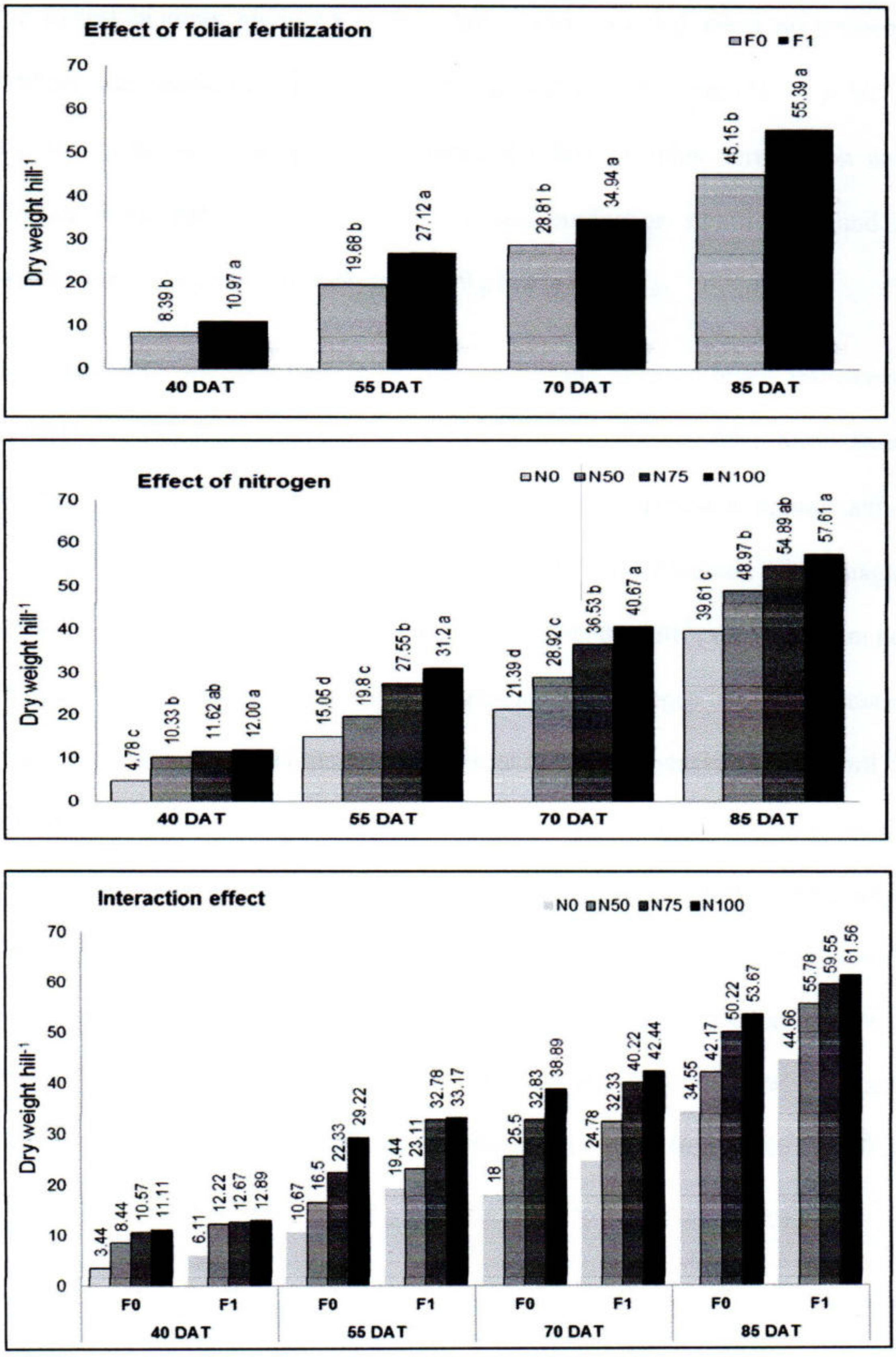

Fig. 4. Effect of foliar fertilization and nitrogen levels on biomass production (g hill^{-1}) of BRRIdhan 28 at different days after transplanting. (Means followed by different letter(s) at specific days after transplanting within main effects and interaction effect differed significantly by DMRT at P $\leq 5\%$).

