LIQUID FERTILIZATION ON KATARIBHOG RICE TO REDUCE SOIL APPLICATION OF NITROGENOUS FERTILIZER

A Thesis

By

Md. Zahanggir Alam

Student No. 1305027

MASTER OF SCIENCE

IN

CROP PHYSIOLOGY AND ECOLOGY

DEPARTMENT OF CROP PHYSIOLOGY AND ECOLOGY

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY

DINAJPUR

JUNE 2014

LIQUID FERTILIZATION ON KATARIBHOG RICE TO REDUCE SOIL APPLICATION OF NITROGENOUS FERTILIZER

A Thesis

By

Md. Zahanggir Alam

Student No. 1305027

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

IN

CROP PHYSIOLOGY AND ECOLOGY

DEPARTMENT OF CROP PHYSIOLOGY AND ECOLOGY

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY

DINAJPUR

JUNE 2014

LIQUID FERTILIZATION ON KATARIBHOG RICE TO REDUCE SOIL APPLICATION OF NITROGENOUS FERTILIZER

A Thesis
By
Md. Zahanggir Alam
Student No. 1305027

Approved as the style and content by

Md. Hafizur Rahman Hafiz
(Supervisor)

Professor Dr. Maniruzzaman Bahadur
(Co-supervisor)

Professor Dr. Md. Abu Hasan
Chairman
Examination Committee

DEPARTMENT OF CROP PHYSIOLOGY AND ECOLOGY
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY
DINAJPUR

JUNE 2014

<u>Dedicated to</u>

Beloved parents

ACKNOWLEDGEMENT

The entire compliment is due to the Almighty Allah, the supreme ruler of the universe, Who enabled me to complete this present piece of work.

I would like to express my whole hearted sense of respect, sincere appreciation and immense indebtedness to my respectable teacher and research supervisor Md. Hafizur Rahman Hafiz, Assistant Professor, Department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science and Technology University, Dinajpur for his scholastic guidance, valuable suggestions, continuous encouragement and all kind of support and help throughout the period of research work and preparation of this manuscript.

Heartiest thanks and deep sense of respect to my respected co-supervisor Dr. Md. Maniruzzaman Bahadur, Professor, Department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science and Technology University, Dinajpur for his valuable suggestions, intellectual instructions and meticulous correction of this manuscript.

I acknowledge a profound appreciation to prof. Dr. Md. Maniruzzaman Bahadur, Chairman of the Department, Dr. Sripati Sikder, Professor, Abu Khayer Md. Muktadirul Bari Chowdhury, Assistant Professor, and Md. Rabiul Islam, Assistant Professor, Department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science and Technology University, Dinajpur for their invaluable suggestions and all round help and co-operation for successful completion of this manuscript.

I also extend thanks to all the staffs of the Department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science and Technology University, Dinajpur for their help and co-operation during the period of the experiment.

I am very gratitude to my intimate friends and existing classmate as well wisher for their enthusiasm and heartfelt co-operation during the period of research work.

I would like to express my gratefulness to my parents, younger brother, sister and other relatives for their great sacrifice and prayers during the study.

June 2014 The Author

LIQUID FERTILIZATION ON KATARIBHOG RICE TO REDUCE SOIL APPLICATION OF NITROGENOUS FERTILIZER

ABSTRACT

An experiment was conducted to find out the effect of liquid fertilization (Magic Growth) on performance of Kataribhog rice and to calculate how much urea can be saved by using liquid fertilization of Magic Growth without the reduction of grain yield. during the period of August 2013 to January 2014. The experiment was conducted in a split plot design. Two levels of liquid fertilization and four levels of nitrogen fertilizer were assigned to the main and sub plot. Liquid fertilization with Magic Growth produced higher plant height, tillers hill^{-1}, SPAD value of the youngest fully expanded leaf and above ground biomass at days after transplanting compared to no liquid fertilization treatment. All the parameters were also increased with the increment of nitrogen level. Liquid fertilization and increasing nitrogen fertilizer levels considerably influenced effective tillers hill^{-1}, spikelets panicle^{-1}, grains panicle^{-1}, 1000- grains weight, grain yield and straw yield of Kataribhog rice. Liquid fertilization (L_1) treatment provided greater grain yield compared to no liquid fertilization treatment (L_0) in all nitrogen levels. With the increment of nitrogen level the grain yield was increased up to N_{100} in no liquid fertilization treatment (L_0) but in liquid fertilization treatment (L_1), grain yield was increased up to N_{75} and there after decreased in $N_{100.}$ Liquid fertilization with Magic Growth along with 75% of the recommended nitrogen fertilizer increased 10.5% grain yield with a saving of 25% of the recommended nitrogen fertilizer compared to recommended practice.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important crops in Bangladesh. It is the largest crop in terms of area and production in Bangladesh (BBS, 2008). Although rice is consuming large acreage, Bangladesh is still far behind than other rice producing countries. The average yield is very low (2 t/ha) as compared to Egypt (8.4 t/ha) and USA (6.6 t/ha). There are many reasons for this low yield. The most important of them is the indiscriminate and improper application of nutrients with unfavorable condition. Many factors determine the fertilizer use efficiency for rice crop during cultivation such as soil, cultivar, season, environment, planting time, water management, weed control, cropping pattern, source, form, rate, time of application and method of application (De Datta, 1978).

Rice is mainly cultivated in 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).

Nearly 70% of the land area of the country has been brought under rice cultivation. Out of this 70%, fine rice is cultivated in roughly 10% land (MoP,1997). This lower coverage is primarily due to the emphasis of government policy and research on food grain production but with low input technogy.

The government is more concerned about the basic staple rice of the country. As a result very little supports found to be on fine rice.

Nutrient management practices determine the sustainability of the most intensively cropping systems (Flinn and De Datta, 1984; Flinn *et al.,* 1982). 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 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 applied at critical times. 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).

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

1. To find out the effect of liquid fertilization (Magic Growth) on performance of Kataribhog rice.
2. To calculate the amount of urea can be saved by liquid fertilization of Magic Growth without any yield reduction.
3. To study the interaction effect of liquid fertilization of Magic Growth and nitrogen levels on performance of Kataribhog rice.

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 on it is available in Bangladesh. However, some of the information on the effect of liquid fertilization on rice has been reviewed below-

Pramanik (2013) conducted an experiment was to find out the effect of foliar fertilization (Magic growth) on performance of BRRIdhan 28 and to calculate how much urea can be saved by foliar fertilization of Magic growth without any yield reduction. He reported that 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. 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 BRRIdhan 28. In general, foliar fertilization (F_1) treatment provided greater grain yield compared to no foliar fertilization treatment (F_0) in all nitrogen levels. 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.

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_2S0_4 and $KN0_3$ on the yield of rice cv. 385. Foliar application of K_2S0_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_2S0_4 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).

An experiment was conducted by Alam *et al.* (2010) 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 (282 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 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.

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. The experiment was arranged in a Randomized Complete Block Design with three replications. Number of fertile tillers, straw and paddy yields 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 statistically at par with soil 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}.

The field trial was conducted Ronen *et al.* (2011) in Thailand to test the effect of three foliar applications of multi-npK (13-3-43) as the rice fertilizer, compared to the traditional growing method. The foliar application with Multi-npK 13-3-43 increased the yield by 1.6MT/H and the revenue by 41.4 USD/Ha. The net income increased by 9.9 USD/Ha.

100 field demo plots, in four regions of Vietnam were conducted by the local extension services in growers' fields, coordinated with the Mekong Research Institute to find out the effect of a liquid fertilizer (Haifa Bonus+Mg) on rice. Average grain yield results obtained from 100 demo plots. 9.68 to 11.75% yield increment were found due to Haifa Bonus+Mg spray (Ronen *et al.*, 2011).

A foliar application of 10 kg KCl m^{-3} to rice at panicle initiation, boot leaf and 50% flowering stages, both in the monsoon and winter seasons, significantly increased seed yield and improved quality (seed germination and 100-seed weight) (Jayaraj and Chandrasekharan, 1997). Splitting a total of 95 kg ha^{-1} of

KCl to rice, a third at sowing in soil, a third as a foliar spray at flag leaf stage and a third as foliar spray at grain development, gave larger yields than a soil application all at sowing (Narang *et al.*, 1997). In Tamil Nadu (India), on the paddy soils of the Cauvery Delta, it is recommended to apply two foliar sprays of diammonium phosphate (DAP) at a rate of 20 kg m^{-3} with 10 kg m^{-3} of urea and KCl, one at panicle initiation and the other at 10% flowering. This may increase yields up to 0.75 t ha^{-1} (Nagarayan, 1999).

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}.

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.

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}.

Shafiee *et al.* (2013) showed that leaf chlorophyll contents (SPAD meter readings) of rice were significantly affected by different foliar fertilizer treatments. The highest chlorophyll content recorded when SBAJATM diluted with water at 1:300 (T3) and 1:400 (T4) were sprayed three times, followed by Vitagro® application whilst, the lowest chlorophyll content was found in normal fertilization without foliar application. 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.

Two field experiments were performed by Sharief et al. (2006) during 2003 and 2004 seasons at El-Manzala district in Egypt to studt 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 upto 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 of House Green after 45 days after from transplanting in both seasons. Grain yield increased by 10.2 and 11.5% when House Green foliar spraying after 35 and 45 days transplanting, respectively compared with those spraying after 15 days after transplanting over both season.

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).

Shafiee *et al.* (2013) showed that 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 difference were recorded in terms of weight of 1000 grains and percentage of filled grains panicle^{-1} among treatment means, the number of grains panicle^{-1} was higher in plots receiving the SBAJATM treatments

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.

CHAPTER III

MATERIALS AND METHODS

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

3.1. Location and duration

The experiment was set up at the research farm and laboratory of Crop Physiology and Ecology Department, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during July 2013 to January 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-Ecological Zone (AEZ-1) of Old Himalayan Piedmont Plain. The soil is 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 matter, 0.064% Nitrogen, 18.56μg / g Phosphorous and 0.18 me/100g Potassium. 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.

3.3. Experimental design

The experiment was conducted in a split plot design with three replications. Two levels of liquid fertilization with magic growth were placed in the main plots as main plot treatments whereas four levels of nitrogen fertilizer were placed randomly in the sub plots as sub plot treatments.

