RESPONSE OF BRRI dhan29 TO DIFFERENT DOSES OF NITROGEN AND LEAF CUTTING

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CERTIFICATE

*This is to certify that the thesis entitled "**RESPONSE OF BRRI dhan29 TO DIFFERENT DOSES OF NITROGEN AND LEAF CUTTING**" submitted to the Department of Agricultural Botany, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTERS OF SCIENCE (MS)**in Agricultural Botany, embodies the result of a piece of bonafide research work carried out by **FARIA ISLAM**, Registration No.**19-10023**under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Date:

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DEDICATED TO

MY

BELOVED PARENTS

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The Author

RESPONSE OF BRRI dhan29 TO DIFFERENT DOSES OF NITROGEN AND LEAF CUTTING

ABSTRACT

An experiment was conducted during December 2020 to May 2021, at the research field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to examine the response of BRRI dhan29 to different doses of nitrogen and leaf cutting. The experiment consisted of two factors, and split plot design was followed.Factor A: Different nitrogen doses (Three) *viz:*N_1 = 138 kg nitrogen ha^{-1}, N_2= 163 kg nitrogen ha^{-1}, N_3=183 kg nitrogen ha^{-1} and Factor B: Leaf cutting at different days after transplanting DAT (Four) *viz:* C_0 = No leaf cutting (Control), C_1 = Leaf cutting at 25 DAT, C_2 = Leaf cutting at 40 DAT and C_3 = Leaf cutting at 55 DAT. The Experiment results showed that different nitrogen doses and leaf cutting either individually or interaction showed significant variations in respect of various parameters inBRRI dhan29. In respect of different nitrogen doses, the maximum number of effective tillers $hill^{-1}$ (15.96), flag leaf area (58.62 cm^2), panicle length (24.94 cm), filled grains $panicle^{-1}$ (143.45), total grains $panicle^{-1}$(163.19), 1000 grains weight (26.24 g), absolute grain growth rate (7.75 mg day^{-1}), grain yield (7.67 t ha^{-1}), straw yield (9.06 t ha^{-1}), biological yield (16.73 t ha^{-1}) and harvest index (45.83 %) were recorded in N_3 treatment. In respect of leaf cutting the maximum number of effective tillers $hill^{-1}$ (17.72), flag leaf area (58.79 cm^2), panicle length (25.99 cm), filled grains $panicle^{-1}$ (145.75), total grains $panicle^{-1}$ (164.78), 1000 grains weight (28.39 g), absolute grain growth rate (8.67 mg day^{-1}), grain yield (7.66 t ha^{-1}), straw yield (9.17 t ha^{-1}), biological yield (16.83 t ha^{-1}) and harvest index (45.45 %) were recorded in C_0 treatment. In case of combined effect N_3 (Application of 183 kg nitrogen ha^{-1}) treatment along with C_0 (no leaf cutting) treatment showed the maximum number of effective tillers $hill^{-1}$ (19.10),highest flag leaf area (63.22 cm^2), panicle length (27.67 cm), filled grains $panicle^{-1}$ (154.63), total grains $panicle^{-1}$ (171.83), 1000 grains weight (30.20 g), absolute grain growth rate (9.67 mg day^{-1}), grain yield (8.54 t ha^{-1}), straw yield (9.62 t ha^{-1}), biological yield (18.16 t ha^{-1}), harvest index (47.03 %). Finally the treatment combination N_3C_0 was best for the production of higher grain yield compared to others treatments in BRRI dhan29 rice variety.

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ABBREVIATIONS

Full word	Abbreviations	Full word	Abbreviations
Agriculture	Agric.	Milliliter	mL
Agro-Ecological Zone	AEZ	Milliequivalents	Meqs
And others	et al.	Triple super phosphate	TSP
Applied	App.	Milligram(s)	Mg
Asian Journal of Biotechnology and Genetic Engineering	AJBGE	Millimeter	mm
Bangladesh Agricultural Research Institute	BARI	Mean sea level	MSL
Bangladesh Bureau of Statistics	BBS	Metric ton	MT
Biology	Biol.	North	N
Biotechnology	Biotechnol.	Nutrition	Nutr.
Botany	Bot.	Pakistan	Pak.
Centimeter	Cm	Negative logarithm of hydrogen ion concentration (-log[H+])	pH
Completely randomized design	CRD	Plant Genetic Resource Centre	PGRC
Cultivar	Cv.	Regulation	Regul.
Degree Celsius	°C	Research and Resource	Res.
Department	Dept.	Review	Rev.
Development	Dev.	Science	Sci.
Dry Flowables	DF	Society	Soc.
East	E	Soil plant analysis development	SPAD
Editors	Eds.	Soil Resource Development Institute	SRDI
Emulsifiable concentrate	EC	Technology	Technol.
Entomology	Entomol.	Tropical	Trop.
Environmment	Environ.	Thailand	Thai.
Food and Agriculture Organization	FAO	United Kingdom	U.K.
Gram	g	University	Univ.
Horticulture	Hort.	United States of America	USA
International	Intl.	Wettable powder	WP
Journal	J.	Serial	Sl.
Kilogram	Kg	Percentage	%
Least Significant Difference	LSD	Number	No.
Liter	L	Microgram	µ

CHAPTER-I
INTRODUCTION

Rice (*Oryza sativa* L.) is the most important food crop and a primary food source for more than one-third of world's population (Sarkar *et al.*2017). Worldwide, rice provides 27% of dietary energy supply and 20% dietary protein (Kueneman, 2006). It constitutes 95% of the cereal consumed and supplies more than 80% of the calories and about 50% of the protein in the diet of the general people of Bangladesh (Yusuf, 1997). World's rice demand is projected to increase by 25% from 2001 to 2025 to keep pace with population growth (Maclean *et al.*2002), and therefore, meeting this ever increasing rice demand in a sustainable way with shrinking natural resources is a great challenge. In Bangladesh, majority of food grains comes from rice. Rice has tremendous influence on agrarian economy of the country. Annual production of rice in Bangladesh is about 36.28 million tons from 11.52 million ha of land (BBS, 2018). According to the USDA report in 2021 rice production for the 2020-21 marketing year is expected to rise to 36.3 million tonnes in Bangladesh as further cultivation of hybrid and high yield variety plantings increase. The country is expected to import 200,000 tonnes of rice in the 2020-21 marketing year to ease food security tensions brought on by the COVID-19 pandemic (USDA, 2021).

There are three distinct growing seasons of rice in Bangladesh, according to changes in seasonal conditions such as *aus*, *aman* and *boro*. More than half of the total production (55.50 %) is obtained in *Boro* season occurring in December–May, second largest production in *Aman* season (37.90 %) occurring in July-November and little contribution from *Aus* season (6.60 %) occurring in April-June (APCAS, 2016).

Among three growing seasons (aus, aman and boro) boro rice is the most important rice crops for Bangladesh with respect to its higher yield and contribution to rice production. Boro cultivation area has declined to 4.75 million hectares in 2020, which was 4.9 million hectares in 2019. The country produced an all-time-high 20.03 million tonnes of Boro rice in 2019, The government expects to achieve 20.04 million tonnes of Boro production target, although acreage of this major crop fell to a three-year low in 2010 which was due to reason that many farmers, upset with low paddy and rice prices, switched to other crops like corn, vegetables and tobacco etc. (Express, 2021).

Recently, food security especially attaining self-sufficiency in rice production is a burning issue in Bangladesh. The average yield of rice is almost less than 50% of the world average rice grain yield. The national mean yield (2.60 t ha^{-1}) of rice in Bangladesh is lower than the potential national yield (5.40 t ha^{-1}) and world average yield (3.70 t ha^{-1}) (Pingali *et al.* 1997).

Now-a-day's different high yielding rice varieties are available in Bangladesh which have more yield potential than different conventional varieties (Akbar, 2004). In 2020, the amount of land used for HYV varieties is 44.47 lakh (4.44 million) hectares, hybrid 2.40 lakh (0.24 million) hectares, local varieties 7.15 lakh (0.75 million) hectares (Magzter, 2021). Almost 78 per cent of the land is occupied by the HYV varieties supported by the Department of Agricultural Extension with fertilizers, pesticides and laboratory seeds, while only 12.5 per cent are local/traditional varieties cultivated by the farmers on their own initiatives in low lands.(BBS, 2017).

The growth process of rice plants under different agro-climatic condition differs due to the specific rice variety (Alam *et al.* 2012). Compared with conventional cultivars, the high yielding varieties have larger panicles resulting in an average increase of rice grain is 7.27% (Bhuiyan *et al.* 2014). These high yielding and hybrid rice variety however, needs further evaluation under different fertilizers and agronomic managements in agro Ecological Zone (AEZ) to interact with different agro-climatic conditions.

For improving crop yields and farm profit fertilizer is considered as the principal inputs. In case of agricultural sector of Bangladesh this is also true, because the country has hardly any possibility of expanding its cultivable land area. For this, the production of food of this country can be accelerated through improving irrigation facilities alongside better practice of fertilizer as well as high yielding variety (HYV) (Shah *et al.* 2008). Fertilizer is mainly recommended for crop plants to supply essential nutrient element throughout the growth and development period. Among the all essential nutrient elements nitrogen is needed most for crop plants.

Nitrogen is essential nutrient element for rice growth and metabolic processes (Noor 2017; Ghoneim and Ebid 2015). Before making recommendations for the nitrogen fertilizer dose for any crop, one should evaluate the efficiency and optimum rate for different application levels for better growth and yield performance of each released rice variety (Noor 2017). Efficient use of N chemical fertilizers can be attained through cultural and agronomic practices. Most importantly by breeding varieties having maximum NUE, thereby reducing risks of environmental and soil water pollution with low nitrogen inputs (Noor 2017; Fageria *et al.* 2008; Sachiko *et al.* 2009). Shaiful Islam *et al*. (2009) found that applying optimum dose of nitrogen can save money while maintaining a safe environment. Excessive use of nitrogen fertilizer has impacts on soil and environment through residual effect. Salem (2006) reported that by maximizing nitrogen, all grain specimens significantly increased in weight and protein content. Ebaid and Ghanem (2000) also revealed in their study that increasing nitrogen dose up to 144 kg N ha^{-1} significantly improved plant growth, yield and yield components. El-Batal *et al.* (2004) recorded that nitrogen application increase from 120 to 190 kg N ha^{-1} improved plant height, panicle length, number of filled grains /panicle and grain yields significantly. Similarly, Yoseftabar (2013) found significant increase in plant growth parameters, yield traits and grain yield at the rate of 100, 200 and 300 kg N ha^{-1}.

In Rice leaves are vitally essential organs for photosynthesis, which is a major process affecting crop growth rates and is affected by either the number or the area of the leaves. In Bangladesh production has to be increased vertically by adopting leaf cutting method. Rice leaf cutting is a farmer wisdom for several reasons such as preventing wind destroy due to too heavy leaves, removal of weeds , easy for pest management, reducing cost of rice pests and weeding, uniform plant height and stimulating all plant to bloom in the same time and easy for harvesting. Leaf cutting in transplanted seedling may have option to translocate assimilate towards root zone for early establishment of seedling and increase growth of the plant (Paez *et. al.*, 1995). Misra and Misra (1991) (for pearl millet) and Mae (1997) (for rice) stated that the top three leaves translocate assimilate towards grain filling. The top three leaves have most contribution for the yield of grain (Yoshida, 1981; Misra, 1987). Leaf cutting practiced in transplanted aman rice can reduce transplanting shock (Bardhan and Mandal, 1988). Leaf cutting during reproductive and ripening stages is directly related to biomass production and grain yield of rice crop (Ray *et al*,. 1983).

Rice leaf cutting length have been recommended for 30 cm, at 30-60 day after planting and before flowering. It can cut multiple times but should not cut flag leaf, because flag leaf is particular provides the most important source of photosynthetic energy during reproduction (Evans and Rawson, 1970). Flag leaf play an important role regarding growth and yield of rice. Flag leaf contribution as much as 45% on rice grain yield and, when it was removed, then it was the major component for the loss of rice yield (Abou-khalifa *et al.* 2008. While Birsin (2005) showed that removal of flag leaf which resulted in approximately 13, 34, 24% reduction in grain per spike, grain weight per spike and 1000-grain weight, respectively, and also increase 2.8% protein contents in grain. The grain yield and straw yield of rice increased significantly with the presence of flag leaf.By considering the importance of leaves for grain yield, it is necessary to analysis the morphological and the physiological characteristics of functional leaves to improve grain yield in rice (Yue *et al.* 2006).

Therefore, this study aimed to examine the different nitrogen dose and leaf cutting effect on growth, yield and yield contributing characters of BRRI dhan29 rice. Considering the above facts the present research work was undertaken to achieve the following objectives:

i. To observe the effect of different nitrogen doses on morpho-physiology and yield of BRRI dhan29.
ii. To find the effect of leaf cutting on morpho-physiology and yield of BRRI dhan29.
iii. To find out the combine effect of different nitrogen doses along with leaf cutting treatments on morpho-physiology and yield of selected rice variety BRRI dhan29.

CHAPTER II

REVIEW OF LITERATURE

Rice is broadly adaptable crop in various environmental condition. Rice production depends on several factors: climate, physical conditions of the soil, soil fertility, water and agronomic management, sowing date, cultivar, seed rate, weed control, and fertilization. For fertilization, N is the main nutrient associated with yield. Leaf is an important part of rice plant and major source of photosynthetic activity. Leaf cutting practice on either at seedling stage or after seedling transplanting stage can impact distinctive development and yield attributes of rice. An attempt was made in this section to collect and study relevant information available regarding to 'response of rice to different doses of nitrogen and leaf cutting in the country and abroad to gather knowledge helpful in conducting the present piece of work and subsequently writing up the result and discussion.