hill^{-1}) recorded in no foliar fertilization treatment (F_0). With the increment of nitrogen level the biomass weight was increased significantly. The highest biomass (40.67 g hill^{-1}) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was statistically equal to that (36.53 g hill^{-1}) obtained from $N_{75.}$ The lowest biomass (21.39 g hill^{-1}) was produced when no nitrogen fertilizer was used as urea N_0 which was followed by that (28.92 g hill^{-1}) observed from N_{50} treatment. Among the interacted effect of foliar fertilization and nitrogen levels it was influence the biomass production significantly and it ranged from (18.00 g hill$^{-1)}$ in F_0N_0 to (42.44 g hill^{-1}) in $F_1N_{100.}$

At 85 days after transplanting the foliar fertilization and nitrogen levels influenced biomass production significantly but interaction effect of foliar fertilizer and nitrogen levels did not influence significantly. Statistically better biomass produced (55.39 g hill^{-1}) was recorded when magic growth was applied on leaf (F_1) compared to that (45.15 g hill^{-1}) was recorded in no foliar fertilization treatment (F_0). With the increment of nitrogen level the biomass weight was increased significantly. The highest biomass produced (57.61 g hill^{-1}) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was statistically equal to that (54.89 g hill^{-1}) obtained from N_{75}. The lowest biomass (39.61g hill^{-1}) was produced when no nitrogen fertilizer applied as urea N_0 which was statistically equal to that (48.97g hill^{-1}) obtained from N_0 treatment. Among the interacted effect of foliar fertilization and nitrogen levels did not influence the biomass production significantly and it ranged from (34.55 g hill$^{-1)}$ in F_0N_0 to (61.56 g hill^{-1}) in $F_1N_{100.}$

Concerning the foliar fertilization treatment the results of the current study was showed the greater biomass production at 40, 55, 70 and 85 DAT due to foliar fertilization with magic growth compared to no foliar fertilization treatment. The results also indicated that at 40, 55, 70 and 85 DAT the biomass production was increased with the increment of nitrogen level in both F_0 and F_1. Advanced rice growth due to foliar fertilization might be increase in chlorophyll content (Tejada and Gonzalez, 2004; Lin and Zhu, 2000), 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 root length, plant height and tillers $hill^{-1}$.

Sultana *et al*. (2001) stated that foliar application of nutrient solutions had influence on photosynthesis and photosynthesis-related parameters. The photosynthetic rates of leaves are dependent on their stomatal and non-stomatal components (Bethke and Drew, 1992). Stomatal conductance is related to turgor pressure of cells. The turgor pressure is controlled by solute regulation within the guard cell protoplast and the relative water content of epidermal tissues. Accumulation of K^+ and other organic ion increased the osmotic activity, causing a reduction in water potential and an influx of water from the surrounding cells. In addition, phytohormones and Ca^{2+} play important signaling role on the regulation of stomata (Sage and Reid, 1994) and Mn^{2+} bind firmly to the lamellae of chloroplasts, possibly to the outer surface of thylakoid membranes, affecting the chloroplast structure and photosynthesis (Lidon and Teixerira, 2000). The optimal balance of these physicochemical components in the cells is directly or indirectly related to photosynthesis. The minerals Na^+, Ca^{2+}, K^+ and Mn^{2+} are not only involved in the regulation of photosynthesis but have other cellular regulatory function, which are directly or indirectly involved in growth and physiology of the plant. Foliar fertilization may be increased the level of macro and micro nutrients in the leaf, thus it enhanced the photosynthetic rate of treated plant.