3.4 Experimental treatments

Main plot treatments: Liquid fertilization

L_0 – No liquid fertilization

L_1 – liquid fertilization with Magic Growth (at 30, 45 and 60 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

3.5. Seedbed preparation and raising of seedlings

The field was ploughed and cross 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 Katarybhog 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 31.07.2013 to obtain 30 days old seedling at transplanting date (30.08.2013). Adequate water was applied to the growing seedling in the seedbed as and when required until the day of uprooting the seedlings.

3.6. 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. The total number of plots was 24 ($3 \times 2 \times 4$) and the unit plot size was 25 m^2 (5m x 5m) having a plot to plot and block to block distance of 1 m and 1.5 m, respectively.

3.7. Fertilizer application

Fertilizer was applied at a rate of 120-100-60-15-5 kg ha^{-1} Urea, Triple Supper Phosphate (TSP), Muriate of Potash (MoP), Gypsum and Zinc Sulphate, respectively as recommended dose for Aman rice. After land preparation, cowdung and 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 liquid fertilization, 32 ml Magic growth + 300 g Urea + 100 g Muriate of Potash was dissolved in 16 liter clean water to spray 445.4 m^2 of land. Urea and Magic growth were applied in different plots as follows-

Table 1. Application schedule of Urea and liquid fertilizer (Magic growth) in different plots

Treatment	At 7 DAT	At 30 DAT	At 45 DAT	At 60 DAT
F_0N_0	-	-	-	-
F_0N_{50}	33.33% Urea	16.67% Urea	-	-
F_0N_{75}	25.00% Urea	25.00% Urea	25.00% Urea	-
F_0N_{100}	33.33% Urea	33.33% Urea	33.33% Urea	-
$F_1 N_0$	-	LF	LF	LF
$F_1 N_{50}$	33.33% Urea	16.67% Urea+ LF	LF	LF
$F_1 N_{75}$	25.00% Urea	25.00% Urea + LF	25.00% Urea + LF	LF
$F_1 N_{100}$	33.33% Urea	33.33% Urea + LF	33.33% Urea + LF	LF

LF indicates liquid fertilization with Magic Groth.
% Urea indicates percent of recommended dose of urea

Magic Growth solution is a liquid fertilizer invented by Md. Arif Hossain Khan, Joint Director (Seed Marketing), Bangladesh Agricultural Development Corporation (BADC) which is ready for government recognition. 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.

3.8. Transplanting

Fourty days old seedlings of rice (Variety- Kataribhog) were transplanted on 30.08.2013 as per treatment. A spacing of line to line distance 20 cm and hill to hill distance 20 cm was maintained. Three healthy seedlings were transplanted per hill.

3.9. Intercultural operations

Weeding was done to keep the crop field free from weed. The crop was kept insects and diseases free. Rat and other pests were controlled by applying recommended practices. Other intercultural operations were done accordingly. Adequate water was maintained in the experimental field whenever necessary.

3.10. Data collection:

1. Plant height, tillers hill^{-1}, leaves hill^{-1} and above ground biomass at 40, 55, 70 and 85 days after transplanting (DAT) was recorded. For recoding those data 5 hills were used per treatment from one side of the each treatment plot.
2. SPAD value of youngest fully expanded leaf at 50 and 70 days after transplanting was recorded and for recording these data 10 leaves (one from one hill) were used per treatment with the help of SPAD meter.
3. Plant height, tillers hill^{-1} and panicle hill^{-1} at harvest were recorded and for recoding those data sample plants were selected from the central 1m^2 area of each unit plot.
4. Spikelets panicle^{-1}, grains panicle^{-1} and 1000-grains weight at harvest were recorded and for recoding these data sample panicles were selected from the central 1m^2 area of each unit plot.
5. Thousand grains weight was recorded using an electrical balance (Model-AND EK- 300 i).

6. Grain and straw yield were recorded by collecting samples from an area of 5 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}.

3.11. Statistical analysis

The data were analyzed by partitioning the total variance with the help of computer by using MSTAT-C program. The treatment means were compared using Duncun's Multiple Range Test (DMRT) at $P \leq 5\%$ level of significance.

CHAPTER IV

RESULTS AND DISCUSSION

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

4.1. Growth characters

4.1.1. Plant height at different days after transplanting

Plant height of Kataribogh rice at different days after transplanting as influenced by liquid fertilization and nitrogen levels is presented in Figure 1. It shows that height of the plant was increased with the advancement of time after transplanting.

At 40 days after transplanting, plant height was influenced significantly by liquid fertilization and nitrogen levels but the interaction of liquid fertilization and nitrogen levels did not influence the height of plant significantly. Liquid fertilization with magic growth provided significantly higher plant height (90.11 cm) than that provided by no liquid fertilization treatment (86.59 cm). With the increment of nitrogen level applied in soil the plant height was increased. The tallest plant (91.67 cm) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was statistically equal to that (91.10 cm) obtained from N_{75}. The shortest plant (86.73 cm) was obtained when no nitrogen fertilizer was applied in soil (N_0) which was statistically equal to that (87.95 cm) obtained

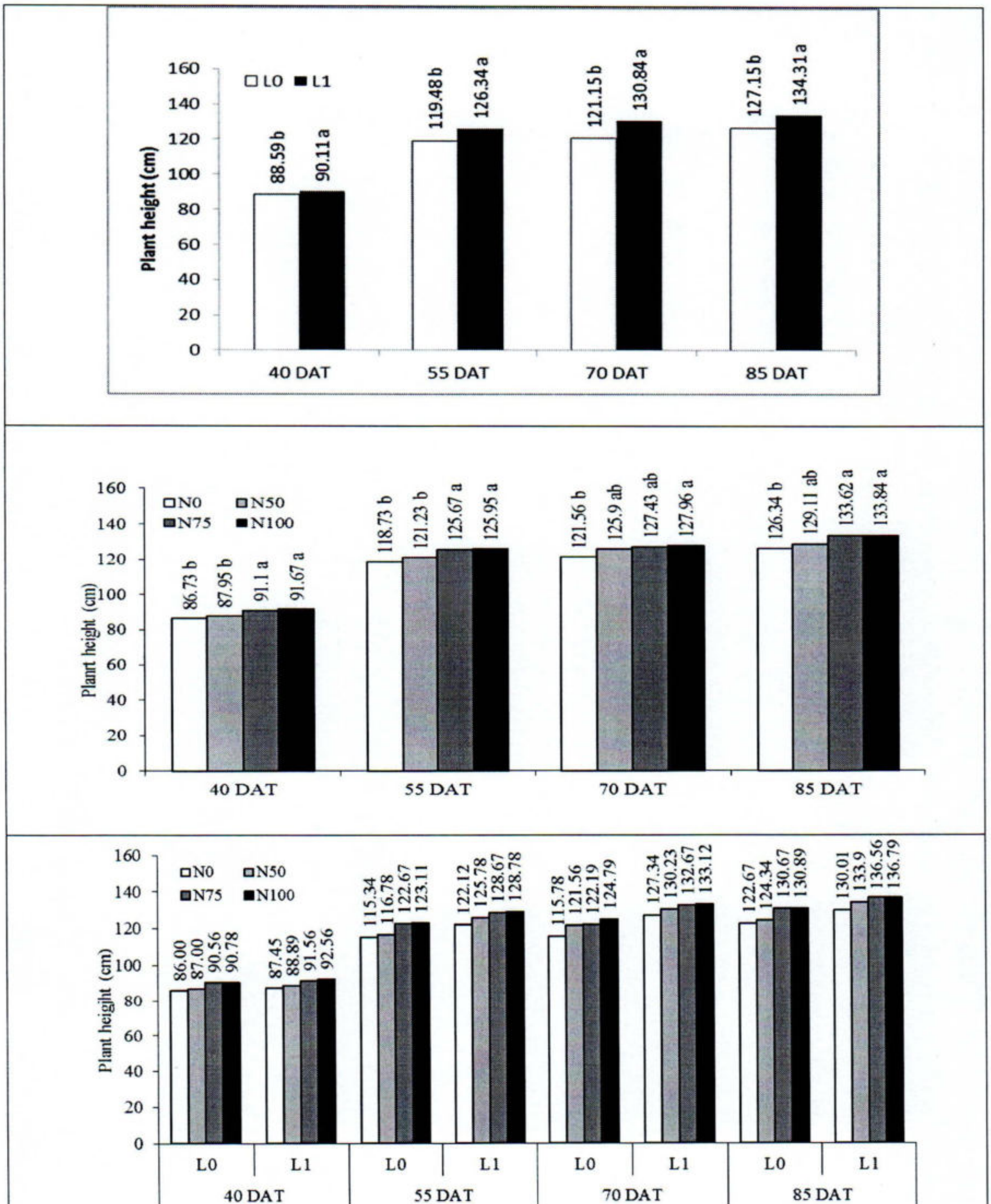

Fig. 1. Effect of liquid fertilization and nitrogen levels on plant height of Kataribhog rice at different days after transplanting. *(Means followed by different letter(s) at specific days after transplanting within main effects and interaction effect differed significantly by DMRT at $P \leq 5\%$). Here, L_0 = No liquid fertilization, L_1 = liquid 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 and N_{100} = 100% of the recommended nitrogen fertilizer).*

from N_{50} treatment. Among the treatment combinations L_1N_{100} provided the tallest plant (92.56 cm) but L_0N_0 provided the shortest plant (86.00 cm).