2.1Effect of different doses of nitrogen

Plant height

Mamun *et al.* (2019) carried out an experiment at the Agronomy Field, Sher-e-Bangla Agricultural University, Dhaka during November 2009 to July 2010 to study the effect of variety and varying levels of nitrogen application to ratoon crop of boro rice. Four varieties (BRRI hybrid dhan2, BRRI dhan29, BRRI dhan35 and BRRI dhan47) and four doses of nitrogen (0%, 25%, 50% and 75% N of recommended dose) were tested. Experiment result showed that However, in N-applied plots, plant height of ratoon crop was significantly higher than control plots (Table 2). They were statistically identical but numerically different. Numerically, the tallest (69.04 cm) plants were obtained from the treatment N_3 (75% N of the recommended dose). On the contrary, the shortest (58.97 cm) plants were produced by control plots.

Paul *et al.* (2016) conduct an experiment with four variety and four level of nitrogen viz. control (no urea), prilled urea (50 kg N ha^{-1}), one pellet (0.9g) of urea super granules-4 hills of two adjacent rows (30 kg N ha^{-1}) was applied at 10 days after transplanting (DAT) and two pellets of USG (0.9g each) one applied at 10 DAT and the another at 45 DAT/4 hills of two adjacent rows (60 kg N ha^{-1}). Results of the experiment showed that levels of nitrogen had significant effect on plant height, number of tillers $hill^{-1}$ and leaf area index (LAI) of HYV transplant rice.

Chamely *et al*. (2015) conducted an experiment with comparative study of three varieties viz., BRRI dhan28 (V_1), BRRI dhan29 (V_2) and BRRI dhan45 (V_3); and five rates of nitrogen viz., control (N_0), 50 kg (N_1), 100 kg (N_2), 150 kg (N_3) and 200 kg (N4) N ha^{-1}. The growth analysis results indicate that the tallest plant (80.88 cm) and the highest number of total tillers $hill^{-1}$ (13.80) were observed in BRRI dhan29 at 70 DATs and the highest total dry matter (66.41 g m^{-2}) was observed in BRRI dhan45. The shortest plant (78.15 cm) and the lowest number of tillers $hill^{-1}$ (12.41) were recorded from BRRI dhan45 and the lowest dry matter (61.24 g) was observed in BRRI dhan29. The tallest plants (84.01 cm), highest number of tillers $hill^{-1}$ (14.06) and the highest dry matter (69.58 g m^{-2}) were obtained from 200 kg N ha^{-1}. The tallest plants (86.48 cm) and maximum dry matter (72.30 g m-2) were recorded from BRRI dhan28 with 200 kg N ha^{-1} and BRRI dhan45 with 200 kg N ha^{-1}, respectively.

Mannan *et al*. (2010) concluded that plant height and number of tillers were significantly increased with the increase in nitrogen level at different growth stages *viz*., 30, 45 and 60 DAT. They found proportionate increase in dry matter with increase in nitrogen levels from 0 to 100 kg ha^{-1} at different growth stages.

Behera and Panda (2009) concluded that the cell size and its elongation and division that determine growth parameters like plant height was increases with nitrogen fertilization.

Number of tillers

Haque and Haque (2016) concluded that the number of tillers $hill^{-1}$ (14.44), dry matter accumulation (1138.40 g m^{-2}), leaf area index (4.17), crop growth rate (33.99 g m^{-2} day^{-1}) and net assimilation rate were found maximum with the nitrogen treatment of 100 kg ha^{-1}

Puteh *et al.*(2014) examined the three nitrogen doses (80, 120 and 160 kg ha^{-1}) with rice cultivars and reported tallest plant (119.5cm), highest leaf area, chlorophyll content, and number of total tillers $hill^{-1}$ (15.33) with 160kg N ha^{-1}.

Yosef Tabar (2012) investigated the effect of nitrogen and phosphorus fertilizer on growth and yield in rice. Nitrogen fertilizer @ 50,100 and 150 kg ha^{-1} was applied in main plot and phosphorus levels 4 level 0, 30, 60 and90kg ha^{-1} in sub plot. Maximum tiller number was observed for 150 kg ha^{-1} nitrogen and minimum of that was obtained for 50 kg ha^{-1} nitrogen fertilizer**.**

Leaf area index

Azarpour *et al.* (2014) conducted experiment with four rice cultivars and four nitrogen fertilizer levels (0, 30, 60, and 90 Kg N ha^{-1}) reported that leaf area index (LAI) significantly increase with 90 kg N ha^{-1} application compared to others treatment.

SPAD value

Ghosh *et al.* (2013) reported that the SPAD value of 36 was found to be critical for Eastern India, unlike the value of 35 recommended for the Philippines and application of less amount of fertilizer N in split during tillering to heading stage under RTNM (real time N management) improved the growth and productivity of rice as compared to those in FTNM (fixed time N management).

Singh *et al.* (2009) suggested that, leaf colour chart (LCC) and chlorophyll meter (SPAD) as important tools to diagnose the nitrogen status in rice to decide time of N topdressing.

Fan *et al*. (2005) conducted experiment at Harbin (China) and reported that 38 to 40 and 3.5 are the critical SPAD and LCC values, respectively for N application in rice crop.

Kumar *et al*. (2001) observed that a higher SPAD and LCC values during winter, indicating higher N content in rice.

Turner and Jund (1991) indicated that chlorophyll meter could be used to predict the requirement of nitrogen top dressing prior to panicle initiation and panicle differentiation stages in semi dwarf rice cultivars. SPAD meter measurement taken on the most recently matured leaf can range from 25-44 depending on N uptake and growth stage. It was recognized that SPAD values were influenced by plant growth stage, cultivar, leaf thickness, plant population and any soil or climatic factor causing leaf chlorosis. SPAD values did not indicate how much N to apply, but they only indicated the need for additional N.

Dry matter weight

Reddy (2000) reported that dry matter accumulation was increasing through increasing vegetative growth resulting from higher photosynthetic activities is well known to be influenced by nitrogen.

Effective tillers

Puteh *et al.* (2014) examined three nitrogen doses (80, 120 and 160 kg ha^{-1}) and reported highest number of effective tillers $hill^{-1}$ with increasing nitrogen doses.

Pandey *et al.* (2008) with three nitrogen levels *viz.*, 50, 100 and 150 kg N ha^{-1} in IGAU campus, Raipur, 6 Chattishgarh. They observed significant increase in the number of effective tillers m^{-2}, with increasing levels of nitrogen from 50 to 150 kg N ha^{-1}.

Panicle length

Yoseftabar (2013) also reported panicle length increased with increasing N fertilizer application the maximum panicle length at highest level of nitrogen application.

Lar *et al.*(2007) concluded that nitrogen application up to 150 kg ha^{-1} significantly increased the plant height, panicle weight, panicle length, number of panicles $hill^{-1}$, number of filled grains $panicle^{-1}$, test weight and fertility % of rice.

Filled grains panicle^{-1}

Gewaily *et al.* (2018) reported that the rice genotypes differed significantly in their response to nitrogen levels. This might be due to source sink interaction, meaning maximum proportion of N source is used to produce maximum spikelets per panicle and grain filling.

Metwally *et al.* (2010) carried out an investigation at the experimental farm of Rice Research and Training Center, Sakha, Kafer El-Sheikh, Egypt during 2008 and 2009 seasons to study the physio-morphological behaviour of some rice genotypes under low and high nitrogen application. Twenty one genotypes were tested under three different nitrogen levels viz, 0, 75 and 150 kg N/ha for ten traits viz, flag leaf area, chlorophyll content, days to heading, panicle weight,, no. of filled grains/panicle, no.

of panicles/plant,1000-grain weight, grain yield t/ha, Grain yield efficiency index (GYEI) and agronomic nitrogen use efficiency (ANUE). Experiment result showed that number of filled grains per panicle was significantly affected by nitrogen fertilizer application and genotypes. Plants which fertilized with 150 kg N/ha produced the highest number of filled grain per panicle, followed by plants which received 75 kg N/ha. However, the plants that didn't receive nitrogen gave the lowest values of number of filled grain per panicle. It could be concluded that nitrogen fertilization resulted in an increase in the amount of metabolites synthesized by rice plant and this, in turn, might account much for the superiority of number of filled grains per panicle. These results were true in both seasons.

Unfilled grain panicle^{-1}

Gewaily *et al.* (2018) reported that with increased rate of nitrogen application, a significant increase in number of unfilled grains per panicle for all rice genotypes was observed. This increase in number of unfilled grains might be associated with production of more spikelets per plant and photoassimilation.

Total grains per panicle

Gill and Walia (2013) experimented with four nitrogen levels, (0%, 75%, 100% and 125% of recommended dose of nitrogen). They recorded highest number of grain panicle^{-1}, with application of 125% of recommended dose of nitrogen.

1000 grains weight

Gewaily *et al.* (2018) conducted a field experiments during 2016 and 2017 growing seasons to evaluate the efficiency of varying nitrogen fertilizer rates on growth and yield parameters, along with nitrogen use efficiency of some newly released rice varieties (Sakha 108) and some promising lines GZ9399-4-1-1-3-2-2, GZ10101-5-1-1-1 and GZ10154-3-1-1-1. Five nitrogen levels (i.e. 0, 55,110, 165 and 220 kg N ha^{-1}) were used. Experiment result showed that nitrogen fertilizer application significantly increased the 1000 grain`s weight. The maximum 1000 grains weight (28.52 and 28.91 in 2016 and 2017) was observed in 220 kg N ha^{-1} fertilizer application. The possible reason behind this may be due to production of higher number of spikelets per panicle in the plants fertilized by nitrogen. This caused the high sink capacity as compared to limited respective source, therefore, the grain filling was more and consequently the grain of weight was high.

Manzoor *et al.* (2015) conducted an experiment with six nitrogen levels i.e. 0, 110, 133, 156, 179, and 202 kg ha and found that 1000 grain weight increased with application of nitrogen from 0 to 133 N kg ha^{-1}.

Grain yield

Hirzel *et al.* (2021) A field experiment determine the effect of N rates and split N fertilization on grain yield and its components was carried out in two locations during two consecutive seasons (2007 to 2009), where five N rates and five split N fertilizations were evaluated. The locations were in Parral (36º2' S; 72º08' W, Vertisol) and San Carlos (36º19' S; 71º59' W, Inceptisol), with N rates of 80, 100, 120, 140, and 160 kg ha^{-1} applied in different development stages, such as sowing, tillering, panicle initiation, and boot. Results indicate an important seasonal effect on grain yield. Yield increased with N rates higher than 120 and 140 kg ha^{-1} in San Carlos and Parral, respectively.

Narayan *et al.* (2017) conducted a field trial with different nitrogen levels and its time of application by in Karnataka and reported that with the application of 125 kg N ha^{-1}, a significant higher grain and straw yield (6498.53 kg ha^{-1} and 7689.50 kg ha^{-1}, respectively) were observed followed by 100 and 75 kg N ha^{-1}.

Dubey *et al.* (2016) conducted an experiment with three levels of nitrogen i. e. 60, 120 and 180 kg N/ha interaction with three Sulphur rate S 20, 40 and 60 kg ha^{-1} along with two levels of Zn 5 and 10 kg/ha and reported that maximum grain and straw yield of 61.38 and 86.58 q ha-1 was recorded at 180 kg N ha^{-1}.

The suitability of scented rice varieties and their response to different nitrogen levels was evaluated by Nawlakhe and Mankar (2009) and reported that Pusa Basmati recorded maximum and significantly higher yield over Kasturi and Haryana Basmati during all the three years of experimentation. On pooled analysis, Pusa Basmati recorded 2721 kg ha^{-1} grain yield which is 17.69 % higher than Kasturi (2312 kg $h^{a-1)}$ and 30.38 % than Haryana Basmati (2082 kg ha^{-1}). Among nitrogen treatments tested, the maximum and significantly higher yield was recorded at 100 kg N ha^{-1} but the treatment 75 kg N ha^{-1} was at par with it.

Srinivasan *et al.* (2008) conducted trial by using hybrid rice (ADTRH 1) to evaluate the effect of different nitrogen levels (0, 100, 150 and 200 kg N ha^{-1}). The significant grain yield response of nitrogen was noticed up to 150 kg N ha^{-1}. After that, increase in grain yield was non significant.

Verma *et al.* (2008) conducted an experiment on hybrid rice (PA 6201) at IGAU, Raipur using three nitrogen treatments *viz.*, 50, 100 and 150 kg N ha^{-1}. There was a comparable difference between the treatments of 100 or 150 kg N ha^{-1} and produced significantly higher grain yield than with treatment 50 kg N ha^{-1}.

Vishwarkarma and Kushwaha (2008) found that the yield attributing characters, grain yield, straw yield and uptake of N was significantly higher under treatment 120 kg N ha^{-1} over other treatments *viz.*, 0, 40 and 80 kg N ha^{-1}.

Fageria *et al.* (2008) conducted an experiment with N rates 0, 50, 100, 150, 300, and 400 mg N kg^{-1} of soil. Grain yield increased significantly in a quadratic fashion, when N rate was increased in the range of 0 to 400 mg kg^{-1}.

Straw yield

Narayan *et al.* (2017) conducted a field trial with different nitrogen levels and its time of application by in Karnataka and reported that with the application of 125 kg N ha^{-1}, a significant higher grain and straw yield (6498.53 kg ha^{-1} and 7689.50 kg ha^{-1}, respectively) were observed followed by 100 and 75 kg N ha^{-1}.

Dubey *et al.* (2016) conducted an experiment with three levels of nitrogen i. e. 60, 120 and 180 kg N/ha interaction with three Sulphur rate S 20, 40 and 60 kg ha^{-1} along with two levels of Zn 5 and 10 kg/ha and reported that maximum grain and straw yield of 61.38 and 86.58 q ha^{-1} was recorded at 180 kg N ha^{-1}.

Das *et al.* (2009) experimented with four levels of nitrogen (0, 60, 120 and 180 kg ha^{-1}) and three levels of potassium (0, 40 and 80 kg ha^{-1}) and reported maximum grain and straw yield with 80 kg N ha^{-1}.