4.2.5. SPAD value of leaf at 55 days after transplanting

Leaf SPAD value of BRRIdhan 28 at 55 days after transplanting as influenced by foliar fertilization and nitrogen levels is presented in Table-2. Table-2 showed that SPAD value of leaf was increased with the advancement of time after transplanting.

At 55 days after transplanting the leaf SPAD value of fully youngest leaf was influenced significantly by foliar fertilization and nitrogen levels but the interaction of foliar fertilization did not influence the leaf SPAD value significantly. Foliar fertilization with magic growth provided significantly greater leaf SPAD value (41.92) was recorded when magic growth was applied on leaf (F_1) compared to that (45.95) was recorded when magic growth was not applied in leaf (F_0). With the increment of nitrogen level leaf SPAD value was influenced significantly. The highest leaf SPAD value (48.03) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was statistically equal to that (45.23) obtained from $N_{75.}$ The lowest leaf SPAD value (40.42) was recorded when no nitrogen fertilizer was applied in soil as urea (N_0) which was statistically equal to that (42.07) obtained from N_{50} treatment. Among the combinations treatment of foliar fertilization and nitrogen levels was influenced leaf SPAD value significantly and it ranged (49.90) in F_1N_{100} to (38.83) in F_0N_0.

Table. 2. Effect of foliar fertilization and nitrogen levels on SPAD value of the youngest fully expanded leaf of BRRIdhan 28 at 55 days after transplanting.

Nitrogen levels	SPAD value		Mean of nitrogen level
	F_0	F_1	
N_0	38.83	42.00	40.42 c
N_{50}	39.73	44.40	42.07 bc
N_{75}	42.97	47.50	45.23 ab
N_{100}	46.17	49.90	48.03 a
CV (%)	4.46		
Mean of foliar fertilization	41.92 b	45.95 a	

The results of the present study presented that SPAD value which indicates the leaf chlorophyll content was increased at 55 days after transplanting due to foliar fertilization compared to control. Shafiee *et al.* (2013) in their study 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.

4.3. Yield and yield contributing characters

4.3.1. Plant height at harvest

Plant height of BRRIdhan 28 at harvest as influenced by foliar fertilization with magic growth and nitrogen levels is presented in Table-3. Plant height was influenced significantly by nitrogen levels and foliar fertilization but it was not influenced by interaction effect of foliar fertilization and nitrogen levels. Statistically longer plant height (89.00 cm) was obtained due to foliar fertilization with magic growth was applied on leaf (F_1) compared to that (82.61cm) recorded in no foliar fertilization treatment (F_0). With the increment of nitrogen level plant height was increased significantly. The tallest plant (91.63 cm) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was statistically equal to that (87.82 cm) obtained from $N_{75.}$ The shortest plant height (78.39 cm) was obtained when no nitrogen fertilizer was applied in soil (N_0) which was followed by that (85.37 cm) obtained from N_{50} treatment. The combined effect of foliar fertilization and nitrogen levels was also influenced the plant height significantly and it ranged from (73.85 cm) in F_0N_0 to (93.77cm) in $F_1N_{100.}$

Table- 3: Effect of foliar fertilization and nitrogen levels on plant height and panicle length of BRRIdhan 28 at harvest

Treatment	Plant height (cm) at harvest	Panicle length (cm) at harvest
Foliar fertilization		
F_0	82.61 b	20.68 b
F_1	89.00 a	22.65 a
Level of significance	*	*
CV (%)	3.53	3.79
Nitrogen levels		
N_0	78.39 c	21.00
N_{50}	85.37 b	22.03
N_{75}	87.82 b	21.88
N_{100}	91.63 a	21.96
Level of significance	**	NS
CV (%)	2.5	3.13
Interaction effect		
F_0N_0	73.85	20.09
F_0N_{50}	81.23	21.05
F_0N_{75}	85.83	20.68
F_0N_{100}	89.50	20.92
F_1N_0	82.93	21.92
F_1N_{50}	89.50	22.60
F_1N_{75}	89.80	23.08
F_1N_{100}	93.77	23.00
Level of significance	NS	NS
CV (%)	2.50	3.13