At 55 days after transplanting, liquid fertilization influenced the plant height significantly. Higher plant height (126.34 cm) was obtained due to liquid fertilization with magic growth (L_1) compared to that (119.48 cm) provided by no liquid fertilization treatment (L_0). Plant height was also influenced by different levels of nitrogen fertilizer applied in soil. With the increment of nitrogen level the plant height was increased. The tallest plant (125.95 cm) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was statistically equal to that (125.67 cm) obtained from N_{75}. The shortest plant (118.73 cm) was obtained when no nitrogen fertilizer was applied in soil (N_0) which was followed by that (121.23 cm) obtained from N_{50} treatment. The combined effect of liquid fertilization and nitrogen levels did not influence the height of plant significantly and it ranged from 115.34 cm in L_0N_0 to 128.78 cm in $L_1N_{100.}$

At 70 days after transplanting, liquid fertilization and nitrogen levels influenced the plant height significantly but they did not interacted significantly to influence the height of plant. Significantly higher plant height (130.84 cm) was obtained due to liquid fertilization with magic growth compared to that (121.10 cm) provided by no liquid fertilization treatment (L_0). The plant height was increased with the increment of nitrogen level applied in soil. Recommended nitrogen fertilizer (N_{100}) provided the tallest plant (127.96 cm) which was statistically similar to that (127.43 cm) and (125.90 cm) obtained when 75% and 50% of the recommended nitrogen fertilizer was applied in soil as urea respectively. No nitrogen fertilizer treatment provided the shortest plant (121.56 cm) which was followed by that (125.90 cm) and (127.43 cm,) recorded in N_{50} and N_{75} treatment respectively. Among the treatment combinations L_1N_{100} provided the tallest plant (133.12 cm) but L_0N_0 provided the shortest plant (115.78 cm).

At 85 days after transplanting, liquid fertilization influenced the plant height significantly. Higher plant height (134.31 cm) was obtained due to liquid fertilization with magic growth (L_1) compared to that (127.15 cm) provided by no liquid fertilization treatment (L_0). Plant height was also influenced by different levels of nitrogen fertilizer applied in soil. With the increment of nitrogen level the plant height was increased. The tallest plant (133.84 cm) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was statistically equal to that (133.62 cm) obtained from N_{75}. The shortest plant (126.34 cm) was obtained when no nitrogen fertilizer was applied in soil (N_0) which was followed by that (129.11 cm) obtained from N_{50} treatment. The combined effect of liquid fertilization and nitrogen levels did not influence the height of plant significantly and it ranged from 122.67 cm in L_0N_0 to 136.79 cm in L_1N_{100}.

The results of the present study revealed that plant height at different days after transplanting was increased due to liquid fertilization compared to control. The results were supported by Khang (2011) and Shafiee *et al.* (2013) who reported that liquid 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 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).

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

Tillers hill^{-1} of Kataribogh rice at different days after transplanting as influenced by liquid fertilization and nitrogen levels is presented in Table 2. Table 2 shows that tillers hill^{-1} increased with the advancement of growth period from 40 to 70 days after transplanting but it became lower at 85 days after transplanting.

At 40 days after transplanting, liquid fertilization did not influence the number of tillers hill^{-1} significantly but it was influenced significantly by different levels of nitrogen fertilizer applied in soil. With the increment of nitrogen level tillers hill^{-1} was increased. The highest number of tillers hill^{-1} (13.23) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was statistically similar to that (12.89) and (12.28) obtained from N_{75} and N_{50}, respectively. The lowest number of tillers hill^{-1} (11.51) was recorded in N_0. The combined effect of liquid fertilization and nitrogen levels on the number of tillers hill^{-1} was not significant and it ranged from 10.67 to 13.56 among the treatments.

At 55 days after transplanting, tillers hill^{-1} was not influenced significantly by liquiid fertilization but it was influenced significantly by different levels of nitrogen fertilizer applied in soil. With the increment of nitrogen level tillers hill^{-1} was increased. The highest number of tillers hill^{-1} (18.34) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was statistically

Table 2. Effect of liquid fertilization and nitrogen levels on tillers $hill^{-1}$ of Kataribhog rice at different days after transplanting.

Treatment	Tillers $hill^{-1}$ at different days after transplantation (DAT)			
	40	55	70	85
L_0	12.14	15.31	16.36	14.70
L_1	12.81	16.72	17.59	15.75
Level of significance	NS	NS	NS	NS
N_0	11.51 b	12.94 c	13.95 c	12.44 c
N_{50}	12.28 ab	15.33 bc	16.16 b	14.45 b
N_{75}	12.89 ab	17.45 ab	18.52 a	16.67 a
N_{100}	13.23 a	18.34 a	19.28 a	17.37 a
Level of significance	**	**	**	**
L_0N_0	10.67	12.67	13.56	12.11
L_0N_{50}	12.23	14.56	15.45	13.78
L_0N_{75}	12.78	16.46	17.56	16.00
L_0N_{100}	12.89	17.56	18.89	16.89
L_1N_0	12.34	13.22	14.33	12.77
L_1N_{50}	12.34	16.11	16.88	15.11
L_1N_{75}	13.00	18.44	19.48	17.34
L_1N_{100}	13.56	19.12	19.67	17.78
Level of significance	NS	NS	NS	NS
CV (%)	5.49	5.46	4.12	4.12

Means followed by different letter(s) at specific days after transplanting in a column within the main effects and the interaction effect differed significantly by DMRT at $P \leq 5\%$).

L_0 = No liquid fertilization
L_1 = liquid 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
NS = Statistically not significant
* = 1% level of significance
** = 5% level of significance

similar to that (17.45) obtained from N_{75} treatment. The lowest number of tillers hill^{-1} (12.94) was recorded in N_0 treatment which was followed by N_{50} (15.33). The combined effect of liquid fertilization and nitrogen levels did not influence the number of tillers hill^{-1} significantly and it ranged from 12.67 to 19.12 among the treatments.

At 70 days after transplanting, tillers hill^{-1} was not influenced significantly by liquid fertilization but it was influenced significantly by different levels of nitrogen fertilizer applied in soil. With the increment of nitrogen level tillers hill^{-1} was increased. The highest number of tillers hill^{-1} (19.28) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was statistically equal to N_{75} (18.52). The lowest number of tillers hill^{-1} was recorded in N_0 (13.95) which was followed by N_{50} (16.16). The combined effect of liquid fertilization and nitrogen levels did not influence the number of tillers hill^{-1} significantly and it ranged from 13.56 to 19.67 within the various treatments.

At 85 days after transplanting, tillers hill^{-1} was not influenced significantly by liquid fertilization but it was influenced significantly by different levels of nitrogen fertilizer applied in soil. With the increment of nitrogen level tillers hill^{-1} was increased. The highest number of tillers hill^{-1} (17.37) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was statistically equal to that (16.67) obtained from N_{75} treatment. The lowest number of tillers hill^{-1} (12.44) was recorded in N_0 treatment which was followed by (14.45) in N_{50} treatment. The combined effect of liquid fertilization and nitrogen levels did not influence the number of tillers hill^{-1} significantly and it ranged from 12.11 in L_0N_0 to 17.78 in L_1N_{100}.

The findings of the present study revealed that tillers hill^{-1} was not influenced significantly at 40 to 85 DAT but it was increased considerably at 70 DAT due to liquid fertilization compared to control. On the other hand, tillers hill^{-1} was increased with the increment of nitrogen level at 40, 55, 70 and 85 DAT. Shafiee *et al.* (2013) did not resister 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.

4.1.3. Leaves hill^{-1} at different days after transplanting

Number of leaves hill^{-1} of Kataribhog rice at different days after transplanting as influenced by liquid fertilization and nitrogen levels is presented in Table 3. Table 3 shows that number of leaves hill^{-1} increased with the advancement of growth period from 40 to 70 days after transplanting but it became lower at 85 days after transplanting.

At 40 days after transplanting liquid fertilization with Magic Growth provided significantly greater number of leaves hill^{-1} (40.22) than that provided by no liquid fertilization treatment (34.75). The number of leaves hill^{-1} increased significantly with the increment of nitrogen levels. Among different nitrogen levels, the highest number of leaves hill^{-1} (41.56) was observed when 100% of the recommended nitrogen fertilizer was applied as urea (N_{100}) which was statistically similar to that obtained from N_{75} (38.78). The lowest number of leaves hill^{-1} (32.78) was obtained when no nitrogen fertilizer was applied in soil (N_0) which was followed by (36.72) in N_{50}. The interaction of liquid fertilization and nitrogen levels influence the number of leaves hill^{-1} significantly. The highest number of leaves hill^{-1} (43.23) was recorded in L_1N_{100} which was statistically equal to that (42.85) obtained from L_1N_{75} and followed by (40.78) in L_1N_{50}. The lowest number of leaves hill^{-1} (31.56) was obtained in L_0N_0 which was statistically similar to that (32.67) and (34.00) obtained from L_0N_{50} and L_1N_0 respectively. L_0N_{75} provided (34.89) number of leaves hill^{-1} which was followed by (39.89) obtained from L_0N_{100}.

At 55 days after transplanting liquid fertilization with Magic Growth provided significantly greater number of leaves hill^{-1} (68.04) than that provided by no liquid fertilization treatment (64.14). The number of leaves hill^{-1} increased significantly with the increment of nitrogen levels. Among different nitrogen levels, the highest number of leaves hill^{-1} (71.62) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}). The lowest number of leaves hill^{-1} (59.06) was obtained when no nitrogen fertilizer was applied in soil (N_0) which was followed by (65.23, 68.45) in N_{50} and N_{75} respectively. The interaction of liquid fertilization and nitrogen levels influence the number of leaves hill^{-1} significantly. The highest number of leaves hill^{-1} (72.56) was recorded

Table 3. Effect of liquid fertilization and nitrogen levels on leaves hill^{-1} of Kataribhog rice at different days after transplanting.

Treatment	Leaves hill^{-1} at different days after transplantation (DAT)			
	40	55	70	85
L_0	34.75 b	64.14 b	70.95 b	64.34 b
L_1	40.22 a	68.04 a	77.48 a	69.78 a
Level of significance	**	**	**	**
N_0	32.78 c	59.06 d	62.23 c	56.11 c
N_{50}	36.72 b	65.23 c	70.40 b	63.45 b
N_{75}	38.78 ab	68.45 b	81.51 a	74.17 a
N_{100}	41.56 a	71.62 a	82.73 a	74.51 a
Level of significance	**	**	**	**
L_0N_0	31.56 d	58.56 d	60.45 c	54.45 c
L_0N_{50}	32.67 cd	62.89 c	62.67 c	56.45 c
L_0N_{75}	34.89 c	64.34 c	79.23 b	73.00 ab
L_0N_{100}	39.89 b	70.78 a	81.45 ab	73.45 ab
L_1N_0	34.00 cd	59.56 d	64.01 c	57.78 c
L_1N_{50}	40.78 ab	67.56 b	78.12 b	70.44 b
L_1N_{75}	42.85 a	72.56 a	83.78 a	75.33 a
L_1N_{100}	43.23 a	72.46 a	84.01 a	75.57 a
Level of significance	**	**	**	**
CV (%)	2.74	1.54	2.21	2.33

Means followed by different letter(s) at specific days after transplanting in a column within the main effects and the interaction effect differed significantly by DMRT at $P \leq 5\%$.