Biological yield

Lar *et al.*(2007) reported that, the grain and straw yield of rice increased significantly at different nitrogen levels up to 100 kg ha^{-1}, but the maximum biological yield (20.63 t ha^{-1}) was recorded with 150 kg N ha^{-1}.

Harvest index

Karmaker and Karmakar (2019) conducted a study to investigate the influence of N-rates and leaf clipping on forage and grain yield; and seed quality of transplant Aman (wet season) rice. Four nitrogen (N) rates (N_1=46, N_2=69, N_3=92 and N_4=115 kg N ha^{-1}) and four times of leaf clipping viz, C_0=No leaf clipping, C_1=leaf clipping at 25 DAT (Days after transplanting), C_2=40 and C_3=55 DAT were evaluated following split-plot design with three replications. Experiment result revealed that in case of N application rates, harvest index varied from 0.42 to 0.46 and harvest index increased with increased N rates.

2.2 Effect of leaf cutting

Plant height

Karmaker and Karmakar (2019) carried out an experiment to investigate the influence of N-rates and leaf clipping on forage and grain yield and seed quality of transplant Aman (wet season) rice. Four nitrogen (N) rates (N_1=46, N_2=69, N_3=92 and N_4=115 kg N ha^{-1}) and four times of leaf clipping viz, C_0=no leaf clipping, C_1=leaf clipping at 25 DAT (Days after transplanting), C_2=40 and C_3=55 DAT were evaluated following split-plot design with three replications. They noticed from their experiment that the highest plant height (128.95 cm) was recorded at C_0 (No leaf clipping) and the lowest plant height (116.83 cm) was found in C_3 (leaf clipping time at 55 DAT). The results also showed that plant height was significantly decreased in later leaf cut treatments compared to those with no and early cuts.

Medhi *et al*. (2015) set up a field trial to study the impact of foliage pruning on growth and yield of two land rice varieties, TTB-303−1-42 (Dhansiri) and TTB-303−1-23 (Difalu) under rain-fed low land condition (50–100 cm water profundity) during wet season. Test results showed that multiple times expulsion of foliage significantly decreased the plant height and prevented lodging.

Sherif *et al.* (2015) carried out and experiment during 2013-2015 to find out the effect of leaf removal on rice growth characteristics and yield. The experiment consisted of six level of defoliation *viz*: 0, 20, 40, 60, 80 and 100% were applied one month after transplanting. From the experiment they reported that the rice plants of the check (non-defoliated) plots exhibited, almost, the tallest plants; 92.60 and 91.55 cm, in the first and second seasons, respectively. Defoliation at 20 or 40% in the first season, and at 20, 40 or 60% in the second one induced slightly shorter rice plants, ranging between 91.80 and 92.64 cm and 89.50- 90.65 cm, respectively, but without significant differences compared to the check. However, the plant heights ranged 90.00-90.50 cm when 60, 80 or 100% of the leaves were removed in the first season, and ranged 87.00-87.05 cm when 80 or 100% of the rice plants were defoliated in the second season.

Si (2011) stated that rice leaf cutting length of 30 cm had been suggested at 30–60 days after planting and prior to flowering. It tends to be cut on different occasions however the flag leaf should not be cut. Rice leaf cutting at 60 days subsequent to planting just one time had impact on uniform plant height and uniform flowering.

Dry matter weight

Sherif *et al.* (2015) carried out an experiment during 2013-2015 to find out the effect of leaf removal on rice growth characteristics and yield. The experiment consisted of six level of defoliation *viz*: 0, 20, 40, 60, 80 and 100% were applied one month after transplanting. From the experiment they showed that the biggest dry matter content were found in the check or 20% defoliation, with levels of 1215.00 and 1103.60 g/m^2 in the first season . The corresponding values of dry matter in the second season were 1061.10 and 1164.94 g/m2. The sharp reduction in dry matter content was observed in the first season at 80 or 100% defoliation (938.15 and 765.00 g/m2 , respectively). In the second season, defoliations at 60, 80 or 100% resulted in low levels of dry matter content; 866.11, 861.26 or 840.04 g/m^2 respectively.

Ros *et al.* (2003) conducted an experiment to explore the concept of seedling vigor of transplanted rice and to determine what plant attributes conferred vigor on the seedlings. Seedling vigor treatments were established by subjecting seedlings to short-term submergence (0, 1 and 2 days/work) in one experiment and to leaf clipping or root pruning and water stress in another to determine their effect on plant growth after transplanting. Pruning 30% of leaves depressed shoot and root dry mater by 30% at panicle initiation (PI) and root dry matter by 20% at maturity. The interaction effects of leaf clipping and root pruning on shoot, root and straw dry matter were largely additive. It was concluded that the response of rice yield to nursery treatments is largely due to increased seedling vigor and can be affected by a range of nutritional as well as non-nutritional treatments of seedlings that increase seedling dry matter, nutrient content and nutrient concentration. Impairment of leaf growth and to a lesser extent root growth in the nursery depressed seedling vigor after transplanting. However, rather than increasing stress tolerance, seedling vigor was more beneficial when post-transplant growth was not limited by nutrient or water stresses.

Effective tillers hill^{-1}

Fatima *et al.* (2019) carried out an experiment to study the effect of flag leaf clipping on growth yield, and yield attributes of hybrid rice varieties in Boro season. The experiment contained two factors. Factor A: Flag leaf cutting: T_1 = Flag leaf cutting at heading and T_2 = Control (without cutting). Factor B: Six hybrid rice varieties: V_1 = BRRI hybrid dhan1, V_2 = BRRI hybrid dhan2, V_3 = Heera 2, V_4 = Heera 4, V_5 = Nobin and V_6 = Moyna. Regardless of variety, all the studied parameters were exhibited superiority in control treatment. The highest number of effective tillers hill^{-1} was recorded from Heera 4 under control condition.

Medhi *et al.* (2015) set up a field trial to know the effect of foliage pruning on growth and yield of two low land rice varieties, TTB-303-1-42 (Dhansiri) and TTB-303-1-23 (Difalu) was studied under rainfed low land situation (50-100 cm water depth) during wet season of 2010 and 2011. Experimental results showed that foliage pruning up to 100 days after germination (DAG) had no adverse impact on tillers of the crop.

Daliri *et al.* (2009) completed a field try to consider the impact of cutting time and cutting height on yield and yield components of ratoon rice (Oryza sativa L.) Tarom langrodi variety. Results showed that the impact of cutting time on number of effective tiller hill^{-1} was found statistically significant. Cutting stature significantly effect on tiller number in hill and number of effective tiller in hill. Interaction between cutting time and cutting height on number of tiller hill^{-1} and number of viable tillers hill^{-1} were significant.

Non-effective tillers hill^{-1}

Ahmed *et al.* (2001) directed a test to consider the impact of nitrogen rate and time of leaf cutting on green fodder as well as seed yield of rice. The test included two factors, (A) Nitrogen level – viz. I) N_1 – 50 kg N ha^{-1}, ii) N_2 – 75 kg N ha^{-1} and iii)

N_3– 100 kg N ha^{-1}, (B) Time of leaf cutting – viz. I) No cutting (control) – C_0, ii) Cutting at 21 DAT – C_1, iii) Cutting at 35 DAT – C_2 and iv) Cutting at 49 DAT – C_3. Greatest number of non-bearing turners $hill^{-1}$ was recorded from no leaf cutting treatment, which was genuinely like leaf cutting at 21 DAT and the minimum was seen in leaf cutting at 49 DAT.

Panicle length

DAS *et al.* (2017) reported that leaf clipping had non-significant effect on panicle length of modern variety and in local variety of rice.

Boonreund and Marsom (2015) carried out an experiments aimed to determine the optimal length of cutting for Pathum Thani1 rice leaf for better yield. Treatments of the study was 7 cutting lengths (0, 5, 10, 15, 20, 25 and 30 cm from the leaf tip) which was performed by sickle after 60 days after planting. The results showed that cutting of leaves had no significant effect on panicle length of rice.

Rahman *et al.* (2013) directed an investigation in order to explore the correlation analysis of flag leaf with yield in several rice cultivars. From their experiment they noticed that when FL length is high the panicle length is also high. In case of BR11 when the average FL length was 21.33, 25.90, 28.19, 37.33, 18.28, 37.84, 37.59, 25.90, 24.13, 35.50 cm, then the average panicle length was 18.03, 18.54, 20.32, 34.98, 17.52, 33.87, 33.36, 19.85, 22.60, 31.65 cm, respectively and in case of correlation analysis, a significant correlation was found between them. Similar significant result was found in case of BR28. Yield was significantly and positively associated with panicle length .They also found that flag leaf length was positively associated with panicle length, thereby indicating associated with grain yield.

Filled grains $panicle^{-1}$

Das *et al.* (2017) study the effect of leaf clipping on yield attributes of modern and local rice varieties and observed thatin Binadhan-8, the highest number of filled grain $panicle^{-1}$ was found in without leaf cutting plants (104.00) which did not vary significantly from 2^{nd} and 3^{rd} leaf cut. Significant reduction in filled grains takes place by flag leaf cut (35.14%), flag leaf with 2^{nd} leaf cut (62.62%) and flag leaf with 2nd and 3rd leaf cut (51.83 %).

Usman *et al.* (2007) directed an experiment to study the effect of detopping on forage and grain yield of rice. The experiment consisted of six treatments viz., Control (T_1,no detopping), detopping at 22 DAT (T_2), detopping at 29 DAT (T_3), detopping at 36 DAT (T_4), detopping at 43 DAT (T_5), and detopping at 50 DAT (T_6). In respect of all the six treatments, the highest number of spikelets panicle^{-1} (106.8) and number of filled grains panicle^{-1} (90) were obtained from control (no detopping) treatment.

Ahmed *et al.* (2001) set up an experiment to study the effect of nitrogen rate and time of leaf cutting on green fodder as well as seed yield of rice. The experiment included two factors, (A) Nitrogen level – viz. i) N_1 – 50 kg N ha^{-1}, ii) N_2 –75 kg N ha^{-1} and iii) N_3 – 100 kg N ha^{-1}, (B) Time of leaf cutting – viz. i) No cutting (control) – C_0, ii) Cutting at 21 DAT – C_1, iii) Cutting at 35 DAT – C_2 and iv) Cutting at 49 DAT – C_3. Number of sterile spikelets panicle^{-1} was found to be the highest for no leaf cutting treatment; which was statistically similar to cutting at 21 DAT. The lowest value for number of sterile spikelets panicle^{-1} was recorded from cutting at 49 DAT.

Unfilled grains panicle^{-1}

Moballeghi*et al.* (2018) carried out an experiment in order to study the effect of source-sink limitations on agronomic traits and grain yield of different lines of rice. The field experiment was carried out as factorial in a randomized complete block design with four replications in Chaparsar Rice Research station of Mazandaran province in 2013. Treatments of source-sink limitation in four levels (including cutting of flag leaf, cutting of one third the end of panicle, cutting of other leaves except flag leaf and control or without limitation) and lines of rice in four levels (line of No. 3, line of No. 6, line of No. 7 and line of No. 8) were the treatments. Among different source-sink limitation treatments, increased the panicle length and unfilled grain number per panicle and decreased the panicle fertility percentage, when all leaves except flag leaf removed.

Das *et al.* (2017) conducted an experiment to investigate the effect of leaf clipping on yield attributes of modern and local rice varieties and observed that in Binadhan-8, Unfilled grain number increased with higher intensity of leaf cutting and was the highest (79.40) in flag leaf with 3rd leaf cut, which was similar with flag leaf with 2nd leaf cut (65.91). The lowest unfilled grain was in the control (33.99) which did not vary with 3rd leaf cut alone (39.57). Flag leaf cut and 2nd leaf cut showed the similar and moderate values.

Grain panicle^{-1}

Karmaker and Karmakar (2019) observed that in BRRI dhan41 the highest mean number of grains panicle^{-1} (118) was found in C_0 (no leaf clipping) and the lowest number of grains panicle^{-1} (106) was obtained from C_3 when leaf clipped at 55 DAT and concluded that forage removal at later stages of crop growth reduce photosynthetic leaf area causing negative impact on carbohydrate accumulation which ultimately effect on producing grains panicle^{-1}.

Hossain (2017) conducted an experiment to evaluate the effect of leaf cutting on plant growth and yield of selected BRRI released Aman varieties. The experiment comprised of two factors: Factor A: five varieties, V_1 = BRRI dhan32, V_2 = BRRI dhan33, V_3 = BRRI dhan39, V_4 = BRRI dhan62 and V_5 = BRRI dhan56 and Factor B: two leaf cutting, T_1 = Leaf cutting (aside from flag and penultimate leaves) T2 = Control (no leaf cutting). Regardless of the all the varieties under study , the maximum grains panicle^{-1} (105.63) was obtained in no leaf cutting (control) treatment than leaf cutting treatment (94.73 grains panicle^{-1}).

1000 grain weight

Fatima *et al.* (2019) led an experiment to study the effect of flag leaf clipping on growth yield, and yield attributes of hybrid rice varieties in Boro season. The test involved two factors. Factor A: Flag leaf cutting: T_1 = Flag leaf cutting at heading and T_2 = Control (without cutting). Factor B: Six hybrid rice varieties: V_1 = BRRI hybrid dhan1, V_2 = BRRI hybrid dhan2, V_3 = Heera2, V_4 = Heera4, V_5 = Nobin and V_6 = Moyna. Chlorophyll content (SPAD value) in penultimate leaf following 15 days after heading, grain filling duration, yield contributing characters and yield were examined subsequent to cutting of flag leaf. Despite variety, all the studied parameters were shown predominance in control treatment. The maximum weight of 1000-grains was recorded from Heera4 under control condition.

DAS *et al.* (2017) reported that leaf clipping had non-significant effect on 1000 grains weight of modern variety while it was significant in local variety.