F_0 = No foliar fertilization

F_1 = Foliar fertilization with Magic growth

N_0 = No nitrogen fertilizer

N_{50} = 50% of the recommended nitrogen fertilizer

N_{75} = 75% of the recommended nitrogen fertilizer

N_{100} = 100% of the recommended nitrogen fertilizer

4.3.2. Panicle length at harvest

Panicle length of BRRIdhan 28 at harvest as influenced significantly by foliar fertilization with magic growth but it was not influenced significantly by nitrogen levels and interaction effect of foliar fertilization. It is presented in Table 3. Statistically longer panicle length (22.65 cm) was recorded when magic growth was applied on leaf (F_1) compared to that (20.68cm) recorded in no foliar fertilization treatment (F_0). With the increment of nitrogen level panicle length was increased significantly. The longest panicle (22.03 cm) was observed when recommended nitrogen fertilizer was applied as urea (N_{50}) which was statistically equal to that (21.96 cm) recorded from N_{100}. The shortest panicle (21.00 cm) was obtained when no nitrogen fertilizer was applied in soil (N_0) which was followed by that (21.88 cm) obtained from N_{50} treatment. The combined effect of foliar fertilization and nitrogen levels also did not influence the length of panicle significantly and it ranged from 20.09 cm in F_0N_0 to 23.00 cm in $F_0N_{100.}$

4.3.3. Panicle hill^{-1} at harvest

Panicle hill^{-1} of BRRIdhan 28 at harvest as influenced significantly by foliar fertilization with magic growth and nitrogen levels but it was not influenced significant by interaction effect of foliar fertilization and nitrogen levels. It is presented in Table 4. Statistically higher panicle hill^{-1} (15.77) was recorded when magic growth was applied on leaf (F_1) compared to that (14.04) recorded in no foliar fertilization treatment (F_0). With the increment of nitrogen level the panicle hill^{-1} was increased significantly. The highest number of panicle hill^{-1} (16.58) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was statistically equal to that (15.74) obtained from N_{75} treatment. The lowest number of panicle hill^{-1} (12.47) was recorded when no nitrogen fertilizer was applied in soil (N_0) which was followed by that (14.82) obtained from N_{50} treatment. The combined effect of foliar fertilization and nitrogen levels also did not influence panicle hill^{-1} significantly and it ranged from (12.40) in F_0N_0 to (17.67) F_1N_{100}.

4.3.4. Spikelet panicle^{-1} at harvest

Number of spikelet panicale^{-1} of BRRIdhan 28 at harvest as influenced by foliar fertilization with magic growth, nitrogen levels and interaction effect of foliar fertilization. It is presented in Table 4. The highest number spikelet panicle^{-1} (163.09) was recorded when magic growth was applied on leaf (F_1) compared to that (147.23) was recorded in no foliar fertilization treatment (F_0). With the increment of nitrogen level the spikelet panicle^{-1} was increased significantly. The highest number of spikelet panicle^{-1} (169.55) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was followed by that (136.75) recorded from $N_{75.}$ The lowest spikelet panicle^{-1} (136.75) was observed when no nitrogen fertilizer was applied in soil (N_0) which was followed by that (152.90) recorded from N_{50} treatment. The combined effect of foliar fertilization and nitrogen levels also influenced the number of spikelet panicle^{-1} significantly. The highest number of spikelet panicle^{-1} (179.73) was observed from F_1N_{100} which was statistically equal to that (170.70) recorded in F_1N_{75}, (161.73) in F_1N_{50} and (140.23) in F_1N_o treatment. The lowest number of spikelet panicle^{-1} (133.27) was recorded in F_0N_0 which was statistically equal to that (144.07) in F_0N_{50}, (152.23) in F_0N_{75} and (140.23) in F_0N_{100} treatment.