L_0 = No liquid fertilization
L_1 = liquid 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
* = 1% level of significance
** = 5% level of significance

in L_1N_{75} which was statistically equal to that (72.46, 70.78 respectively) obtained from L_1N_{100} and L_0N_{100}. The lowest number of leaves hill^{-1} (58.56) was obtained in L_0N_0 which was statistically equal to that (59.56) obtained from L_1N_0. L_0N_{50} provided (62.89) number of leaves hill^{-1} which was statistically equal to that (64.34) obtained from L_0N_{75}. L_1N_{50} provided (67.56) number of leaves hill^{-1}.

At 70 days after transplanting liquid fertilization with Magic Growth provided significantly greater number of leaves hill^{-1} (77.48) than that provided by no liquid fertilization treatment (70.95). The number of leaves hill^{-1} increased significantly with the increment of nitrogen levels. Among different nitrogen levels, the highest number of leaves hill^{-1} (82.73) was observed when 100% of the recommended nitrogen fertilizer was applied as urea (N_{100}) which was statistically equal to those obtained from N_{75} (81.51). The lowest number of leaves hill^{-1} (62.23) was obtained when no nitrogen fertilizer was applied in soil (N_0) which was followed by (70.40) in N_{50}. The interaction of liquid fertilization and nitrogen levels influence the number of leaves hill^{-1} significantly. The highest number of leaves hill^{-1} (84.01) was recorded in L_1N_{100} which was statistically equal to that (83.78) obtained from L_1N_{75}. The lowest number of leaves hill^{-1} (60.45) was obtained in L_0N_0 which was statistically equal to that (62.67) and (64.01) obtained from L_0N_{50} and L_1N_0 respectively. L_0N_{75} provided (79.23) number of leaves hill^{-1} which was statistically equal to that (78.12) obtained from L_1N_{50} and followed by (81.45) obtained from L_0N_{100}. The increased number of leaves hill^{-1} due to liquid fertilization and increasing nitrogen dose might be due to increase in number of tillers hill^{-1} in the respective treatments.

At 85 days after transplanting liquid fertilization with magic growth provided significantly greater number of leaves hill^{-1} (69.78) than that provided by no liquid fertilization treatment (64.34). The number of leaves hill^{-1} increased significantly with the increment of nitrogen levels. Among different nitrogen levels, the highest number of leaves hill^{-1} (74.51) was observed when 100% of the recommended nitrogen fertilizer was applied as urea (N_{100}) which was statistically equal to those obtained from N_{75} (74.17). The lowest number of leaves hill^{-1} (56.11) was obtained when no nitrogen fertilizer was applied in soil (N_0) which was followed by (63.45) in $N_{50.}$ The interaction of liquid fertilization and nitrogen levels influence the number of leaves hill^{-1} significantly. The highest number of leaves hill^{-1} (75.57) was recorded in L_1N_{100} which was statistically equal to that (75.33) obtained from L_1N_{75}. The lowest number of leaves hill^{-1} (54.45) was obtained in L_0N_0 which was statistically equal to that (56.45) and (57.78) obtained from L_0N_{50} and L_1N_0 respectively. L_0N_{75} provided (73.00) number of leaves hill^{-1} which was statistically equal to that (73.45) obtained from L_1N_{100} and followed by (70.44) obtained from $L_1N_{50.}$ The increased number of leaves hill^{-1} due to liquid fertilization and increasing nitrogen dose might be due increase in number of tillers hill^{-1} in the respective treatments.

4.1.4. SPAD value of leaves at different days after transplanting

Leaf SPAD value of Kataribogh rice at different days after transplanting as influenced by liquid fertilization and nitrogen levels is presented in Table 4. It shows that SPAD value of leaf was increased with the advancement of time after transplanting.

At 50 days after transplanting, leaf SPAD value was influenced significantly by liquid fertilization and nitrogen levels as well as the interaction of liquid fertilization and nitrogen levels. Liquid fertilization with Magic Growth provided significantly greater leaf SPAD value (32.49) than that provided by no liquid fertilization treatment (28.22). With the increment of nitrogen level applied in soil leaf SPAD value was increased. The highest leaf SPAD value (34.87) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}).The lowest leaf SPAD value was recorded in N_0 (25.72). which was followed by (28.45, 32.40 respectively) obtained in N_{50} and $N_{75.}$ The combined effect of liquid fertilization and nitrogen levels influenced the leaf SPAD value significantly. The highest leaf SPAD value (36.9) was recorded in L_1N_{100} which was statistically equal to that (34.9) recorded in L_1N_{75} whereas the lowest leaf SPAD value (23.5) was recorded in $L_0N_{0.}$ L_0N_{50} provided leaf SPAD value (26.7) which was statistically similar to that (27.9) recorded in $L_1N_{0.}$ On the otherhand L_0N_{75} provided with leaf SPAD value (29.9) which was statistically similar to that (30.2) recorded in $L_1N_{50.}$ L_0N_{100} provided with leaf SPAD value (32.8)

At 70 days after transplanting, liquid fertilization influenced the leaf SPAD value significantly. Statistically greater leaf SPAD value (40.63) was recorded when magic growth was applied on leaf (L_1) compared to that (37.43) recorded in no liquid fertilization treatment (L_0). Leaf SPAD value was also influenced significantly by different levels of nitrogen fertilizer applied in soil. The highest leaf SPAD value (41.48.) was recorded in N_{100} which was statistically equal to that (41.38) recorded in N_{75}. The lowest leaf SPAD value (35.30) was observed when no nitrogen fertilizer was applied in soil (N_0) which was followed by that

Table 4. Effect of liquid fertilization and nitrogen levels on SPAD value at different days after transplanting of Kataribhog rice at different days after transplanting.

Treatment	SPAD value at different days after transplanting	
	50 DAT	70 DAT
L_0	28.22 b	37.43 b
L_1	32.49 a	40.63 a
Level of significance	**	**
N_0	25.72 d	35.30 c
N_{50}	28.45 c	38.02 b
N_{75}	32.40 b	41.38 a
N_{100}	34. 87 a	41.48 a
Level of significance	**	**
L_0N_0	23.5 f	32.9 e
L_0N_{50}	26.7 e	36.3 d
L_0N_{75}	29.9 cd	39.7 c
L_0N_{100}	32.8 b	40.8 bc
L_1N_0	27.9 de	37.7 d
L_1N_{50}	30.2 c	39.8 c
L_1N_{75}	34.9 a	43.0 a
L_1N_{100}	36.9 a	42.1 ab
Level of significance	*	**
CV (%)	2.65	1.48

Means followed by different letter(s) at specific days after transplanting in a column within the main effects and the interaction effect differed significantly by DMRT at $P \leq 5\%$.

L_0 = No liquid fertilization
L_1 = liquid 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
* = 1% level of significance
** = 5% level of significance

(38.02) observed in N_{50} treatment. The combined effect of liquid fertilization and nitrogen levels influenced the leaf SPAD value significantly. The highest leaf SPAD value (43.0) was recorded in L_1N_{75} which was statistically similar to that (42.1) recorded in L_1N_{100} whereas The lowest leaf SPAD value (32.9.) was recorded in $L_0N_{0.}$ L_0N_{50} provided leaf SPAD value (36.3) which was statistically equal to that (37.7) recorded in $L_1N_{0.}$ On the other hand L_0N_{75} provided with leaf SPAD value (39.7) which was statistically equal to that (39.8) recorded in $L_1N_{50.}$ Other treatments perform moderately.

The results of the present study revealed that SPAD value which indicates the leaf chlorophyll content was increased at different days after transplanting due to liquid 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.

4.1.5. Above ground biomass (g hill^{-1}) at different days after transplanting

Above ground biomass of Kataribogh rice at different days after transplanting as influenced by liquid fertilization and nitrogen levels is presented in figure 2. Figure 2 displays that the above ground biomass of Kataribogh rice was increased with the advancement of time after transplanting.

At 40 days after transplanting, liquid fertilization and nitrogen levels influenced the above ground biomass significantly. Statistically greater above ground biomass (11.75 g $hill^{-1}$) was recorded when magic growth was applied on leaf (L_1) compared to that (10.35 g $hill^{-1}$) recorded in no liquid fertilization treatment (L_0). With the increment of nitrogen level above ground biomass was increased. The highest above ground biomass (12.04 g $hill^{-1}$) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was statistically similar to that (11.04 g $hill^{-1}$) obtained from N_{75}. The lowest above ground biomass (10.49 g $hill^{-1}$) was observed in N_0 which was statistically equal to that (10.59 g $hill^{-1}$) obtained from N_{50}. The combined effect of liquid fertilization and nitrogen levels influenced the above ground biomass significantly. The highest above ground biomass (12.21 g $hill^{-1}$) was recorded in L_0N_{100} which was statistically equal to that (11.97 g $hill^{-1}$, 11.87 g $hill^{-1}$) obtained from L_1N_{100} and L_1N_{75} respectively. The lowest above ground biomass (9.32 g $hill^{-1}$) was obtained in L_0N_0 which was statistically equal to that (9.68 g $hill^{-1}$) obtained from L_0N_{50} and followed by (10.20 g $hill^{-1}$) in L_0N_{75}. Other treatments perform moderately.