Hossain (2017) guided an experiment to evaluate the effect of leaf cutting on plant growth and yield of selected BRRI released Aman varieties. The experiment comprised of two factors: Factor A: five varieties, V_1 = BRRI dhan32, V_2 = BRRI dhan33, V_3 = BRRI dhan39, V_4 = BRRI dhan62 and V_5 = BRRI dhan56 and Factor B: two leaf cutting, T_1 = Leaf cutting (aside from flag and penultimate leaves) T2 = Control (no leaf cutting). Regardless of the all the varieties under study, the maximum weight of 1000-grains was obtained in no leaf cutting (control) treatment. The yield and yield contributing characters was diminished by leaf cutting when compared with the control. 1000-grains weight was significantly reduced in plants those had the leaves cut compared with the plant in control treatment.

Sherif *et al.* (2015) reported that defoliation at 0, 20, 40 or 60% induced statistically the same values of 1000- grain weights, which ranged between 21.87 and 23.18 g in the first season (2013), and ranged between 27.47 and 29.21 g/1000 grains in the second season (2014). The least 1000- grain values were obtained at 80% (20.73 and 26.67 g) and at 100% (20.28 and 24.71 g) in the first and second seasons, respectively.

Grain yield

Fatima *et al.* (2019) set up an experiment to study the effect of flag leaf clipping on growth, yield and yield attributes of hybrid rice varieties in Boro season. The experiment consisted of two factors. Factor A: Flag leaf clipping: T_1 = Flag leaf clipping at heading and T_2 = Control (without clipping). Factor B: Six hybrid rice varieties: V_1 = BRRI hybrid dhan1, V_2 = BRRI hybrid dhan2, V_3 = Heera 2, V_4 = Heera 4, V_5 = Nobin and V_6 = Moyna. All the test varieties exhibited superiority in control condition. Chlorophyll content (SPAD value) in penultimate leaf after 15 days after heading, grain filling duration, yield contributing characters and yield were investigated after cutting of flag leaf. Regardless of variety, all the studied parameters were exhibited superiority in control treatment. Chlorophyll and nitrogen content (SPAD value) in penultimate (1.35% to 17.27%) and grain filling duration were increased (4.5 to 6.25 days) by virtue of clipping of flag leaf. The highest grain yield was recorded from Heera 4 under control condition. The clipping of the flag leaf reduced grain yield from 15.69% to 29.43% in the test Boro rice varieties.

Karmaker and Karmakar (2019) carried out an experiment to investigate the influence of N-rates and leaf clipping on forage and grain yield and seed quality of transplant Aman (wet season) rice. Four nitrogen (N) rates (N_1=46, N_2=69, N_3=92 and N_4=115 kg N ha^{-1}) and four times of leaf clipping viz, C_0=no leaf clipping, C_1=leaf clipping at 25 DAT (Days after transplanting), C_2=40 and C_3=55 DAT were evaluated following split-plot design with three replications. They noticed from their experiment that the highest mean grain yield (5.25 t ha^{-1}) was obtained from the treatment combination of 115 kg N ha^{-1} and no leaf clipping (N_4C_0) comparable to other treatment

Hossain (2017) guided an experiment to assess the effect of leaf cutting on plant growth and yield of selected BRRI released Aman varieties. The experiment consisted of two factors: Factor A: five varieties, V_1 = BRRI dhan32, V_2 = BRRI dhan33, V_3 = BRRI dhan39, V_4 = BRRI dhan62 and V_5 = BRRI dhan56 and Factor B: two leaf cutting, T_1 = Leaf cutting (except flag and penultimate leaves) T_2 = Control (no leaf cutting). Irrespective of all the varieties under study, the highest grain yield was obtained in no leaf cutting (control). The yield and yield contributing characters was decreased by leaf cutting as compared to the control. Among the varieties, BRRI dhan33 gave the significantly higher yield in control (control 6.75 t ha^{-1}, treated 4.75 t ha^{-1}). The highest grain yield was obtained in no leaf cutting (6.75 t ha^{-1}). The leaf cutting (except flag leaf and penultimate leaves) reduced about 10 to 28% loss of grain yield. Remarkable variation in grain filling duration was also noticed in the different varieties due to leaf cutting. Reduction of grain yield was minimum (10%) in BRRI dhan39 (control 5.75 t ha^{-1}, treated 5.15 t ha^{-1}) with leaf cutting than that of the rest varieties.

Boonreund and Marsom (2015) carried out experiments aimed at searching for the optimal length of cutting for Pathum Thani1 rice leaf for better yield. Length of rice leaf cutting was reported to have positive effect on broadcasting Thai jasmine rice yield but was not clarified in other variety. Treatments of the study was 7 cutting lengths (0, 5, 10, 15, 20, 25 and 30 cm from the leaf tip) which was performed by sickle after 60 days after planting. The results showed that cutting of leaves had no significant effect on yield. Grain yield was significantly increased after cutting. The optimal length of rice leaf cutting at 15–30 cm tended to obtain the highest grain yield.

Khatun *et al.* (2011) from their research work on influences of leaf cutting on growth and yield of rice and observed that the lowest grain yield of rice was produced from flag leaf cutting treatment.

Prakash *et al.* (2011) found that the grain yield was positively related with flag leaf area in rice cultivars.

Abou-khalifa *et al*. (2008) stated that flag leaf contributed to 45% of grain yield andremoval of flag leaf is the single most component for yield loss.

Ros *et al.* (2003) found that pruning 30% of leaves depressed grain yield by 20%.

Straw yield

Hossain (2017) set up an experiment to assess the effect of leaf cutting on plant growth and yield of selected BRRI released Amanvarieties. The experiment consisted of two factors: Factor A: five varieties, V_1 = BRRI dhan32, V_2 = BRRI dhan33, V_3 = BRRI dhan39, V_4 = BRRI dhan62 and V_5 = BRRI dhan56 and Factor B: two leaf cutting, T_1 = Leaf cutting (except flag and penultimate leaves) T_2 = Control (no leaf cutting). Irrespective of all the varieties under study, the highest straw yield was obtained in no leaf cutting (control).

Ahmed *et al.* (2001 a) led an experiment to study the effect of pre-flowering leaf cutting on forage and seed yield of transplant aman rice. The possibility of extent usage of rice for human and livestock simultaneously was studied. The experiment consisted of four varieties namely Latishail, BR 10, BR 11 and BRRI dhan32 and four leaf cuttings *viz.*, no leaf cutting (T_1), leaf cutting at 21 DAT (T_2), leaf cutting at 28 DAT (T_3) and leaf cutting at 35 DAT (T_4). The results revealed that among the varieties and the different leaf cutting treatments, Latishail variety with leaf cutting at 35 DAT gave the significantly higher forage yield. The highest value of straw yield (5.60 t ha^{-1}) was found in control. The yield and yield contributing characters decreased by leaf cutting as compared to control. The lowest value for all crop characters were observed when the leaf was cut at 35 DAT. Leaf cutting at early stage (leaf cutting at 28 DAT for studied modern varieties and 35 DAT for Latishail) of crop growth could produce almost similar grain or seed yield of control crops with the additional forage yield.

Biological yield

Fatima *et al.* (2019) directed an experiment to study the effect of flag leaf clipping on growth yield, and yield attributes of hybrid rice varieties in Boro season. The experiment comprised of two factors. Factor A: Flag leaf clipping: T_1 = Flag leaf clipping at heading and T_2 = Control (without clipping). Factor B: Six hybrid rice varieties: V_1 = BRRI hybrid dhan1, V_2 = BRRI hybrid dhan2, V_3 = Heera2, V_4 = Heera4, V_5 = Nobin and V_6 = Moyna. The highest biological yield were recorded from Heera4 under control condition.

Usman *et al.* (2007) conducted an experiment to study the effect of detopping on forage and grain yield of rice. The experiment comprised of six treatments viz., Control (T_1, no detopping), detopping at 22 DAT (T_2), detopping at 29 DAT (T_3), detopping at 36 DAT (T_4), detopping at 43 DAT (T_5), and detopping at 50 DAT (T_6). In respect of all the six treatments, the highest biological yield (9.6 t ha^{-1}) was obtained from control (no detopping) treatment.

Harvest index

Karmaker and Karmakar (2019) driven an experiment to investigate the influence of N-rates and leaf clipping on forage and grain yield and seed quality of transplant Aman (wet season) rice. Four nitrogen (N) rates (N_1=46, N_2=69, N_3=92 and N_4=115 kg N ha^{-1}) and four times of leaf clipping viz, C_0=no leaf clipping, C_1=leaf clipping at 25 DAT (Days after transplanting), C_2=40 and C_3=55 DAT were evaluated following split-plot design with three replications. They noticed from their experiment that the highest mean harvest index (46%) was obtained from the treatment combination of 115 kg N ha^{-1} and no leaf clipping (N_4C_0) comparable to others treatment combinations.

Usman *et al.* (2007) set up an experiment to study the effect of detopping on forage and grain yield of rice. The experiment consisted of six treatments viz., Control (T_1,no detopping), detopping at 22 DAT (T_2), detopping at 29 DAT (T_3), detopping at 36 DAT (T_4), detopping at 43 DAT (T_5), and detopping at 50 DAT (T_6). In respect of all the six treatments, the highest harvest index (42.70%) were obtained from control (no detopping).

CHAPTER III

MATERIALS AND METHODS

This chapter presents a concise depiction about experimental period, site description, climatic condition, crop or planting materials that were being used in the experiment, treatments, experimental design and layout, crop growing technique, fertilizers application, uprooting of seedlings, intercultural operations, data collection and statistical analysis.

3.1 Location of the experimental site

3.1.1 Geographical location

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University (SAU),Sher-e-Bangla Nagar Agargong, Dhaka, 1207. The experimental site is geographically situated at 23°77′ N latitude and 90°33′ E longitude at an altitude of 8.6 meter above sea level (Anon., 2004).

3.1.2 Agro-Ecological Zone

The experimental field belongs to the Agro-ecological zone (AEZ) of “The Modhupur Tract”, AEZ-28 (Anon., 1988 a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as ‘islands’ surrounded by floodplain (Anon., 1988 b). For better understanding about the experimental site has been shown in the Map of AEZ of Bangladesh in Appendix-I.

3.2 Experimental Duration

The experiment was conducted during the period from December 2020 to May2021 in Transplanting *Boro* season.

3.3 Soil characteristics of the experimental field

Soil of the experimental site was silty clay loam in texture belonging to Tejgaon series (Anon., 1988 a). The area represents the Agro-Ecological Zone of Madhupur tract (AEZ No. 28) with pH 5.8–6.5, ECE-25–28 (Anon., 1988 b). Soil samples from 0- 15 cm depths were collected from the experimental field. The analytical data of the soil sample collected from the experimental area were analyzed in the Soil Resources Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka and have been presented in Appendix II.

3.4 Climate condition of the experimental field

The experimental area was under the subtropical climate and was characterized by high temperature, high humidity and heavy precipitation with occasional gusty winds during the period from March to August, but scanty rainfall associated with moderately low temperature prevailed during the period from March to August (Edris *et al.* 1979). The detailed meteorological data in respect of Maximum and minimum temperature, relative humidity and total rainfall were recorded by the meteorology centre, Dhaka for the period of experimentation have been presented in Appendix III.

3.5 Planting material

BRRI dhan29 was being used as test crops for this experiment.

3.6 Description of the planting material

Rice Variety: BRRI dhan 29	
Main Features of the Variety	
Developed by	Bangladesh Rice Research Institute (BRRI), Gazipur, Bangladesh
Method of development/origin	Origin BR 802-118-4-2
Year of release	1994
Main characteristics	Plant height 95 cm, medium slender and white
Planting season and time	Rabi, Boro, late October to Mid November
Harvesting time	Mid April to early May
Yield	7.5 t/ha
Resistance/tolerance	Moderately resistance to leaf blight, sheath blight

3.7 Seed collection and sprouting

BRRI dhan29 rice variety seed was collected from BRRI (Bangladesh Rice Research Institute), Joydebpur, Gazipur. Healthy and disease free seeds were selected following standard technique. Seeds were immersed in water in a bucket for 24 hrs. These were then taken out of water and kept in gunny bags. The seeds started sprouting after 48 hours which were suitable for sowing in 72 hours.

3.8 Raising of the T. *Boro* seedlings

A typical system was followed in raising of seedlings in the seedbed. The nursery bed was set up by puddling with continued ploughing followed by laddering. The sprouted seeds were planted as uniformly as possible. Irrigation was delicately given to the bed as and when required. No fertilizers were used in the nursery bed.

3.9 Preparation of experimental field

The experimental field was first opened on 20 January 2021 with the help of a power tiller, later the land was irrigated and prepared by three successive ploughings and cross-ploughings. Each ploughing was followed by laddering, to have a good puddled field. Various kind of weeds and developments of pest crop were disposed of from the field. Final land preparation and the field layout was made on 24 January 2021. Each plots were cleared in and finally leveled out with the help of wooden board.

3.10 Fertilizer management

The following doses of fertilizer were applied for cultivation of T. Boro rice (FRG, 2012).

Fertilizers	Quantity (kg/ha)
TSP	100
MP	120
Gypsum	60

Plant Macronutrients (*viz*. nitrogen, phosphorus, potash, sulfur) for rice were given through urea, triple super phosphate, muriate of potash, and gypsum, respectively. Plant micronutrients *viz*. Zinc and boron were as given through Zinc sulphate and boric acid according to the treatment requirements. All of the fertilizers except urea were applied as basal dose at the time of final land preparation. Urea supply nitrogen and it was applied in equal three splits according with par treatment requirement. The first dose of urea was applied at 21 days after transplanting (DAT). The second dose of urea was added as top dressing at 45 days (active vegetative stage) after transplanting and third dose was applied at 60 days (panicle initiation stage) after transplanting recommended by BRRI.

3.11 Experimental design and layout

The experiment was laid out in Split plot design having 3 replications. There were 12 treatment combinations and 36 unit plots. The unit plot size was 5.76 m^2 (2.4 m × 2.4

m). The blocks and unit plots were separated by 1.0 m and 0.50 m spacing, respectively. The treatments were assigned in plot at random. The layout of the experimental field was shown in Appendix- IV.