Table 4. Effect of foliar fertilization, nitrogen levels and interaction effect on Panicle hill^{-1} and Spikelet panicle^{-1} of BRRIdhan 28 at harvest

Treatment	Panicle hill^{-1} at harvest	Spikelet panicle^{-1}	1000 grain weight (g)
Foliar fertilization			
F_0	14.04 b	147.23 b	23.13 b
F_1	15.77 a	163.09 a	23.37 a
Level of significance	*	**	*
CV (%)	4.16	0.68	0.42
Nitrogen levels			
N_0	12.47 c	136.75 d	22.87
N_{50}	14.82 b	152.90 c	23.27
N_{75}	15.74 ab	136.75 b	23.41
N_{100}	16.58 a	169.55 a	23.45
Level of significance	**	**	NS
CV (%)	5.53	2.41	1.54
Interaction effect			
F_0N_0	12.40	133.27 b	22.76
F_0N_{50}	13.41	144.07 b	23.14
F_0N_{75}	14.84	152.23 b	23.26
F_0N_{100}	15.50	159.36 b	23.34
F_1N_0	12.53	140.23 a	22.98
F_1N_{50}	16.23	161.73 a	23.39
F_1N_{75}	16.63	170.70 a	23.56
F_1N_{100}	17.67	179.73 a	23.55
Level of significance	NS	*	NS
CV (%)	5.53	2.41	1.54

F_0 = No foliar fertilization

F_1 = Foliar fertilization with Magic growth

N_0 = No nitrogen fertilizer

N_{50} = 50% of the recommended nitrogen fertilizer

N_{75} = 75% of the recommended nitrogen fertilizer

N_{100} = 100% of the recommended nitrogen fertilizer

4.3.5. 1000-grain weight

Thousand grain weight of BRRIdhan 28 as influenced significantly by foliar fertilization with magic growth but was not influenced by nitrogen level and interaction effect. It is presented in Table 4. Statistically higher thousand grain weight (23.37 g) was recorded when foliar fertilization with magic growth was applied on leaf (F_1) compared to that (23.13 g) was recorded when no foliar fertilization treatment (F_0). With the increment of nitrogen level 1000-grain weight was increased significantly. The highest 1000 grain weight (23.45 g) was obtained when nitrogen fertilizer was applied in soil (N_{100}) which was followed by that (23.41) obtained from N_{75}. The lowest 1000 grain weight (22.87 g) was obtained when no foliar fertilization treatment in soil as (N_0) that was followed by that (23.27 g) obtained from (N_{50}) treatment. The combined effect of foliar fertilization and nitrogen levels was also influenced significantly and it ranged from (22.76 g) in F_0N_0 to (23.55 g) in $F_1N_{100.}$

4.3.6. Grain yield t ha^{-1}

Grain yield of BRRIdhan 28 was influenced by foliar fertilization with magic growth and nitrogen levels are presented in Table 5. Table 5 showed that the grain yield was influenced significantly by foliar fertilization and nitrogen levels but was not influenced by the interaction effect of foliar fertilization and nitrogen levels. In overall, foliar fertilization (F_1) treatment provided greater grain yield (5.82 t ha^{-1}) compared to that (4.68 t ha^{-1}) provided by no foliar fertilization treatment (F_0). With the increment of nitrogen level grain yield was increased up to N_{75} thereafter remained more or less same at N_{100}.