At 55 days after transplanting, liquid fertilization, nitrogen levels and the combined effect of liquid fertilization and nitrogen levels influenced the above ground biomass significantly. With the increment of nitrogen level above ground biomass was increased both in liquid fertilization (L_1) and no liquid fertilization treatment (L_0). Among the treatment combinations, L_1N_{100} provided the highest above ground biomass (31.86 g $hill^{-1}$) which was statistically equal to that provided by L_1N_{75} (31.58 g $hill^{-1}$). L_0N_0 provided the lowest above ground

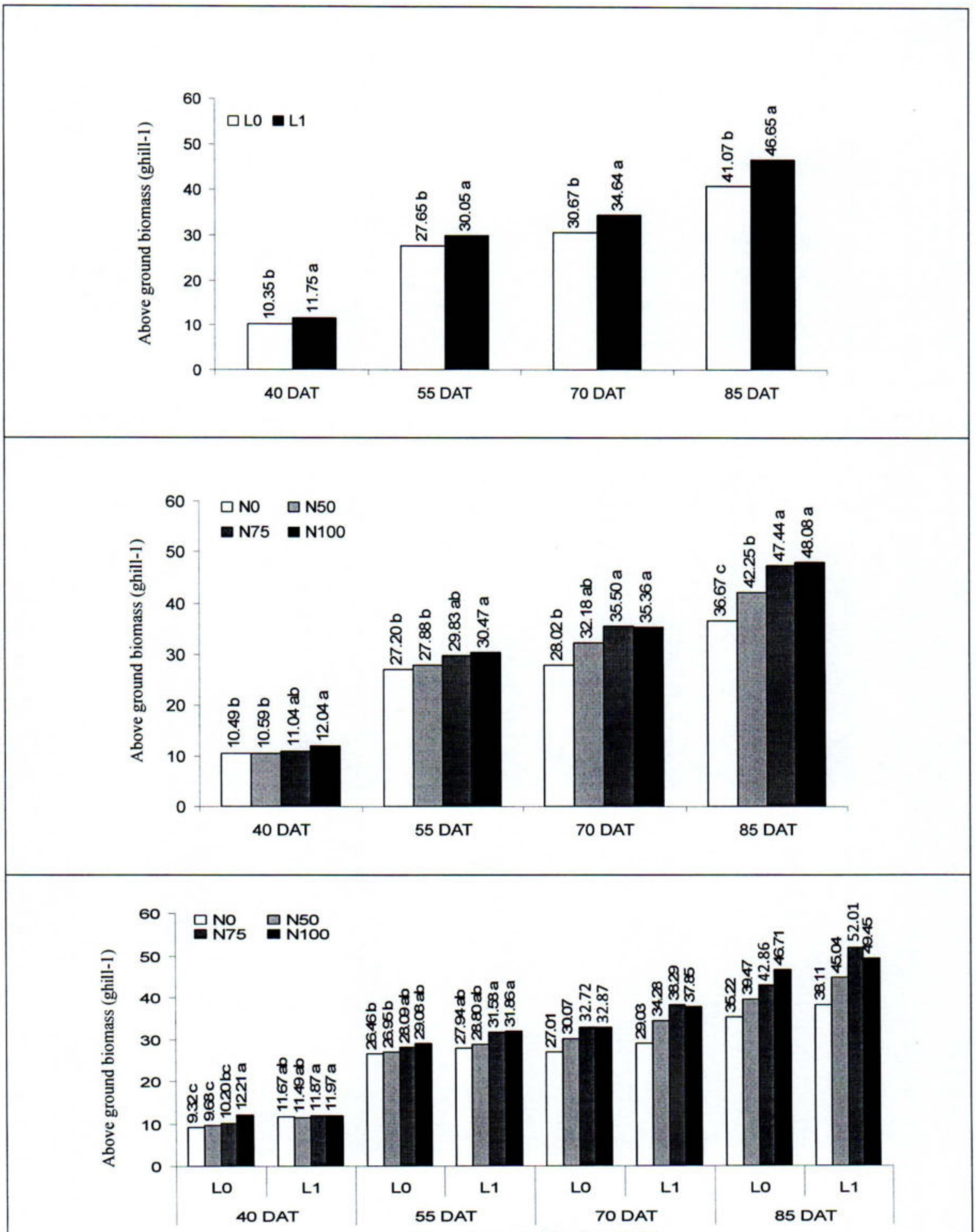

Fig. 2. Effect of liquid fertilization and nitrogen levels on above ground biomass of Kataribhog rice at different days after transplanting. *(Means followed by different letter(s) at specific days after transplanting within main effects and interaction effect differed significantly by DMRT at $P \leq 5\%$). Here, L_0 = No liquid fertilization, L_1 = liquid 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 and N_{100} = 100% of the recommended nitrogen fertilizer).*

biomass (26.46 g $hill^{-1}$) which was statistically equal to that provided by L_0N_{50} (26.95 g $hill^{-1}$). Other treatment combinations perform moderately.

At 70 days after transplanting, liquid fertilization and nitrogen levels influenced the above ground biomass significantly. Statistically greater above ground biomass (34.64 g $hill^{-1}$) was recorded when magic growth was applied on leaf (L_1) compared to that (30.67 g $hill^{-1}$) recorded in no liquid fertilization treatment (L_0). With the increment of nitrogen level above ground biomass was increased. The highest above ground biomass (35.50 g $hill^{-1}$) was observed when 75% of the recommended nitrogen fertilizer was applied as urea (N_{75}) which was statistically equal to that (35.36 g $hill^{-1}$) obtained from N_{100}. The lowest above ground biomass (28.02 g $hill^{-1}$) was observed in N_0 which was statistically similar to that (32.18 g $hill^{-1}$) obtained from N_{50}. The combined effect of liquid fertilization and nitrogen levels did not influence the above ground biomass significantly and it ranged from (27.01 g $hill^{-1}$) in L_0N_0 to (38.29 g $hill^{-1}$) in $L_1N_{75.}$

At 85 days after transplanting, liquid fertilization and nitrogen levels influenced the above ground biomass significantly. The highest above ground biomass (46.65 g $hill^{-1}$) was recorded when magic growth was applied on leaf (L_1) compared to that (41.07 g $hill^{-1}$) recorded in no liquid fertilization treatment (L_0). With the increment of nitrogen level above ground biomass was increased. The highest above ground biomass (48.08 g $hill^{-1}$) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was statistically equal to that (47.44 g $hill^{-1}$) obtained from N_{75}. The lowest above ground biomass (36.67 g $hill^{-1}$) was observed in N_0 which was statistically equal to that (42.25 g $hill^{-1}$) obtained from

N_{50}. The combined effect of liquid fertilization and nitrogen levels did not influence the above ground biomass significantly and it ranged from (35.22 g hill^{-1}) in L_0N_0 to (52.01 g hill^{-1}) in L_1N_{75}.

Regarding liquid fertilization treatment the results of the present study showed greater above ground biomass at 40, 55, 70 and 85 DAT due to liquid fertilization with magic growth compared to no liquid fertilization treatment. The results also indicated that at 40 and 55 DAT, the above ground biomass was increased with the increment of nitrogen level in both L_0 and L_1. At 70 DAT, the above ground biomass was increased with the increment of nitrogen level in no liquid fertilization treatment (L_0) but in liquid fertilization treatment (L_1), the above ground biomass was increased with the increment of nitrogen level up to N_{75} and there after decreased in $N_{100.}$ Improved rice growth due to liquid fertilization might be due to 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 plant height, tillers hill^{-1} and leaves 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. Yield and yield contributing characters

4.2.1. Plant height at harvest

Plant height of Kataribhog rice at harvest as influenced by liquid fertilization and nitrogen levels is presented in Table 5. Plant height was influenced significantly by liquid fertilization, nitrogen levels and combined effect of liquid fertilization and nitrogen levels. Statistically greater plant height (124.81 cm) was recorded when magic growth was applied on leaf (L_1) compared to that (120.81 cm) recorded in no liquid fertilization treatment (L_0). With the increment of nitrogen level plant height was increased. The tallest plant (125.55 cm) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was statistically equal to that recorded from N_{75} (125.58 cm). The shortest plant (118.60 cm) was recorded in N_0 treatment and followed by N_{50} treatment (121.51 cm). The combined effect of liquid fertilization and nitrogen levels also influenced the plant height significantly. The tallest plant (128.40 cm) was observed in L_1N_{75} which was statistically similar to that recorded from L_1N_{100} (127.31 cm). The shortest plant (117.36 cm) was recorded in L_0N_0 treatment and followed by L_0N_{50} treatment (119.33 cm). Other treatment combinations perform moderately. This result closely coincides with the result of Pramanik (2013) in BRRIdhan 28.

4.2.2. Panicle length

Panicle length of Kataribhog rice at harvest as influenced by liquid fertilization and nitrogen levels is presented in Table 5. Panicle length was influenced significantly by both nitrogen levels and liquid fertilization. Statistically greater panicle length (20.94 cm) was recorded when magic growth was applied on leaf (L_1) compared to that (20.57 cm) recorded in no liquid fertilization treatment (L_0).With the increment of nitrogen level panicle length was increased. The longest panicle (21.68 cm) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}) which was statistically similar to those (21.12 cm, 20.27 cm) recorded from N_{75} and N_{50} respectively. The shortest panicle (13.22 cm) was recorded in N_0 treatment. The combined effect of liquid fertilization and nitrogen levels did not influence the length of panicle significantly and it ranged from 19.87 cm in L_0N_0 to 22.07 cm in $L_1N_{100.}$ This result closely coincides with the result of Pramanik (2013) in BRRIdhan 28.

Table 5. Effect of liquid fertilization and nitrogen levels on plant height, panicle length, tillers hill^{-1} and effective tiller hill^{-1} of Kataribhog rice at harvest.

Treatment	Plant height (cm)	Panicle length (cm)	Tillers hill^{-1}	Panicle hill^{-1}
L_0	120.81 b	20.57 b	15.58 b	12.59 b
L_1	124.81 a	20.94 a	16.44 a	13.93 a
Level of significance	*	**	**	*
N_0	118.60 b	13.22 b	14.80 a	12.53 a
N_{50}	121.51 ab	20.278 ab	15.51 a	13.13 a
N_{75}	125.58 a	21.12 ab	16.41 a	13.72 a
N_{100}	125.55 a	21.68 a	16.55 a	13.66 a
Level of significance	**	**	NS	NS
L_0N_0	117.36 e	19.87	13.73	11.72 c
L_0N_{50}	119.33 de	20.50	14.67	12.57 bc
L_0N_{75}	122.76 cd	20.60	15.73	12.85 bc
L_0N_{100}	123.78 bc	21.30	16.60	13.22 abc
L_1N_0	119.84 cde	19.97	15.87	13.33 abc
L_1N_{50}	123.69 bc	20.07	16.35	13.68 ab
L_1N_{75}	128.40 a	21.64	17.08	14.60 a
L_1N_{100}	127.31 ab	22.07	16.45	14.10 ab
Level of significance	**	NS	NS	**
CV (%)	1.23	2.18	6.07	4.47

Means followed by different letter(s) at specific days after transplanting in a column within the main effects and the interaction effect differed significantly by DMRT at $P \leq 5\%$.