3.12 Experimental details

Seed bed preparation Date: 22 December 2020

Seed Sowing Date:23 December 2020

Spacing: 15 cm × 20 cm

Fertilizer apply Date: All the fertilizers were applied at 24 November 2020 during final land preparation except total urea

Transplanting Date: 27 January 2021

Harvesting Date: 21 May 2021

3.13 Experimental treatments

The experiment consisted of two factors as mentioned below:

Factor A: Different nitrogen doses (3) *viz:*

N_1 = 138 kg nitrogen ha^{-1}

N_2= 163 kg nitrogen ha^{-1}

N_3= 183 kg nitrogen ha^{-1} and

Factor B: Leaf cutting at different DAT (4) *viz:*

C_0 = No cutting (Control)

C_1 = Leaf cutting at 25 DAT

C_2 = Leaf cutting at 40 DAT

C_3 = Leaf cutting at 55 DAT

All leaves were cut except top three leaves

3.14 Experimental treatment combinations

There were 12 treatment combinations for this experiment. N_1C_0, N_1C_1, N_1C_2, N_1C_3, N_2C_0, N_2C_1 ,N_2C_2, N_2C_3, N_3C_0, N_3C_1, N_3C_2 and N_3C_3 were used as treatment combinations for this experiment.

3.15 Intercultural operations

3.15.1 Gap filling

Dead off Seedlings in some hills, were replaced by vigor and healthy seedling from same source within 7 days of transplantation.

3.15.2 Application of irrigation water

Irrigation water was added to each plot according to the critical stage. Irrigation was done up to 5 cm.

3.15.3 Method of water application

The experimental plots were irrigated through irrigation channels. Centimeter marked sticks were installed in each plot which were used to measure depth of irrigation water.

3.15.4 Weeding

Two hand weedings were done during plant growth period. First weeding was done at 20 DAT (Days after transplanting) followed by second weeding at 38 DAT.

3.15.5 Plant protection measures

The crop was attacked by yellow rice stem borer (*Scirpopagain certulas*) at the panicle initiation stage which was successfully controlled with Sumithion @ 1.5 L ha^{-1}. Yet to keep the crop growth in normal, Basudin was applied at tillering stage @ 17 kg ha^{-1} while Diazinon 60 EC @ 850 ml ha^{-1} were applied to control rice bug andleaf hopper. Crop was protected from birds during the grain filling period by using net and covering the experimental field.

3.15.6 General observations of the experimental field

Regular observations were made to see the growth and visual different of the crops, due to application of different treatment were applied in the experimental field. In general, the field looked nice with normal green plants. Incidence of stem borer, green leaf hopper, leaf roller was observed during tillering stage and there were also some rice bug were present in the experimental field. But any bacterial and fungal disease was not observed.

3.15.7 Harvesting and post harvest operation

The rice plant was harvested depending upon the maturity of grains and harvesting was done manually from each plot. Maturity of crop was determined when 80–90% of the grains become golden yellow in colour.Five (5) pre-selected hills per plot from which different data were collected and 1.00 m^2 areas from middle portion of each plot was separately harvested and bundled, properly tagged and then brought to the threshing floor.. Threshing was done by pedal thresher. The grains were cleaned and sun dried to moisture content of 12%. Straw was also sun dried properly. Finally grain and straw yields $plot^{-1}$ were recorded and converted to t ha^{-1}.

3.16 Data collection

The data were recorded on the following parameters

1. Morphological characters

i. Plant height (cm)
ii. Number of tillers $hill^{-1}$

2.Physiological Characters

iii. Leaf area index
iv. SPAD value
v. Above ground dry matter weight of $plant^{-1}$
vi. Stem reserve translocation (%)

3. Yield contributing characters

vii. Number of effective tillers $hill^{-1}$
viii. Number of non-effective tillers $hill^{-1}$
ix. Flag leaf area (cm^2)
x. Panicle length (cm)
xi. Number of filled grains $panicle^{-1}$
xii. Number of unfilled grains $panicle^{-1}$
xiii. Number of total grains $panicle^{-1}$
xiv. Weight of 1000- grain (g)

xv. Absolute grain growth rate

4. Yield

xvi. Grain yield (t ha^{-1})

xvii. Straw yield (t ha^{-1})

xviii. Biological yield (t ha^{-1})

xix. Harvest index (%)

3.17 Procedure of recording data

i) Plant height (cm)

The height of the randomly selected 5 plant was determined by measuring the distance from the soil surface to the tip of the leaf at different days after transplanting 25, 40, 55 and harvest respectively.Mean plant height of rice plant were calculated and expressed in cm.

ii) Number of tillers $hill^{-1}$

Number of tillers $hill^{-1}$ were counted at 25, 40, 55 days after transplanting and harvest respectively from pre selected hills and finally averaged as their number $hill^{-1}$. Only those tillers having three or more leaves were considered for counting.

iii) Leaf area index

Leaf area index were estimated manually by counting the total number of leaves per plant and measuring the length and average width of leaf and multiplying by a factor of 0.75 (Kluen and Wolf, 1986). It was done at 25, 40 and 55 DAT.

$$\text{Leaf area index} = \frac{\text{Surface area of leaf sample } (\text{cm}^2) \times \text{Correction factor}}{\text{Ground area from where the leaves were collected}}$$

iv) SPAD value

Spade value was measured by using chlorophyll meter. Five plants per plot were selected randomly and SPAD values at 35, 50 and 65 DAT were recorded from the fully matured leaves counted from the top of the plants, the youngest fully expanded leaf.

v) Above ground dry matter weight plant^{-1} (g)

Total above ground dry matter weight plant^{-1} was recorded at different days after transplanting and harvest respectively by drying plant sample. The sample plants were oven dried for 72 hours at 70°C and then data were recorded from plant samples selected at random from the outer rows of each plot leaving the border line and expressed in gram.

vi) Stem reserve translocation (%)

To determine the pre-anthesis photosynthetic stem translocation towards the final kernel weight the method describe by Gallagher *et al.* (1976) has beed used. This is based on the net loss in weight of stem between anthesis and maturity with the difference between yield and net assimilation. It was calculated as follows-

$$\text{Stem reserve translocation (\%)} = \frac{S_1\text{-}S_2}{G_2\text{-}G_1} \times 100$$

where,

S_1= Stem dry weight at anthesis

S_2= Stem dry weight at maturity

G_1= Grain dry weight at anthesis

G_2= Grain dry weight at maturity

vii) Number of effective tillers hill^{-1}

The total number of effective tillers hill^{-1} was counted as the number of panicle bearing tillers per hill. Data on effective tiller per hill were recorded from 5 randomly selected hill at harvesting time and average value was recorded.

viii) Number of non-effective tillers hill^{-1}

The total number of non-effective tillers hill^{-1} was counted as the tillers, which have no panicle on the head. Data on non-effective tiller per hill were counted from 5 pre-selected (used in effective tiller count) hill at harvesting time and average value was recorded.

ix) Flag leaf area (cm^2)

Flag leaf area of rice can be measured by flowing formula given by Aldesuquy *et al.* 2014.

Flag leaf area = Length x Breadth x 0.75

x) Panicle length

Measurement of panicle length was taken from basal node of the rachis to apex of each panicle. Panicle length was measured with a meter scale from 5 selected panicles and average value was recorded.

xi) Number of filled grains panicle^{-1}

The total number of filled grains was collected randomly from selected 5 plants of a plot and then average number of filled grains per panicle was recorded.

xii) Number of unfilled grains penicle^{-1}

The total number of unfilled grains was collected randomly from selected 5 plants of a plot based on, no or partially developed grain in spikelet and then average number of unfilled grains per panicle was recorded.

xiii) Number of total grains panicle^{-1}

The number of fertile grains panicle^{-1} alone with the number of sterile grains panicle^{-1} gave the total number of grains panicle^{-1}.

xiv) Weight of 1000-grain

One thousand cleaned dried seeds were counted randomly from each sample and weighed by using a digital electric balance at the stage the grain retained 12% moisture and the mean weight were expressed in gram.

xv) Absolute grain growth rate (AGGR)

The absolute grain growth rate (AGGR) was calculated by using the formula presented by Radford (1967) and expressed in g/day as follows:

$$AGGR = \frac{W_2 - W_1}{T_2 - T_1}$$

where, W_1 and W_2 are dry weights of grains at time T_1 and T_2, respectively.

xvi) Grain yield

Grain yield was adjusted at 14% moisture. Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of central 1m^2 area was measured and then record the final grain yield of each plot^{-1} and finally converted to t ha^{-1} in both locations. The grain yield t ha^{-1}was measured by the following formula:

$$\text{Grain yield (t ha}^{-1}\text{)} = \frac{\text{Grain yield per unti plot (kg)} \times 10000}{\text{Area of unit plot in square meter} \times 1000}$$

xvii) Straw yield

After separating the grains, straw yield was determined from the central 1 m^2 area of each plot. After threshing the sub-samples were sun dried to a constant weight and finally converted to t/ha-^{1}. The straw yield t ha^{-1} was measured by the following formula:

$$\text{Straw yield (t ha}^{-1}\text{)} = \frac{\text{Straw yield per unti plot (kg)} \times 10000}{\text{Area of unit plot in square meter} \times 1000}$$

xviii) Biological yield (t ha^{-1})

The summation of grain yield and above ground straw yield was the biological yield. Biological yield =Grain yield + straw yield.

xix) Harvest index (%)

Harvest index was calculated on dry weight basis with the help of following formula.

$$\text{Harvest index (HI \%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

Here, Biological yield = Grain yield + straw yield

3.18 Data analysis technique

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program name Statistix 10 data analysis softwareand the mean differences were adjusted by Least Significant Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

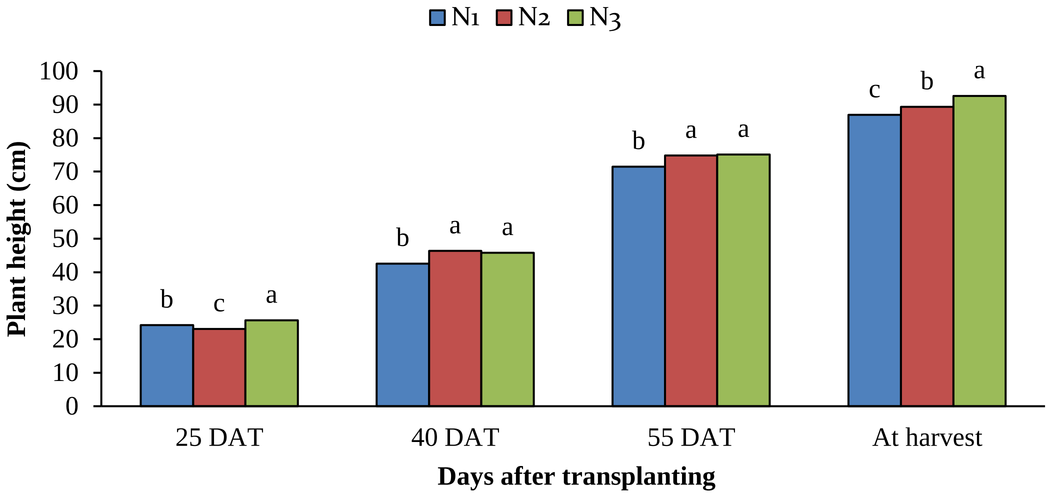
Results obtained from the present study have been presented and discussed in this chapter with a view to study the response of BRRI dhan29 to different dose of nitrogen and leaf cutting. The data are given in different tables and figures. The results have been discussed, and possible interpretations are given under the following headings.

4.1 Plant growth parameters

4.1.1 Plant height (cm)

4.1.1.1 Effect of nitrogen dose

Plant height is an important morphological character that acts as a potential indicator of availability of growth resources in its approach from the experiment, result revealed that, plant height showed significant variation due to application of different nitrogen doses (Figure.1, Appendix V). The maximum plant height (25.63, 45.81, 75.11 and 92.61 cm) were recorded at 25, 40, 55 DAT and at harvest respectively in N_3 treatment which was statistically similar with N_2treatment(46.33 and 74.81 cm) at 40 and 55 DAT respectively. Whereas the minimum plant height (23.07 cm) was recorded in N_2 treatment at 25 DAT. At 40, 55 DAT and at harvest respectively minimum plant height (42.56, 71.49 and 86.91 cm) were recorded in N_1 treatment. The increase in plant height in response to increasing application of N fertilizers is probably due to enhanced availability of nitrogen which enhanced more leaf area resulting in higher photo assimilates and thereby resulted in more dry matter accumulation. The result obtained from the present study was similar with the findings of Paul *at al.* (2016) who reported that levels of nitrogen had significant effect on plant height of HYV transplant rice. Mannan *et al*. (2010) reported that plant height was significantly increased with the increase in nitrogen level at different growth stages. Behera and Panda (2009) also reported that the cell size and its elongation and division that determine growth parameters like plant height was increases with nitrogen fertilization.