Table 5. Effect of foliar fertilization, nitrogen levels and interaction effect on grain yield t ha^{-1} and straw yield t ha^{-1} of BRRIdhan 28 at harvest

Treatment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
Foliar fertilization		
F_0	4.68 b	4.26 b
F_1	5.82 a	5.00 a
Level of significance	**	*
CV (%)	2.86	4.27
Nitrogen levels		
N_0	4.21 c	4.04 c
N_{50}	5.07 b	5.69 b
N_{75}	6.03 a	6.79 b
N_{100}	5.69 a	6.00 a
Level of significance	**	**
CV (%)	5.61	6.31
Interaction effect		
F_0N_0	3.67	3.85
F_0N_{50}	4.41	4.46
F_0N_{75}	5.25	5.54
F_0N_{100}	5.38	5.83
F_1N_0	4.75	4.92
F_1N_{50}	5.74	5.82
F_1N_{75}	6.81	7.07
F_1N_{100}	5.99	6.59
Level of significance	NS	NS
CV (%)	5.61	6.31

F_0 = No foliar fertilization

F_1 = Foliar fertilization with Magic growth

N_0 = No nitrogen fertilizer

N_{50} = 50% of the recommended nitrogen fertilizer

N_{75} = 75% of the recommended nitrogen fertilizer

N_{100} = 100% of the recommended nitrogen fertilizer

The combined effect of foliar fertilization and nitrogen levels also did not influence the straw yield significantly. Foliar fertilization and nitrogen levels was increased straw yield (7.07 t ha^{-1}) up to 75% of recommended nitrogen fertilizer with foliar fertilization (F_1N_{75}) which was followed by that (6.59 t ha $^{-1}$) obtained from F_1N_{100} and other combinations were produced moderate straw yield.

Concerning to the effect of foliar fertilization and nitrogen fertilizer levels on grain yield and its attributes the results of the present study indicated that tillers $hill^{-1}$, grain $pnicle^{-1}$, thousand grains weight, grain yield and straw yield of BRRIdhan 28. Foliar fertilization and increment nitrogen level dose might improve rice growth, photosynthesis rate, strayed of assimilates, translocation of assimilates and magnified the all yield attributes leading to higher grain. These results are in good accordance with those reported by Lin and Zhu (2000), Manivannan *et al.* (2001), Ramamathan *et al.* (2002), Shafiee *et al.* (2013) and Abd El-Razik (2003).

Recently, it has been reported that a small amount of nutrients (nitrogen, potash or phosphate) applied by foliar spraying increases significantly the yield of crops (Asenjo *et al.*, 2000; Haq and Mallarino, 2000). Many researchers have reported the positive response of K_2SO_4 foliar application to rice and wheat crops as well as higher plants (Ali *et al.*, 2005). Chopra and Chopra (2004) reported that nitrogen had significantly effects on yield attributes such as plant height, panicle $plant^{-1}$ and 1000-seed weight with increasing levels of N up to 120 kg N ha^{-1} in rice. It has been reported that application of either 80 or 120 kg N ha^{-1} improved the entire yield attributes compared with control (Chopra and Chopra, 2000).

Soylu *et al*. (2005) and Guenis *et al.* (2003) reported a significant increase in 1000 grain weight with the foliar application of micronutrients. Fang *et al.* (2008) reported that foliar application of zinc, selenium and iron fertilizers increased grain yield. 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. Tejada and Gonzalez (2004) reported that the foliar fertilization with a byproduct rich in humic substances with macro- and micronutrients increased the concentration of micronutrients Fe, Cu, Zn and Mn, and macronutrients N, P, and K in leaves up taken by plants.

grains weight, grain yield (t ha^{-1}) and straw yield (t ha^{-1}) were also recorded at the time of harvest.

Seedling height, root length, dry weight of BRRIdhan 28 at transplanting date were found higher due to foliar fertilization compared to no foliar fertilization but the differences were significant only seedling height and root length.

Root length, plant height, tillers $hill^{-1}$ and dry weight $hill^{-1}$at 40, 55, 70 and 85 days after transplanting and SPAD value of the youngest fully expanded leaf at 55 days after transplanting were found higher due to foliar fertilization compared to no foliar fertilization treatment. These parameters were also increased significantly the increment of nitrogen levels light in soil. The interaction of foliar fertilization and nitrogen levels did not influenced all the growth parameters studied in the present investigation.