L_0 = No liquid fertilization
L_1 = liquid 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
NS = Statistically not significant
* = 1% level of significance
** = 5% level of significance

4.2.3. Tillers hill^{-1} at harvest

Number of tillers hill^{-1} of Kataribhog rice at harvest as influenced by liquid fertilization and nitrogen levels is presented in Table 5. Number of tillers hill^{-1} was influenced significantly by liquid fertilization and nitrogen levels. Statistically higher tillers hill^{-1} (16.44) was recorded when Magic Growth was applied on leaf (L_1) compared to that (15.58) recorded in no liquid fertilization treatment (L_0). With the increment of nitrogen level tillers hill^{-1} was not increased significantly and it ranged from 14.80 to 16.55 within the various treatments. The combined effect of liquid fertilization and nitrogen levels did not influence the number of tillers hill^{-1} significantly and it ranged from 13.73 to 17.08 among the treatments. This result closely coincides with the result of Pramanik (2013) in BRRIdhan 28.

4.2.4. Panicle hill^{-1}

Number of effective tillers hill^{-1} of Kataribhog rice at harvest as influenced by liquid fertilization and nitrogen levels is presented in Table 5. Liquid fertilization, nitrogen levels and the combined effect of liquid fertilization and nitrogen levels showed significant influence on the number of panicle hill^{-1} but the levels of nitrogen did not influenced significantly on panicle hill^{-1}. The number of panicle hill^{-1} was increased in liquid fertilization treatment (L_1) compared to that no liquid fertilization treatment (L_0). The number of panicle hill^{-1} was not influenced significantly by nitrogen levels. Among the treatment combinations, L_1N_{75} provided the highest number of panicle hill^{-1} (14.60) which was statistically at par with those provided by L_1N_{100} (14.10) and L_1N_{50} (13.68). L_0N_0 provided the lowest number of panicle hill^{-1} (11.72) which was similar to those provided by L_0N_{50} (12.57) and L_0 N_{75} (12.85) The other treatment combination L_0N_{100} and L_1N_0 provided the statistically equal number of panicle hill^{-1} (13.22) and (13.33) respectively. This result closely coincides with the result of Pramanik (2013) in BRRIdhan 28.

4.2.5. Spikelets panicle^{-1}

Spiklets panicle^{-1} of Kataribhog rice at harvest as influenced by liquid fertilization and nitrogen levels is presented in Table 6. Number of spikelets panicle^{-1} was not influenced significantly by liquid fertilization but influenced significantly by nitrogen levels. With the increment of nitrogen level number of spiklets panicle^{-1} was increased. The highest number of spiklets panicle^{-1} (137.10) was observed when recommended nitrogen fertilizer was applied as urea (N_{100}). The lowest number of spiklets panicle^{-1} (108.67) was recorded in N_0 treatment which was statistically equal to those recorded from N_{50} (114.98). The other treatment combination N_{75} performs moderately.The combined effect of liquid fertilization and nitrogen levels did not influence the number of spiklets panicle^{-1} significantly and it ranged from 107.65 in L_0N_0 to 137.29 in L_1N_{100}. This result closely coincides with the result of Pramanik (2013) in BRRIdhan 28.

Table 6. Effect of liquid fertilization and nitrogen levels on spikelets panicle^{-1}, grains panicle^{-1} and 1000-grains weight of Kataribhog rice at harvest.

Treatment	Spikelets panicle^{-1}	Grains panicle^{-1}	1000-grains weight
L_0	120.59	96.66 b	12.10 b
L_1	122.95	103.93 a	12.88 a
Level of significance	NS	**	**
N_0	108.67 c	91.27 b	11.50 b
N_{50}	114.98 c	95.52 b	12.49 ab
N_{75}	126.38 b	106.47 a	12.95 a
N_{100}	137.10 a	107.92 a	12.98 a
Level of significance	**	**	**
L_0N_0	107.65	89.00 e	11.25
L_0N_{50}	113.51	91.40 e	12.21
L_0N_{75}	124.36	98.42 cd	12.15
L_0N_{100}	136.85	107.81 b	12.64
L_1N_0	109.69	93.53 de	11.75
L_1N_{50}	116.45	99.64 c	12.76
L_1N_{75}	128.39	114.52 a	13.67
L_1N_{100}	137.29	108.03 b	13.31
Level of significance	NS	**	NS
CV (%)	1.85	2.15	2.65

Means followed by different letter(s) at specific days after transplanting in a column within the main effects and the interaction effect differed significantly by DMRT at $P \leq 5\%$.

L_0 = No liquid fertilization
L_1 = liquid 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
NS = Statistically not significant
** = 5% level of significance

4.2.6. Grains panicle^{-1}

Grains panicle^{-1} of Kataribhog rice at harvest as influenced by liquid fertilization and nitrogen levels is presented in Table 6. Number of grains panicle^{-1} was influenced significantly by liquid fertilization, nitrogen levels and the combined effect of liquid fertilization and nitrogen levels. The number of grains panicle^{-1} was increased in liquid fertilization treatment (L_1) compared to that no liquid fertilization treatment (L_0). The number of grains panicle^{-1} was increased with the increment of nitrogen level up to N_{100}. The highest number of grains panicle^{-1} (107.92) recorded from N_{100} which was statistically equal to that (106.47) obtained from N_{75}. The lowest number of grains panicle^{-1} (91.27) recorded from N_0 which was statistically equal to that (95.52) obtained from N_{50}. Among the treatment combinations, L_1N_{75} provided the highest number of grains panicle^{-1} (114.52). L_1N_{100} provided number of grains panicle^{-1} (108.03) provided which was statistically equal to that (107.81) recorded from L_0N_{100}. L_0N_0 provided the lowest number of grains panicle^{-1} (89.00) which was statistically equal to that (91.40) recorded from L_0N_{50}. Other treatment combinations provided moderate number of grains panicle^{-1}. This result closely coincides with the result of Pramanik (2013) in BRRIdhan 28.

4.2.7. 1000-grain weight

Thousand grain weight of Kataribhog rice as influenced by liquid fertilization and nitrogen levels is presented in Table 6. 1000-grain weight of Kataribhog rice was influenced significantly by liquid fertilization and nitrogen levels. 1000-grain weight was increased in liquid fertilization treatment (L_1) compared to that no liquid fertilization treatment (L_0). 1000-grain weight was increased with the increment of nitrogen level up to $N_{100.}$ The highest 1000-grain weight (12.98) was recorded in N_{100} which was statistically equal to that (12.95) obtained from N_{75}. The lowest 1000-grain weight (11.50) was recorded in N_0 which was statistically similar to that (12.49) obtained from N_{50}.The combined effect of liquid fertilization and nitrogen levels did not influence the 1000-grain weight significantly and it ranged from 11.25 in L_0N_0 to 13.67 in L_1N_{75}. This result closely coincides with the result of Pramanik (2013) in BRRIdhan 28.

4.2.8. Grain yield

Grain yield of Kataribhog rice as influenced by liquid fertilization and nitrogen levels is presented in Table 7 and Fig. 3. Grain yield was not influenced significantly by liquid fertilization but there found the significant variation due to nirogen levels and the interaction effect of liquid fertilization and nitrogen levels. In general, liquid fertilization (L_1) treatment provided greater grain yield compared to no liquid fertilization treatment (L_o). Grain yield was increased with the increment of nitrogen level up to N_{75} and there after decreased in $N_{100.}$ The highest grain yield (2.48 t ha^{-1}) was recorded in N_{75} which was statistically equal to N_{100} and N_{50} (2.46 and 2.30 t ha^{-1}, respectively). The lowest grain yield (1.93 t ha^{-1}) was found in $N_{0.}$ Among the treatment combinations, L_1N_{75} provided the highest grain yield (2.58 t ha^{-1}) which was statistically similar to that provided by L_1N_{100} (2.54 t ha^{-1}), L_0N_{100} (2.40 t ha^{-1})

Table 7. Effect of liquid fertilization and nitrogen levels on grain yield (t ha^{-1}) and straw yield (t ha^{-1}) of Kataribhog rice at harvest

Treatment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
L_0	2.23	3.84
L_1	2.37	4.38
Level of significance	NS	NS
N_0	1.93 b	3.55 b
N_{50}	2.30 a	4.14 ab
N_{75}	2.48 a	4.24 ab
N_{100}	2.46 a	4.50 a
Level of significance	**	**
L_0N_0	1.84 c	3.56 b
L_0N_{50}	2.28 b	3.65 b
L_0N_{75}	2.38 ab	3.75 b
L_0N_{100}	2.40 ab	4.40 a
L_1N_0	2.02 c	3.53 b
L_1N_{50}	2.32 b	4.62 a
L_1N_{75}	2.58 a	4.74 a
L_1N_{100}	2.54 ab	4.60 a
Level of significance	**	**
CV (%)	4.14	5.56

Means followed by different letter(s) at specific days after transplanting in a column within the main effects and the interaction effect differed significantly by DMRT at $P \leq 5\%$.