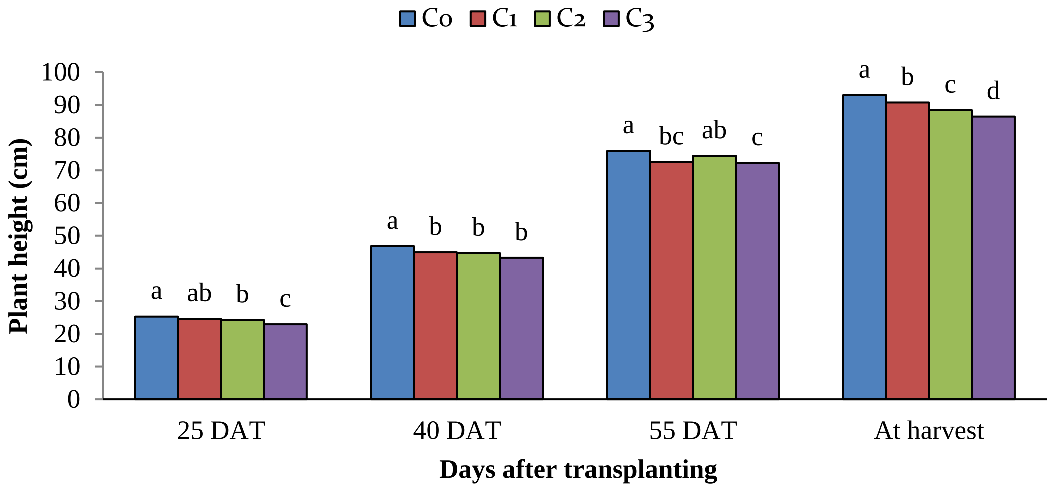


Note: Here, N_1 = 138 kg nitrogen ha^{-1} (Recommended), N_2= 163 kg nitrogen ha^{-1} and N_3= 183 kg nitrogen ha^{-1}

Fig. 1. Effect of nitrogen dose on plant height of BRRI dhan29 at different DAT ($LSD_{(0.05)}$= 0.65, 1.88, 1.73 and 1.90 at 25, 40, 55 DAT and at harvest respectively)

4.1.1.2 Effect of leaf cutting

Leaf cutting showed significant effect on plant height of BRRI dhan29 at different days after transplanting (Figure.2, Appendix V). From the experiment result revealed that the tallest plant height (25.33, 46.76, 75.98 and 92.96 cm) were recorded in C_0 treatment at 25, 40, 55 DAT and at harvest respectively which was statistically similar with C_1 (24.63 cm) treatment at 25 DAT and with C_2 (74.40 cm) treatment at 55 DAT. Whereas the lowest plant height (22.95, 43.24, 72.29 and 86.40 cm)were recorded in C_3 treatment at 25, 40, 55 DAT and at harvest respectively. Photosynthesis occurs in mesophyll cells of specialized organs such as leaves. The rigid cell wall encapsulating photosynthetic cells controls the expansion and distribution of cells within photosynthetic tissues. The relationship between photosynthesis and plant growth is affected by leaf area. Clipping of the leaves reduces photosynthesis area which reduces photosynthesis and ultimately impact on dry matter accumulation by plant as a result plant height become shorter comparable to non clipping of plants. The findings of the present study corroborate with the findings of Karmaker and Karmakar (2019); Medhi *et al*. (2015); Sherif *et al.* (2015). Karmaker and Karmakar (2019) reported that the highest plant height (128.95 cm) was recorded at C_0 (No leaf clipping) and the lowest plant height (116.83 cm) was found in C_3 (leaf clipping time at 55 DAT). Medhi *et al*. (2015) also showed that multiple times expulsion of foliage significantly decreased the plant height and prevented lodging.



Note: Here, C_0= No leaf cutting (Control), C_1 = Leaf cutting at 25 DAT, C_2 = Leaf cutting at 40 DAT and C_3 = Leaf cutting at 55 DAT

Fig. 2. Effect of leaf cutting on plant height of BRRI dhan29 at different DAT ($LSD_{(0.05)}$= 0.76, 1.70, 2.08 and 1.55 at 25, 40, 55 DAT and at harvest respectively)

4.1.1.3 Interaction effect of nitrogen dose and leaf cutting

BRRI dhan29 showed significant variation due to interaction effect of nitrogen dose and leaf cutting at different days after transplanting (Table 1, Appendix V). From the experiment result revealed that the maximum plant height (27.00, 49.05, 79.30 and 96.95 cm)were recorded at 25, 40, 55 DAT and at harvest respectively in N_3C_0 treatment combination which was statistically similar with N_3C_1 (26.66 cm) at 25 DAT; with N_2C_1 (47.94 cm) and N_2C_0 (47.33 cm) treatment combination at 40 DAT; with N_2C_2 (76.56 cm) treatment combination at 55 DAT. Whereas the minimum plant height (21.50, 40.09, 68.10 and 82.80 cm)were recorded at 25, 40, 55 DAT and at harvest respectively in N_1C_3 treatment combination which was statistically similar with N_2C_3(22.00 cm) and N_2C_3 (22.76 cm) treatment combination at 25 DAT and with N_1C_1 (41.62 and 71.53 cm) treatment combination at 40 and 55 DAT.

Table 1. Interaction effect of nitrogen dose and leaf cutting on plant height of BRRI dhan29 at different DAT

Treatment Combinations	Plant height			
	25 DAT	**40 DAT**	**55 DAT**	**At harvest**
N_1C_0	25.00 b	43.89 de	74.12 b-d	88.77 e-g
N_1C_1	25.23 b	41.62 ef	71.53 de	89.54 d-f
N_1C_2	25.00 b	44.64 cd	72.20 cd	86.53 g
N_1C_3	21.50 e	40.09 f	68.10 e	82.80 h
N_2C_0	24.00 b-d	47.33 a-c	74.53 b-d	93.17 b
N_2C_1	22.00 e	47.94 ab	72.83 cd	90.30 c-e
N_2C_2	23.53 cd	44.84 cd	76.56 ab	86.53 g
N_2C_3	22.76 de	45.20 b-d	75.33 bc	87.20 fg
N_3C_0	27.00 a	49.05 a	79.30 a	96.95 a
N_3C_1	26.66 a	45.22 b-d	73.27 b-d	92.23 bc
N_3C_2	24.26 bc	44.52 c-e	74.43 b-d	92.04 b-d
N_3C_3	24.60 bc	44.44 c-e	73.43 b-d	89.20 e-g
$LSD_{(0.05)}$	1.31	2.93	3.61	2.68
CV(%)	3.14	3.81	2.85	1.74

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

Notes viz:

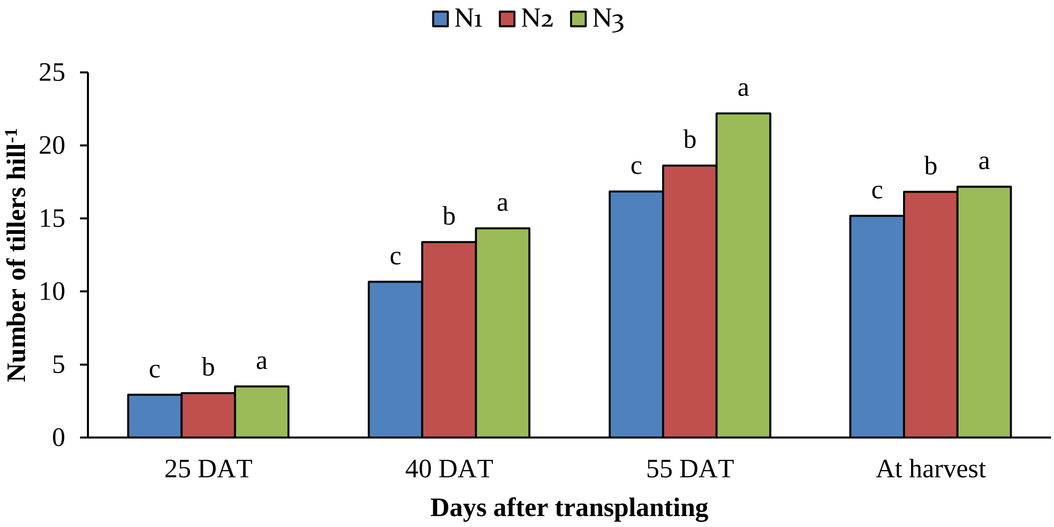
N_1 = 138 kg nitrogen ha^{-1} (Recommended)
N_2= 163 kg nitrogen ha^{-1}
N_3= 183 kg nitrogen ha^{-1}

C_0= No leaf cutting (Control)
C_1 = Leaf cutting at 25 DAT
C_2 = Leaf cutting at 40 DAT
C_3 = Leaf cutting at 55 DAT

4.1.2 Number of tillers hill^{-1}

4.1.2.1 Effect of nitrogen dose

BRRI dhan29 showed significant variation on number of tillers hill^{-1} due to the effect of nitrogen dose at various days after transplanting (Fig. 3, Appendix VI). The maximum tillers number hill^{-1} (3.50, 14.33, 22.20 and 17.18) were recorded at 25, 40, 55 DAT and at harvest respectively in N_3 treatment. Whereas the minimum tillers number hill^{-1} (2.92, 10.66, 16.85 and 15.18 cm)were recorded at 25, 40, 55 DAT and at harvest respectively in N_1 treatment. Number of tillers per hill is the most important component of yield. More the number of tillers, especially fertile tillers, the more will be the yield. Numbers of tillers were increased within increasing amount of N which could be attributed to the influence of N on leaf development, tiller production and increasing leaf photosynthetic activity. Haque and Haque (2016) also found similar result which supported the present finding and reported that maximum the number of tillers hill^{-1} (14.44) was recorded with the increasing nitrogen treatment. Yosef Tabar (2012) reported that maximum tiller number was observed for 150 kg ha^{-1} nitrogen and minimum of that was obtained for 50 kg ha^{-1} nitrogen fertilizer.



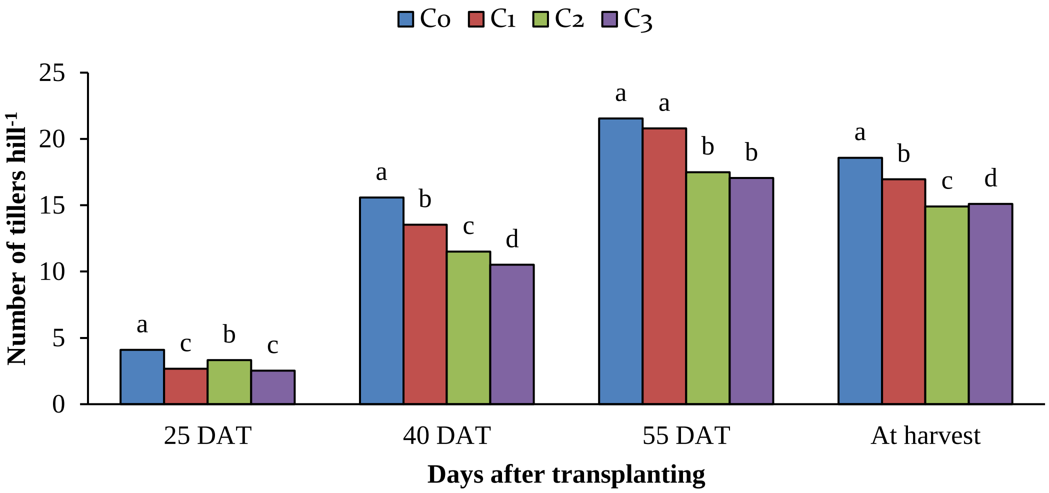
Note: Here, N_1 = 138 kg nitrogen ha^{-1} (Recommended), N_2= 163 kg nitrogen ha^{-1} and N_3= 183 kg nitrogen ha^{-1}

Fig. 3. Effect of nitrogen dose on number of tillers of BRRI dhan29 at different DAT ($LSD_{(0.05)}$= 0.12, 0.22, 0.50 and 0.33 at 25, 40, 55 DAT and at harvest respectively)

4.1.2.2 Effect of leaf cutting

Significant effect was observed on number of tillers hill^{-1} of BRRI dhan29 due to leaf cutting at various days after transplanting (Fig.4, Appendix VI). The maximum number of tillers hill^{-1} (4.10, 15.59, 21.54 and 18.59) were recorded at 25, 40, 55

DAT and at harvest respectively in C_0 treatment which was statistically similar with C_1 treatment (20.80) at 55 DAT. While the minimum number of tillers hill^{-1} (2.53, 10.51 and 17.05)were recorded at 25, 40 and 55 DAT in C_3 treatment which was statistically similar C_1(2.67)treatment at 25 DAT and with C_3 (17.50) treatment at 55 DAT. At harvest respectively the minimum number of tillers hill^{-1} (14.92) was recorded in C_2 treatment which was statistically similar with C_3 (15.10) treatment.



Note: Here, C_0= No leaf cutting (Control), C_1 = Leaf cutting at 25 DAT, C_2 = Leaf cutting at 40 DAT and C_3 = Leaf cutting at 55 DAT

Fig. 4. Effect of leaf cutting on number of tillers of BRRI dhan29 at different DAT ($LSD_{(0.05)}$= 0.17 , 0.54, 0.79 and 0.35 at 25, 40, 55 DAT and at harvest respectively)

4.1.2.3 Interaction effect of nitrogen dose and leaf cutting

BRRI dhan29 showed significant variation on number of tillers hill^{-1}due to interaction effect of nitrogen dose and leaf cutting at different days after transplanting (Table 2, Appendix VI). The maximum number of tillers hill^{-1}(5.00, 17.33, 23.97 and 19.60)were recorded in N_3C_0 treatment combination at 25, 40, 55 DAT and at harvest respectively which was statistically similar with N_2C_0 (16.77) treatment combination at 40 DAT; with N_3C_1 (23.97) treatment combination at 55 DAT and with N_2C_0 (19.20) treatment combination at harvest respectively. Whereas the minimum number of tillers hill^{-1} (2.00, 9.20, 13.86 and 14.10)were recorded in N_1C_3 treatment combination at 25, 40, 55 DAT and at harvest respectively which was statistically similar with N_2C_1 (2.00) and N_1C_1 (2.00) treatment combination at 25 DAT; with N_2C_3 (10.00) treatment combination at 40 DAT and with N_1C_2 (14.86 and 14.10) treatment combination at 55 DAT and at harvest respectively.