Plant height, panicle length, panicle $hill^{-1}$, spikelets $panicle^{-1}$, 1000 grain weight, grain and straw yield were increased due to foliar fertilization (F_1) compared to no foliar fertilization of magic growth (F_0) treatment. Most of the yield parameters were significantly increased with the increment of nitrogen levels applied in soil. The interaction of foliar fertilization and nitrogen levels did not influence all the yield parameters except spikelet $panicle^{-1}$ studied in the present investigation.

The overall result demonstrated that the increment of nitrogen level the grain yield was increased up to N_{100} in no foliar fertilization treatment (F_0) but in foliar fertilization treatment (F_1) grain yield was increased with the increment of nitrogen level up to N_{75} and thereafter decreased in $N_{100.}$ Foliar fertilization with magic growth with 50% of the recommended nitrogen fertilizer i.e F_1N_{50} provided 6.7% higher grain yield compared to recommended practice (F_0N_{100}) with a saving of 50% recommended nitrogen fertilizer whereas F_1N_{75} provided 26.6% higher grain yield compared to F_0N_{100} with a saving of 25% nitrogen fertilizer. On the other hand additional foliar fertilizer (F_1N_{100}) provided 11.3% higher grain yield compared to recommended practice.

From the overall results it may be concluded that

- Foliar fertilization with magic growth showed higher root length, plant height, tillers $hill^{-1}$, biomass dry weight at 40, 55, 70 and 85 DAT and SPAD value of the youngest fully expanded leaf at 55 days after transplanting compared to no foliar fertilization treatment. All the parameters were also increased with the increment of nitrogen levels.
- Plant height, panicle length, panicle $hill^{-1}$, spikelets $panicle^{-1}$, 1000 grain weight, grain and straw yield at harvest were found higher due to foliar fertilization compared to no foliar fertilization.
- Foliar fertilization with magic growth along with 75% of the recommended nitrogen fertilizer (F_0N_{75}) provided highest grain yield compared to recommended nitrogen fertilizer treatment (F_0N_{100}). Therefore, 26.6% grain yield increased with saving 75% of the recommended nitrogen fertilizer can be saved without any yield reduction. On the other hand, F_1N_{50} treatment combination can increased 9.33% grain yield compared to recommended practice (F_0N_{100}) with a saving of 50% of the recommended nitrogen fertilizer per hectare of land whereas F_1N_{75} provided 26.6% higher grain yield

compared to F_0N_{100} with a saving of 25% nitrogen fertilizer. On the other hand additional foliar fertilizer (F_1N_{100}) provided 11.3% higher grain yield compared to recommended practice (F_0N_{100}).

- Final recommendation of 26.6% grain yield increased with saving 75% of the recommended nitrogen fertilizer can be saved without any yield reduction.

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APPENDICES

Appendix I: Weather data for growing season of wheat, 2013-2014

Month	Relative humidity (%)	Temperature		Total rainfall (mm)
		Minimum (°C)	Maximum (°C)	
December	83	11.9	24.8	0.0
January	86	10.5	22.0	0.0
February	86	11.5	24.10	28.0
March	85	16.5	30.7	1.0
April	86	18.8	29.5	20.0
May	87	20.7	31.2	22.0

Source: Wheat Research Centre, Dinajpur

Appendix II: Analysis of variance table for Root length, shoot length, number of tillers and biomass dry weight 40 days after transplanting

Sources of variation	Degrees of freedom	Mean square value			
		Root length at 40 DAT	Shoot length at 40 DAT	No of tillers at 40 DAT	Biomass dry weight at 40 DAT
Replication	2	2.57	11.81	7.13	1.89
Factor A	1	27.46 *	316.68 *	82.47 **	39.99 *
Error	2	1.47	10.89	0.55	1.76
Factor B	3	5.95**	117.27**	78.57 **	67.21 **
AB	3	0.53^{NS}	0.33^{NS}	0.48^{NS}	1.16^{NS}
Error	12	0.57	7.97	0.93	1.56
Total	23				