L_0 = No liquid fertilization
L_1 = liquid 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
NS = Statistically not significant
** = 5% level of significance

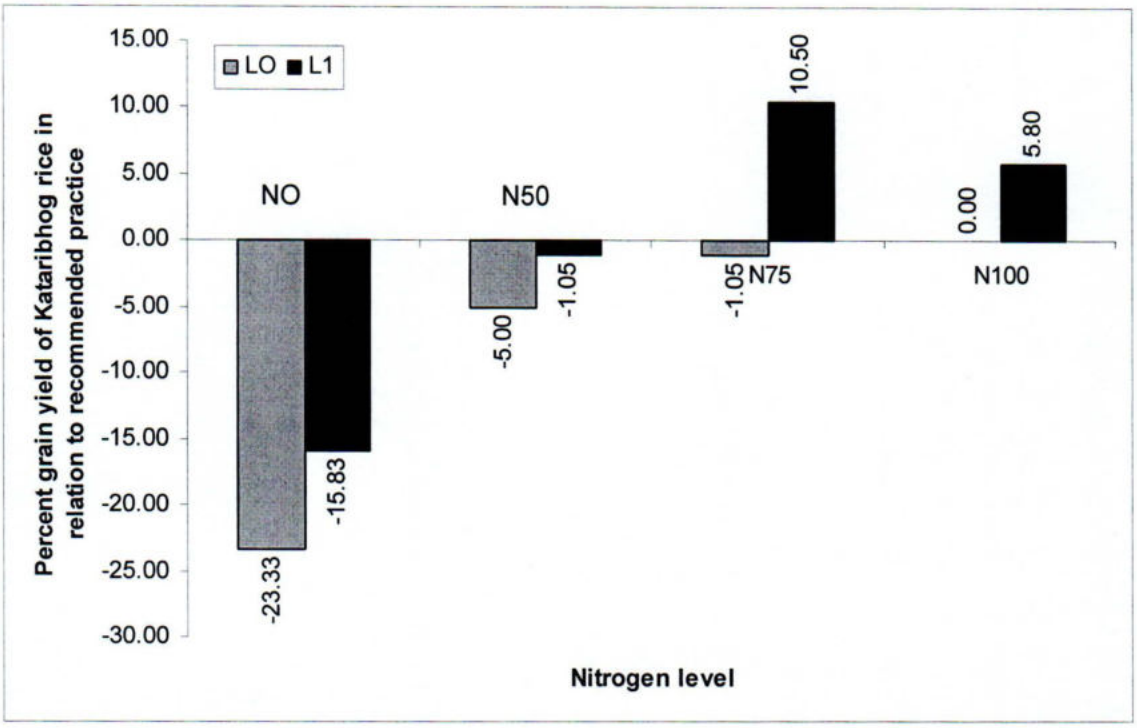

Fig. 3. Percent grain yield of Kataribhog in relation to recommended practice as influenced by liquid fertilization and nitrogen levels. *(Here, L_0 = No liquid fertilization, L_1 = liquid fertilization with Magic Growth, N_0 = No nitrogen fertilizer, N_{50} = 50% of the recommended nitrogen fertilizer, N_{75} = 75% of the recommended nitrogen fertilizer and N_{100} = 100% of the recommended nitrogen fertilizer).*

and L_0N_{75} (2.38 t ha^{-1}). L_0N_0 provided statistically the lowest grain yield (1.84 t ha^{-1}) which was statistically equal to that provided by L_1N_0 (2.02 t ha^{-1}). Other treatment combinations provided moderate grain yield. Increased grain yield due to different treatment combinations was mainly contributed by increased effective tillers $hill^{-1}$, grains $panicle^{-1}$ and thousand grains weight of the respective treatment combinations.

The results presented in Figure 3 revealed that liquid fertilization with magic growth along with 50% of the recommended nitrogen fertilizer i.e., L_1N_{50} provided only 1.05% lesser grain yield provided by recommended nitrogen fertilizer treatment only (L_0N_{100}). In that case, 50% of the recommended nitrogen fertilizer can be saved with minimum yield reduction. L_1N_{75} treatment combination can increased 10.50% grain yield compared to recommended practice (L_0N_{100}) with a saving of 25% of the recommended nitrogen fertilizer per hectare of land. Liquid fertilization along with recommended nitrogen fertilizer (L_1N_{100}) can increased 5.80% grain yield compared to recommended practice (L_0N_{100}).

4.2.9. Straw yield

Straw yield of Kataribhog rice at harvest as influenced by liquid fertilization and nitrogen levels is presented in Table 7. Straw yield was not influenced significantly by liquid fertilization but influenced significantly by nitrogen levels and the interaction effect of liquid fertilization and nitrogen levels. The highest straw yield (4.38 t ha^{-1}) was obtained in liquid fertilization treatment (L_1) compared to that no liquid fertilization treatment (L_0) (3.84 t ha^{-1}). With the increment of nitrogen level straw yield was increased. The highest straw yield (4.50 t ha^{-1}) was obtained when recommended nitrogen fertilizer was applied as urea (N_{100}) which was statistically similar to those recorded in N_{75} (4.24 t ha^{-1}) and N_{50} (4.14 t ha^{-1}). The lowest straw yield (3.55 t ha^{-1}) was recorded in N_0 treatment. The combined effect of liquid fertilization and nitrogen levels also influenced the straw yield significantly. Among the treatment combinations, L_1N_{75} provided the highest straw yield (4.74 t ha^{-1}) which was statistically equal to those provided by L_1N_{100} (4.60 t ha^{-1}) and L_1N_{50} (4.62 t ha^{-1}) and L_0N_{100} (4.40 t ha^{-1}) respectively. L_0N_0 provided statistically the lowest grain yield (3.56 t ha^{-1}) which was statistically equal to those provided by L_0N_{50} (3.65 t ha^{-1}), L_0N_{75} (3.75 t ha^{-1}) and L_1N_0 (3.53 t ha^{-1}) respectively. Increased grain yield due to different treatment combinations was mainly contributed by increased effective tillers $hill^{-1}$, grains $panicle^{-1}$ and thousand grains weight of the respective treatment combinations.

Regarding to the effect of liquid fertilization and nitrogen fertilizer levels on grain yield and its attributes the results of the present study indicated that liquid fertilization with magic growth and increasing nitrogen fertilizer levels significantly affected effective tillers $hill^{-1}$, grains $panicle^{-1}$, thousand grains weight grain yield and straw yield of Kataribhog rice liquid fertilization and increasing nitrogen fertilizer dose might improve rice growth, photosynthesis rate, spread 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 Pramanik (2013) 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.

CHAPTER V

SUMMARY AND CONCLUSION

Nitrogen fertilizer is more urgent for security rice production. 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. Liquid fertilization in rice might reduce the use of chemical fertilizer specially the nitrogenous fertilizer in soil.

An experiment was conducted to find out the effect of liquid fertilization (Magic Growth) on performance of Kataribhog rice and to calculate how much urea can be saved by liquid fertilization of Magic Growth without any yield reduction at the research field and laboratory of Crop Physiology and Ecology department, Hajee Mohammad Danesh Science and Technology University, Dinajpur during the period of August 2013 to January 2014. The experiment was conducted in a split plot design with three replications. Two levels of liquid fertilization of Magic Growth (no liquid fertilization and liquid fertilization with Magic Growth) 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. The total number of plots was 24 ($3 \times 2 \times 4$) and the unit plot size was 25 m^2 (5m x 5m) having a plot to plot and block to block distance of 1.0 m and 1.5 m, respectively. 30 days old seedlings of rice (Variety-Kataribhog) were transplanted on 30.08.2013 maintaining a line to line and hill to hill distance 20 cm. Three healthy seedlings were transplanted per hill. Observations were made on plant height, tillers $hill^{-1}$, leaves $hill^{-1}$ and above ground biomass hill^{-1} were recorded at 40, 55, 70 and 85 DAT. SPAD value of youngest fully expanded leaf at 50 and 70 days after transplanting and plant height, tillers hill^{-1}, panicle hill^{-1}, grains panicle^{-1}, 1000- grains weight, grain and straw yield at harvest.

Liquid fertilization and nitrogen levels influenced the plant height significantly but they did not interacted significantly to influence the height of plant at different days after transplanting. Plant height was increased due to liquid fertilization compared to control. Increasing nitrogen levels also increased the plant height at different days after transplanting. Tillers hill^{-1} was not influenced significantly by liquid fertilization and the interaction of liquid fertilization and nitrogen level at 40, 55, 70 and 85 DAT but it was increased considerably at 70 DAT due to liquid fertilization compared to control and thereafter it was decline. On the other hand, tillers hill^{-1} was increased with the increment of nitrogen level at 40, 55 70 and 80 DAT. Number of leaves hill^{-1} of Kataribhog rice was considerably increased up to 70 DAT and then decreased at 85 DAT was influenced significantly by liquid fertilization and nitrogen levels. Liquid fertilization with Magic Growth provided significantly greater number of leaves hill^{-1} than that provided by no liquid fertilization treatment. Among different nitrogen levels, different doses of nitrogen fertilizer provided significantly greater number of leaves hill^{-1} compared to no nitrogen fertilizer application. Leaf SPAD value which indicates the leaf chlorophyll content was influenced significantly by liquid fertilization and nitrogen levels and the interaction of liquid fertilization and nitrogen levels. Liquid fertilization with Magic Growth provided significantly greater leaf SPAD value than that provided by no liquid fertilization treatment. Leaf SPAD value was also increased with the increment of nitrogen level applied in soil at 50 and 70 days after transplanting. Liquid fertilization with Magic Growth showed greater above ground biomass at 40, 55, 70 and 85 DAT compared to no liquid fertilization treatment. The above ground biomass was increased with the increment of nitrogen level in both L_0 and L_1 at 40 55, 70 and 85 DAT.

Regarding to the effect of liquid fertilization and nitrogen fertilizer levels on grain yield and its attributes the results of the present study indicated that liquid fertilization with Magic Growth and increasing nitrogen fertilizer levels significantly affected panicle hill^{-1}, spikelets panicle^{-1}, grains panicle^{-1}, thousand grains weight, grain yield and straw yield of Kataribhog. In general, liquid fertilization (L_1) treatment provided greater grain yield compared to no liquid fertilization treatment (L_0) in all nitrogen levels. On the other hand, with the increment of nitrogen level the grain yield was increased in no liquid fertilization treatment (L_0) up to N_{100} but in liquid fertilization treatment (L_1), grain yield was increased with the increment of nitrogen level up to N_{75} and there after decreased in N_{100}.

Liquid fertilization with Magic Growth along with 50% of the recommended nitrogen fertilizer (L_1N_{50}) provided 1.05% less grain yield provided by recommended nitrogen fertilizer treatment (L_0N_{100}). In that case, 50% of the recommended nitrogen fertilizer can be saved with minor yield reduction. L_1N_{75} treatment combination can increased 10.50% more grain yield compared to recommended practice (L_0N_{100}) with a saving of 25% of the recommended nitrogen fertilizer per hectare of land. Liquid fertilization along with recommended nitrogen fertilizer (L_1N_{100}) can increased 5.80% more grain yield compared to recommended practice (L_0N_{100}).