Table 2. Interaction effect of nitrogen dose and leaf cutting number of tillers hill of BRRI dhan29 at different DAT

Treatment Combinations	Number of tillers per hill			
	25 DAT	**40 DAT**	**55 DAT**	**At harvest**
N_1C_0	4.00 b	12.67 d	19.33 c	16.97c
N_1C_1	2.00 f	10.42 e	19.33 c	15.53 d
N_1C_2	3.66 c	10.33 e	14.86 e	14.10 e
N_1C_3	2.00 f	9.20 f	13.86 e	14.10 e
N_2C_0	3.30 de	16.77 a	21.33 b	19.20 a
N_2C_1	2.00 f	14.53 c	19.10 c	17.23 c
N_2C_2	3.30 de	12.20 d	16.87 d	15.43 d
N_2C_3	3.60 cd	10.00 ef	17.20 d	15.43 d
N_3C_0	5.00 a	17.33 a	23.97 a	19.60 a
N_3C_1	4.00 b	15.67 b	23.97 a	18.10 b
N_3C_2	3.00 e	12.00 d	20.76 b	15.23 d
N_3C_3	2.00 f	12.33 d	20.10 bc	15.77 d
$LSD_{(0.05)}$	0.30	0.93	1.37	0.60
CV(%)	5.57	4.25	4.16	2.14

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

Notes viz:

N_1 = 138 kg nitrogen ha^{-1} (Recommended)

N_2= 163 kg nitrogen ha^{-1}

N_3= 183 kg nitrogen ha^{-1}

C_0= No leaf cutting (Control)

C_1 = Leaf cutting at 25 DAT

C_2 = Leaf cutting at 40 DAT

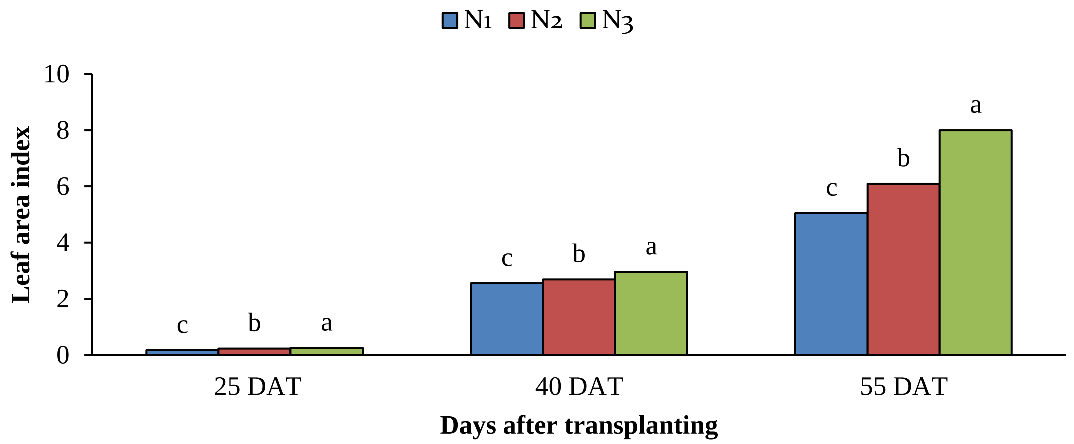
C_3 = Leaf cutting at 55 DAT

4.2 Physiological Characters

4.2.1 Leaf area index

4.2.1.1 Effect of nitrogen dose

The levels of LAI will vary with the canopy architecture, which depends on the cultivars, geography, and different field management practices. Due to different dose of nitrogen application leaf area index of BRRI dhan29 significantly different at different days after transplanting (Fig. 5, Appendix VII). The maximum leaf area index (0.25, 2.96 and 8.00)were recorded at 25, 40 and 55 DAT in N_3 treatment whereas minimum leaf area index (0.17, 2.55 and 5.05) were recorded in N_1 treatment. Nitrogen is needed to produce leaves, stems and vegetation growth. Nitrogen is part of the chlorophyll molecule, which gives plants their green color and is involved in creating food for the plant through photosynthesis. The main effect of N fertilizer is to increase the rate of leaf expansion, leading to increased interception of daily solar radiation by the canopy. The difference of leaf area index was due to reason that increasing nitrogen dose gradually increasing leaf number and leaf area though utilization of nitrogen which ultimately impact on leaf area index. The result obtained from the present study was similar with the findings of Azarpour *et al.* (2014) who reported that leaf area index (LAI) significantly increase with 90 kg N ha^{-1} application compared to control treatment.

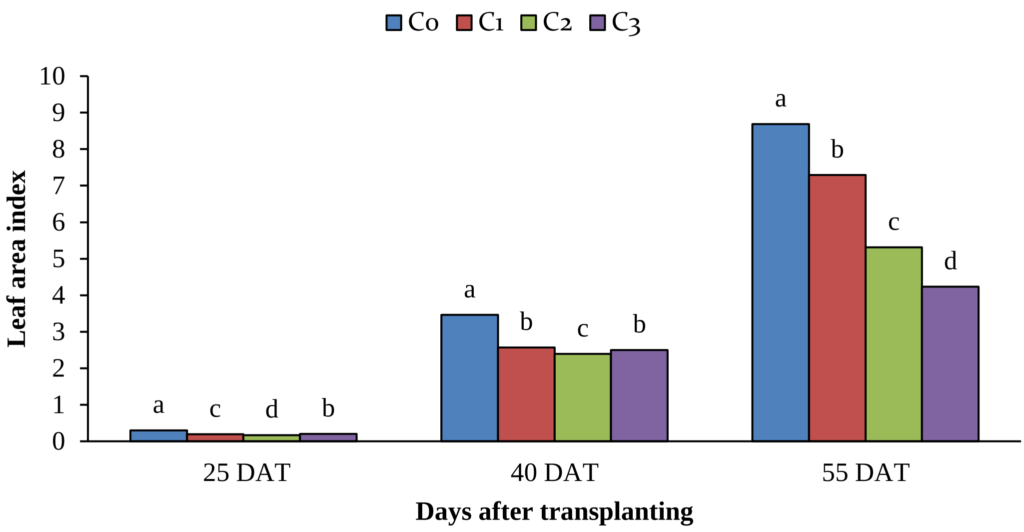


Note: Here, N_1 = 138 kg nitrogen ha^{-1} (Recommended), N_2= 163 kg nitrogen ha^{-1} and N_3= 183 kg nitrogen ha^{-1}

Fig. 5. Effect of nitrogen dose on leaf area index of BRRI dhan29 at different DAT ($LSD_{(0.05)}$= 0.003, 0.07 and 0.36 at 25, 40 and 55 DAT)

4.2.1.2 Effect of leaf cutting

In case of leaf area index no clipping showed significantly better result comparable to others treatment (Fig. 6, Appendix VII). The maximum leaf area index (0.30, 3.46 and 8.69)were recorded in C_0 treatment at 25, 40 and 55 DAT respectively. Whereas minimum leaf area index (0.17and 2.39) were recorded in C_2 treatment at 25 and 40 DAT. And at 55 DAT minimum leaf area index (4.23) was recorded in C_3 treatment. Various leaf cutting reduced the number of leaves which ultimately impact on leaf area and leaf area index, as leaf area index is related with the number of leaves and reduction of its reduces photosynthesis activities of the plant as a results its impacts on growth, development and grain yield in rice.



Note: Here, C_0= No leaf cutting (Control), C_1 = Leaf cutting at 25 DAT, C_2 = Leaf cutting at 40 DAT and C_3 = Leaf cutting at 55 DAT

Fig. 6. Effect of leaf cutting on leaf area index of BRRI dhan29 at different DAT ($LSD_{(0.05)}$= 0.008, 0.09 and 0.44 at 25, 40 and 55 DAT)

4.2.1.3 Interaction effect of nitrogen dose and leaf cutting

Interaction effect of nitrogen dose and leaf cutting showed significant effect on leaf area index at different days after transplanting (Table 3, Appendix VII). Experiment result showed that the maximum leaf area index (0.40, 3.65 and 11.20) at 25, 40 and 55 DAT was recorded in N_3C_0 treatment combination which was statistically similar with N_2C_0(3.62) treatment combination at 40 DAT. Whereas at 25 DAT the minimum leaf area index (0.10) was recorded in N_3C_2 treatment combination which was statistically similar with N_2C_1 (0.11) treatment combination. At 40 DAT the minimum leaf area index (1.87) was recorded in N_1C_2 treatment combination and at 55 DAT the minimum leaf area index (3.07) was recorded in N_1C_3 treatment combination which was statistically similar with N_1C_2 (3.68) treatment combination.

Table 3. Interaction effect of nitrogen dose and leaf cutting on leaf area index of BRRI dhan29 at different DAT

Treatment Combinations	Leaf Area Index		
	25 DAT	**40 DAT**	**55 DAT**
N_1C_0	0.20 de	3.10 b	7.65 c
N_1C_1	0.14 f	2.51 d	5.80 e
N_1C_2	0.19 e	1.87 g	3.68 g
N_1C_3	0.15 f	2.70 c	3.07 g
N_2C_0	0.31 b	3.62 a	7.21 cd
N_2C_1	0.11 g	2.65 cd	7.12 cd
N_2C_2	0.21 d	2.35 e	5.56 e
N_2C_3	0.27 c	2.12 f	4.48 f
N_3C_0	0.40 a	3.65 a	11.20 a
N_3C_1	0.31 b	2.55 cd	8.97 b
N_3C_2	0.10 g	2.95 b	6.69 d
N_3C_3	0.19 e	2.68 c	5.15 ef
$LSD_{(0.05)}$	0.01	0.15	0.77
CV(%)	4.03	3.28	6.99

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

Notes viz:

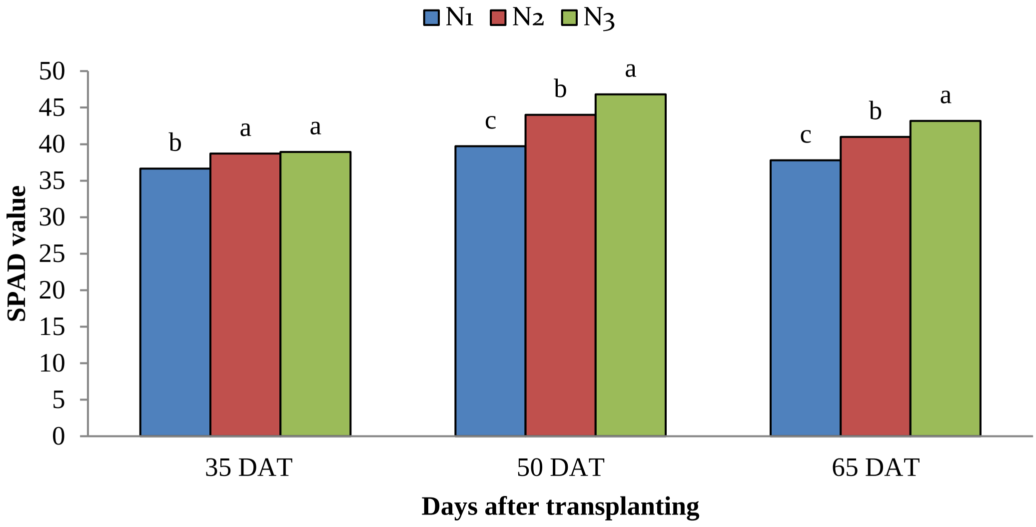
N_1 = 138 kg nitrogen ha^{-1} (Recommended)
N_2= 163 kg nitrogen ha^{-1}
N_3= 183 kg nitrogen ha^{-1}

C_0= No leaf cutting (Control)
C_1 = Leaf cutting at 25 DAT
C_2 = Leaf cutting at 40 DAT
C_3 = Leaf cutting at 55 DAT

4.2.2 SPAD value

4.2.2.1 Effect of nitrogen dose

SPAD value determine the nitrogen status in the leaf. Due to different doses of nitrogen application SPAD value differ significantly at different days after transplanting of BRRI dhan29 (Fig. 7, Appendix VIII). Experiment result showed that maximum SPAD value (38.94, 46.82 and 43.20) were recorded at 35, 50 and 65 DAT in N_3 treatment which was statistically similar with N_2 (38.71) treatment at 35 DAT, whereas minimum SPAD value (36.67, 39.72 and 37.79) were recorded at 35, 50 and 65 DAT in N_1 treatment. The result obtained from the present study was similar with the findings of Ghosh *et al.* (2013) who reported that the SPAD value of 36 was found to be critical for Eastern India, unlike the value of 35 recommended for the Philippines and application of less amount of fertilizer N in split during tillering to heading stage under RTNM (real time N management) improved the growth and productivity of rice as compared to those in FTNM (fixed time N management). Singh *et al.* (2009) reported that, leaf colour chart (LCC) and chlorophyll meter (SPAD) as important tools to diagnose the nitrogen status in rice to decide time of N topdressing. Turner and Jund (1991) reported that SPAD values were influenced by plant growth stage, cultivar, leaf thickness, fertilizers, plant population and any soil or climatic factor causing leaf chlorosis. SPAD values did not indicate how much N to apply, but they only indicated the need for additional N.