Appendix III: Analysis of variance table for Root length, shoot length, number of tillers hill^{-1}, biomass dry weight and SPAD value at 55 days after transplanting

Sources of variation	Degrees of freedom	Mean square value				
		Root length at 55 DAT	Shoot length at 55 DAT	No of tillers hill^{-1} at 55 DAT	Biomass dry weight at 55 DAT	SPAD vale at 55 DAT
Replication	2	0.64	4.10	0.04	3.42	4.44
Factor A	1	25.36 *	400.25 *	136.04 NS	332.42 *	97.24 *
Error	2	1.36	7.38	9.03	17.48	3.85
Factor B	3	8.83 **	328.26 **	119.71 **	321.18 **	68.71 **
AB	3	0.59 NS	24.99**	1.34 NS	11.86 NS	0.75 NS
Error	12	1.22	1.91	0.84	5.50	11.29
Total	23					

Appendix IV: Analysis of variance table for Root length, shoot length, number of tillers hill^{-1} and biomass dry weight 70 days after transplanting

Sources of variation	Degrees of freedom	Mean square value			
		Root length at 70 DAT	Shoot length at 70 DAT	No of tillers hill^{-1} at 70 DAT	Biomass dry weight at 70 DAT
Replication	2	0.18	10.32	2.62	41.91
Factor A	1	22.72 **	264.21 *	87.44 *	226.07 NS
Error	2	0.13	6.92	2.80	12.47
Factor B	3	9.63 **	409.77 **	127.06 **	435.34 **
AB	3	0.32 NS	5.62 NS	1.40 NS	4.57 NS
Error	12	0.93	9.41	0.80	10.41
Total	23				

Sources of variation	Degrees of freedom	Mean square value		
		Root length at 85 DAT	Shoot length at 85 DAT	Biomass dry weight at 85 DAT
Replication	2	1.86	8.53	23.39
Factor A	1	14.51 NS	121.46 *	628.63 *
Error	2	0.84	6.34	25.99
Factor B	3	12.92 **	143.96 **	381.14 **
AB	3	0.14 NS	0.89 NS	8.86 NS
Error	12	1.04	10.87	41.14
Total	23			

Appendix VI: Analysis of variance table for plant height, Panicle hill $^{-1}$, Panicle length and Spikelet panicle $^{-1}$ at harvest at harvest.

Sources of variation	Degrees of freedom	Mean square value			
		Plant height at harvest	Panicle hill $^{-1}$ at harvest	Panicle length at harvest	Spikelet panicle $^{-1}$ at harvest
Replication	2	5.22	2.78	0.02	4.37
Factor A	1	245.38 *	17.91 *	23.19 *	1510.98 **
Error	2	9.19	0.38	0.67	1.11
Factor B	3	186.28 **	18.93 **	1.19 NS	1181.48 **
AB	3	10.57 NS	1.97 NS	0.20 NS	54.78 *
Error	12	4.61	0.68	0.46	13.98
Total	23				

Appendix VII: Analysis of variance table for Grain yield t ha^{-1}, Straw yield t ha^{-1}, and 1000 grain weight (g) m^{-2} at harvest.

Sources of variation	Degrees of freedom	Mean square value		
		Grain weight t ha^{-1}	Straw weight t ha^{-1}	1000 grain weight (g) m^{-2}
Replication	2	15.78	51.97	0.02
Factor A	1	786.90 **	129.81 *	0.36 *
Error	2	2.25	15.64	0.01
Factor B	3	392.24 **	3541.87 **	0.42^{NS}
AB	3	14.22^{NS}	67.29^{NS}	0.01^{NS}
Error	12	8.68	34.16	0.13
Total	23			