From the overall results it may be concluded that-

- Liquid 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, 70 and 85 DAT compared to no liquid fertilization treatment. All the parameters were also increased with the increment of nitrogen level.
- Liquid fertilization and increasing nitrogen fertilizer levels significantly influenced the grain yield of Kataribhog rice. Increased grain yield due to different treatment combinations was mainly contributed by increased panicle hill^{-1}, grains panicle^{-1} and thousand grains weight in respective treatment combinations.
- Liquid fertilization with Magic Growth along with 50% of the recommended nitrogen fertilizer saved 50% of the recommended nitrogen fertilizer with minimum (1.05%) yield reduction compared to recommended practice(L_0N_{100}). Liquid fertilization with Magic Growth along with 75% of the recommended nitrogen fertilizer increased 10.5% grain yield with a saving of 25% of the recommended nitrogen fertilizer whereas liquid fertilization along with 100% recommended nitrogen fertilizer increased 5.80% grain yield compared to recommended practice alone.

REFERENCES

Abd El-Razik, M. A. 2003. Effect of foliar application of urea on yield and seed quality of some rice varieties grown in salinity soils. J. Agric. Sci. Mansoura Univ. 22: 7571-7580.

Alam S. S., A. Z. M. Moslehuddin, M. R. Islam and A. M. Kamal. 2010. Soil and foliar application of nitrogen for Boro rice (BRRIdhan 29). J. Bangladesh Agril. Univ. 8(2): 199–202.

Ali A., I.A. Mahmood, F. Hussain and M.Salim. 2007. Response of rice to soil and foliar application of K_2SO_4 fertilizer. Sarhad J. Agric. Vol. 23 (4): 847-850.

Ali A., M. Salim, M.S. Zia, I.A. Mahmood and A. Shahzad. 2005. Performance of rice as affected by foliar application of different k fertilizer sources. Pak. J. Agri. Sci. 42: 38-41.

Asenjo M. C., J. L. Gonzalez and J. M. Maldonado. 2000. Influence of humic extracts on germination and growth of ryegrass. Comm Soil Sci Plant Anal. 31: 101–114.

BBS (Bangladesh Bureau of Statistics), 2008. Bangladesh Bureau of Statistics, Agriculture wing [online]. *In: http://www.bbs.gov.bd* (last update 2008, accessed 18 July 2013.) People's Republic of Bangladesh, Dhaka.

Bethke P. C. and M. C. Drew. 1991. Stomatal and nonstomatal components to inhibition of photosynthesis in leaves of *Capsicum annuum* during progressive exposure to NaCl salinity. Plant Physiol. 99:219–226.

Chopra N. K. and N. Chopra. 2000. Effect of row spacing and N level on growth, yield and seed quality of scented rice (*Oryza sativa*) under transplanted conditions. Indian J Agron. 45(2): 304-308.

Chopra N. K. and N. Chopra. 2004. Seed yield and quality of "Pusa 44" rice (*Oryza sativa L*) as influenced by nitrogen fertilizer and raw spacing. Indian J Agric Sci . 74(3): 144-146.

De Datta, S.K. 1978. Fertilizer Management for Efficient Use in Wetland Rice Soils. *In* F.N. Ponnamperuma, ed. *Soil and Rice*. p. 671-670. Intl. Rice Res. Inst. Los Banos, Philippines.

El-Kalla, S. E., A. T. El-Kassaby, A. A. Kandil, A. N. Attia and I. O. El-Sayed. 1988. Growth and yield of rice cultivar IR 50 as affected by nitrogen fertilizer and blue green algae treatments. J. Agric. Sci. Mansoura Univ. 13: 623-628.

Fang Y., L. Wang, Z. Xin, L. Zhao, X. An and Q. Hu. 2008. Effect of foliar application of zinc, selenium, and iron fertilizers on nutrients concentration and yield of rice grain in China. J Agr Food Chem. 56:2079–2084.

Finck A. 1982. Fertilizers and Fertilization. Verlag Chimie GmbH, Weinheim, Germany.

Flinn J. C. and S. K. De Datta. 1984. Trend in irrigated rice yield under intensive cropping at Philippine Research Station. Field Crops Res. 9: 1-15.

Flinn J. C., S. K. De Datta and E. Labadan. 1982. An analysis of long term rice yield in a wet land soil. Field Crops Res. 5: 201-216.

Ghildyal B. P. 1978. Effect of method of planting and puddling on soil properties and rice growth. Soil and Rice. IRRI, Philippines. pp. 317-336.

Guenis A., M. Alpaslan and A. Unal. 2003. Effects of boron fertilization on the yield and some yield components of bread and durum wheat. Turk J Agric. 27: 329-335.

Haq M. U. and A. P. Mallarino. 2000. Soybean yield and nutrient composition as affected by early-season foliar fertilization. J. Agron. 92:16–24.

Jamal, Z., Hamayun, M., Ahmad, N. and Chaudhary, M.F. 2006. Effect of soil and foliar application of different concentrations of NPK and foliar application of $(NH_4)_2SO_4$ on different parameters in wheat. J. Agron., 5(2): 251-256.

Jayaraj T. and B. Chandrasekharan. 1997. Foliar fertilization to enhance seed yield and quality in rice. Seed Res. 25: 50-52.

Kenbaev B. and B. Sade. 2002. Response of field grown barley cultivars grown on zinc-deficient soil to zinc application. Comm. Soil Sci Plant Anal. 33:533–544.

Khang V.T. 2011. Fulvic foliar fertilizer impact on growth of rice and radish at first stage. Omonrice 18: 144-148.

Lidon F. C. and M. G. Teixerira. 2000. Rice tolerance to excess Mn: Implication in the chloroplast lamellae and synthesis of a novel Mn protein. Plant Physiol. Biochem. 38:969–978.

Lin X. and D. F. Zhu. 2000. Effects of regent on growth and yield in rice. Acta. Agric Zhejiangensis. 12: 70-73.

Manivannan V., K. Thanunathan, V. Mayavaramban, N. Ramanathan and R. Singaravel. 2001. Foliar application of nutrients a low cost technology for yield maximization in rice fallow pulse. Res. Crops 2: 289-292.

Nagarayan R. 1999. Improving P nutrition on acid sulphate soils of the Mekong Delta. INMnet Bulletin 07/1999. p. 12. International Rice Research Institute, Philippines.

Narang R. S., S. S. Mahal, B. Seema, K. S. Gosal and S. Bedi. 1997. Response of rice and wheat to K-fertilization under maximum yield research strategies. Envir. Eco. 15: 474-477.

Neelam K. C. and N. Chopra. 2000. Effect of row spacing and nitrogen level on growth, yield and seed quality of rice (*Oryza sativa*) under transplanted conditions. Indian J. Agron. 45: 304-308.

Planning Division, 1997. Final Report (Agriculture and Fisheries). Bangladesh-Northwest Region Development and Investment Study. Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka.

Pramanik A. H. M. M. Foliar fertilization on BRRIdhan 28 to reduce soil application of nitrogenous fertilizer. 2013. MS thesis. Department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200. P 60.

Ramanathan S., P. Stalin, T. Thilagavathi, K. Nata Kajan and Y. Ankorion. 2002. Foliar nutrition of Peak on rice. 17th WCSS, 14-21 August 2002, Thailand, pp: 2231-2242.

Ronen Y, J. Golovaty and E. Barak. 2011. Foliar Nutrition: an Extra Bonus for the rice Grower. http://www.haifa-group.com/knowledge_center/research/an_ effective_ fertilization_ of_ rice_ method. aspx #sthash. dnrBcKFN.dpuf

Sage R. F. and C. D. Reid. 1994. Photosynthetic response mechanism to environmental change in C3 plants. In: Plant-Environmental Interactions, R. E. Wilkinson (Ed.), Marcel Dekker, New York, pp. 413–499.

Shafiee M. I., A. N. Boycea, M. M. Khandakera, J. M. Saadb, T. A. Aziz, M. S. Mispana, M. S. M. Anuara and B. H. Bakara. 2013. Pilot Studies on Rice Yield Enhancement with Foliar Application of SBAJA in Sungai Besar, Selangor, Malaysia. Life Sci. J. 10(1): 329-335.

Sharief A. E., S. E. El-Kalla, A. T. El-Kassaby, M. H. Ghonema and G. M. Q. Abdo. 2006. Effect of bio-chemical fertilization and times of nutrient foliar application on growth, yield and yield components of rice. J. Agron. 5(2):212-219.

Shayganya J, Peivandy N, and Ghasemi S. 2011. Increased yield of direct seeded rice (*Oryza sativa* L.) by foliar fertilization through multicomponent fertilizers. *Archives of* Agronomy and Soil Science. pp. 1-8.

Shivay Y. S. and S. Singh. 2003. Effect of planting geometry and nitrogen level on growth, yield and nitrogen use efficiency of scented hybrid rice (*Oryza sativa*). Indian J. Agron. 48: 42-44.

Singh V. P. and V. K. Singh. 2000. Effect of sowing date and nitrogen level on the productivity of spring sown rice (*Oryza sativa*) varieties in low hills of Uttaranchal. Indian J. Agron. 45: 560-563.

Soylu S., B. Sade, A. Topal, N. Akgun and S. Gezgin. 2005. Responses of irrigated durum and bread wheat cultivars to boron application in low boron calcareous soil. Turk. J. Agr. 29:275–286.

Sultan N., T. Ikeda and M. A. Kashem. 2001. Effects of foliar spray of nutrient on photosynthesis, dry matter accumulation and yield in sea water stress rice. Environ. Exp. Biol. 46:129-140.

Tejada M. and J. L. Gonzalez. 2004. Effects of foliar application of a by product of the two-step olive oil mill process on rice yield. Europ. J. Agron. 21:31-40.

APPENDICES

Appendix I: Weather data for growing season of wheat, August 2013 to January 2014

Month	Relative humidity (%)	Temperature		Total rainfall (mm)
		Minimum (°C)	Maximum (°C)	
August	86	26.0	32.0	406.0
September	84	25.2	33.1	207.0
October	86	22.0	29.7	269.0
November	88	15.5	29.0	0.0
December	88	11.9	24.8	0.0
January	87	10.5	22.0	0.0

Source: Wheat Research Centre, Dinajpur