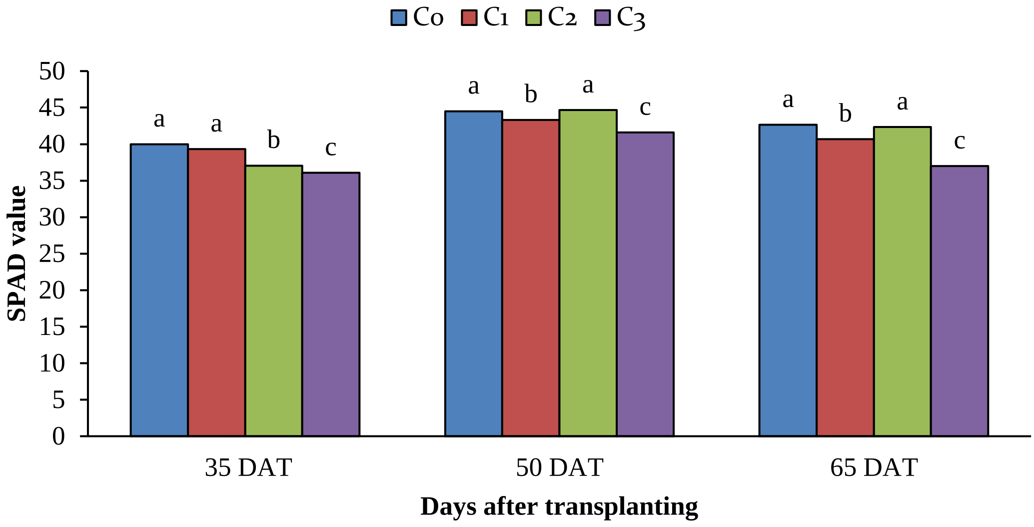


Note: Here, N_1 = 138 kg nitrogen ha^{-1} (Recommended), N_2= 163 kg nitrogen ha^{-1} and N_3= 183 kg nitrogen ha^{-1}

Fig. 7. Effect of nitrogen dose on SPAD value of BRRI dhan29 at different DAT ($LSD_{(0.05)}$= 1.14, 0.33 and 0.25 at 35, 50 and 65 DAT)

4.2.2.2 Effect of leaf cutting

Leaf cutting showed significant different on SPAD value of BRRI dhan29 at different days after transplanting (Fig. 8, Appendix VIII). Experiment result showed that at 35 DAT maximum SPAD value (40.00) was recorded in C_0 treatment which was statistically similar with C_1 (39.31) treatment. At 50 DAT maximum SPAD value (44.65) was recorded in C_2 treatment which was statistically similar with C_0 (44.50) treatment. At 65 DAT maximum SPAD value (42.67) was recorded in C_0 treatment which was statistically similar with C_2 (42.33) treatment. Whereas the minimum SPAD value (36.06, 41.60, 36.99) at 35, 50 and 65 DAT was recorded in C_3 treatment. Different leaf cutting at different DAT influence SPAD value due to reason that most species had higher nitrogen in young leaves compared to mature leaves and removal of leaves reduced nitrogen content as a result its impact on SPAD value.



Note: Here, C_0= No leaf cutting (Control), C_1 = Leaf cutting at 25 DAT, C_2 = Leaf cutting at 40 DAT and C_3 = Leaf cutting at 55 DAT

Fig. 8. Effect of leaf cutting on SPAD value of BRRI dhan29 at different DAT ($LSD_{(0.05)}$= 0.94, 0.92 and 1.00 at 35, 50 and 65 DAT)

4.2.2.3 Interaction effect of nitrogen dose and leaf cutting

Interaction effect of nitrogen dose and leaf cutting showed significant effect on SPAD value at different days after transplanting (Table 4, Appendix VIII). Experiment result showed that the maximum SPAD value (42.00, 48.50, 45.20) at 35, 50 and 65 DAT was recorded in N_3C_0 treatment combination which was statistically similar with N_3C_1 (41.76) treatment combination at 35 DAT; with N_3C_2 (47.40) treatment combination at 50 DAT and with N_3C_2 (44.80), N_2C_0 (44.80), N_1C_2 (44.50) and N_3C_1 (43.80) treatment combination at 65 DAT. Whereas the minimum SPAD value (34.43, 38.53 and 34.06) at 35, 50 and 65 DAT was recorded in N_1C_3 treatment combination which was statistically similar with N_3C_3 (35.16) and N_1C_2 (35.86) treatment combination at 35 DAT; with N_1C_1 (39.10) and N_1C_0 (40.00) treatment combination at 50 DAT and with N_1C_1 (34.60) treatment combination at 65 DAT.

Table 4. Interaction effect of nitrogen dose and leaf cutting on SPAD value of BRRI dhan29 at different DAT

Treatment Combinations	SPAD Value 35 DAT	50 DAT	65 DAT
N_1C_0	38.50 b	40.00 de	38.00 c
N_1C_1	37.90 bc	39.10 e	34.60 d
N_1C_2	35.86 de	41.26 d	44.50 ab
N_1C_3	34.43 e	38.53 e	34.06 d
N_2C_0	39.50 b	45.00 c	44.80 ab
N_2C_1	38.26 bc	44.80 c	43.60 b
N_2C_2	38.50 b	45.30 c	37.70 c
N_2C_3	38.59 b	41.00 d	37.90 c
N_3C_0	42.00 a	48.50 a	45.20 a
N_3C_1	41.76 a	46.10 bc	43.80 ab
N_3C_2	36.83 cd	47.40 ab	44.80 ab
N_3C_3	35.16 e	45.26 c	39.00 c
$LSD_{(0.05)}$	1.62	1.59	1.73
CV(%)	2.48	2.13	2.49

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

Notes viz:

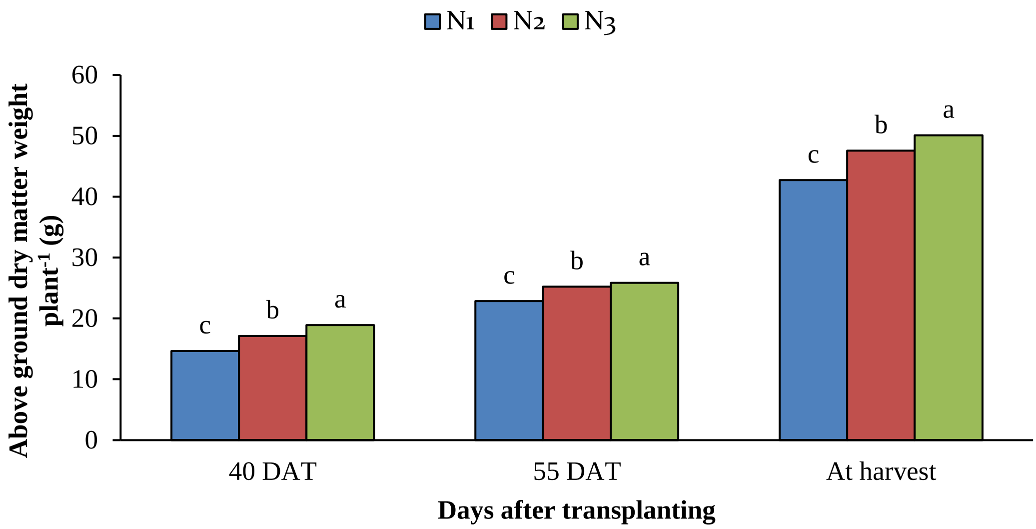
N_1 = 138 kg nitrogen ha^{-1} (Recommended)
N_2= 163 kg nitrogen ha^{-1}
N_3= 183 kg nitrogen ha^{-1}

C_0= No leaf cutting (Control)
C_1 = Leaf cutting at 25 DAT
C_2 = Leaf cutting at 40 DAT
C_3 = Leaf cutting at 55 DAT

4.2.3 Above ground dry matter weight $plant^{-1}$ (g)

4.2.3.1 Effect of nitrogen dose

The above ground dry matter weight $plant^{-1}$consists of all its constituents excluding water. Different nitrogen doses showed significant effect on above ground dry matter weight $plant^{-1}$of BRRI dhan29 at various days after transplanting (Fig. 9, Appendix IX). The maximum dry matter weight $plant^{-1}$ (18.92, 25.87 and 50.09 g) were recorded at 40, 55 DAT and at harvest respectively in N_3 treatment whereas the minimum dry matter weight plant^{-1} (14.66, 22.84 and 42.72 g) were recorded in N_1 treatment at 40, 55 DAT and at harvest respectively. The higher dry mass of increasing nitrogen treated plants could be connected with the positive effect of nitrogen in some important physiological processes. Reddy (2000) also found similar result which supported the present finding and reported that dry matter accumulation was increasing through increasing vegetative growth resulting from higher photosynthetic activities is well known to be influenced by nitrogen.

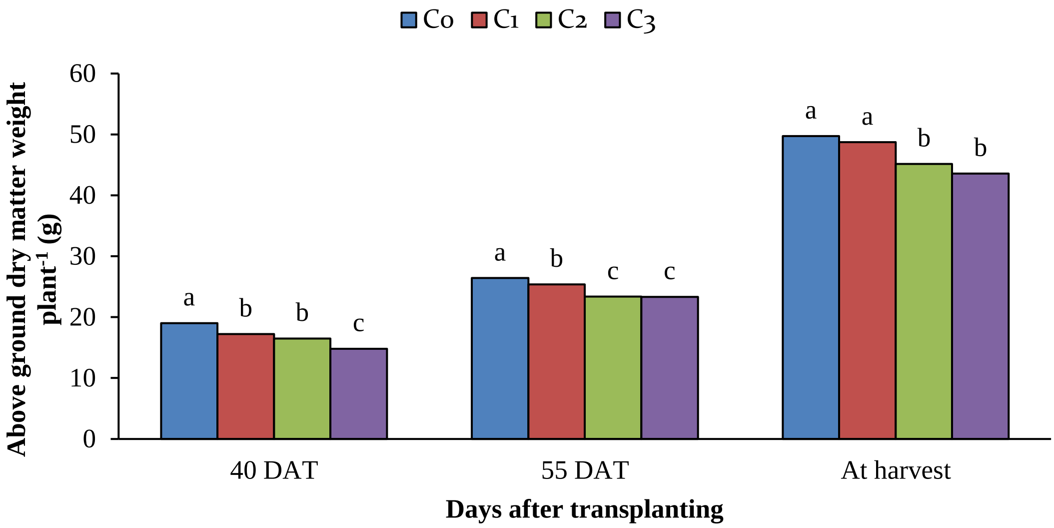


Note: Here, N_1 = 138 kg nitrogen ha^{-1} (Recommended), N_2= 163 kg nitrogen ha^{-1} and N_3= 183 kg nitrogen ha^{-1}

Fig. 9. Effect of nitrogen dose on above ground dry matter weight plant^{-1} of BRRI dhan29 at different DAT ($LSD_{(0.05)}$= 0.93, 0.66 and 1.45 at 40, 55 DAT and at harvest respectively)

4.2.3.2 Effect of Leaf cutting

Leaf cutting of BRRI dhan29 showed significant variation on above ground dry matter weight plant^{-1} at various days after transplanting (Fig. 10, Appendix IX). The maximum above ground dry matter weight plant^{-1} (19.04, 26.41 and 49.72 g)were recorded in C_0 treatment at 40, 55 DAT and at harvest respectively which was statistically similar with C_1 (48.71 g) treatment at harvest. Whereas the minimum above ground dry matter weight plant^{-1} (14.83, 23.35 and 43.57 g)were recorded in C_3 treatment at 40, 55 DAT and at harvest respectively which was statistically similar with C_2 (23.37 and 45.15 g) treatment at 55 DAT at harvest respectively. Number of leaves influences the leaf area where photosynthesis take place. Plant dry matter accumulation increasing when photosynthesis is greater than respiration which sustains the plant's growth and development. But clipping of leaves reduces leaf area as a result lesser photosynthesis take place which impact on development of the plant comparable to no clipping plant. Sherif *et al.* (2015) reported that the sharp reduction in dry matter content was observed in the first season (2013-14) at 80 or 100% defoliation (938.15 and 765.00 g/m^{2}respectively. In the second season (2014-15), defoliations at 60, 80 or 100% resulted in low levels of dry matter content; 866.11, 861.26 or 840.04 g/m^2 respectively.



Note: Here, C_0= No leaf cutting (Control), C_1 = Leaf cutting at 25 DAT, C_2 = Leaf cutting at 40 DAT and C_3 = Leaf cutting at 55 DAT

Fig. 10. Effect of leaf cutting on above ground dry matter weight plant^{-1} of BRRI dhan29 at different DAT (LSD$_{(0.05)}$= 0.87, 0.88 and 1.72 at 40, 55 DAT and at harvest respectively)

4.2.3.3 Interaction effect of nitrogen dose and leaf cutting

Interaction effect of nitrogen dose and leaf cutting showed significant variation in respect of above ground dry matter weight plant^{-1} of BRRI dhan29 at various days after transplanting (Table 5, Appendix IX). From the experiment result revealed that the maximum above ground dry matter weight plant^{-1} (21.23. 27.57 and 54.09 g) were recorded in N_3C_0 treatment at 40, 55 DAT and at harvest respectively which was statistically similar with N_3C_1 (27.53) and N_2C_0 (27.40) treatment combination at 55

DAT and with N_3C_1 (52.44) treatment combination at harvest respectively. Whereas the minimum dry matter weight plant^{-1} (11.12, 21.65 and 38.01 g)were recorded in N_1C_3 treatment combination at 40, 55 DAT and at harvest respectively which was statistically similar with N_1C_1 (22.69) and N_1C_2 (22.74) treatment combination at 55 DAT.

Table 5. Interaction effect of nitrogen dose and leaf cutting on above ground dry matter weight (g) of BRRI dhan29 at different DAT

Treatment Combinations	Above ground dry matter weight		
	40 DAT	**55 DAT**	**At harvest**
N_1C_0	16.80 de	24.27 c	46.29 d-f
N_1C_1	15.47 ef	22.69 e	43.38 fg
N_1C_2	15.23 f	22.74 de	43.20 g
N_1C_3	11.12 g	21.65 e	38.01 h
N_2C_0	19.10 bc	27.40 ab	48.78 cd
N_2C_1	16.58 d-f	25.98 b	50.31 bc
N_2C_2	16.58 d-f	23.18 cd	45.03 e-g
N_2C_3	16.25 d-f	24.22 c	46.08 d-g
N_3C_0	21.23 a	27.57 a	54.09 a
N_3C_1	19.61 b	27.53 a	52.44 ab
N_3C_2	17.72 cd	24.19 cd	47.22 de
N_3C_3	17.12 d	24.18 cd	46.62 de
$LSD_{(0.05)}$	1.51	1.47	2.98
CV(%)	5.22	3.62	3.72

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

Notes viz:

N_1 = 138 kg nitrogen ha^{-1} (Recommended)

N_2= 163 kg nitrogen ha^{-1}

N_3= 183 kg nitrogen ha^{-1}

C_0= No leaf cutting (Control)

C_1 = Leaf cutting at 25 DAT

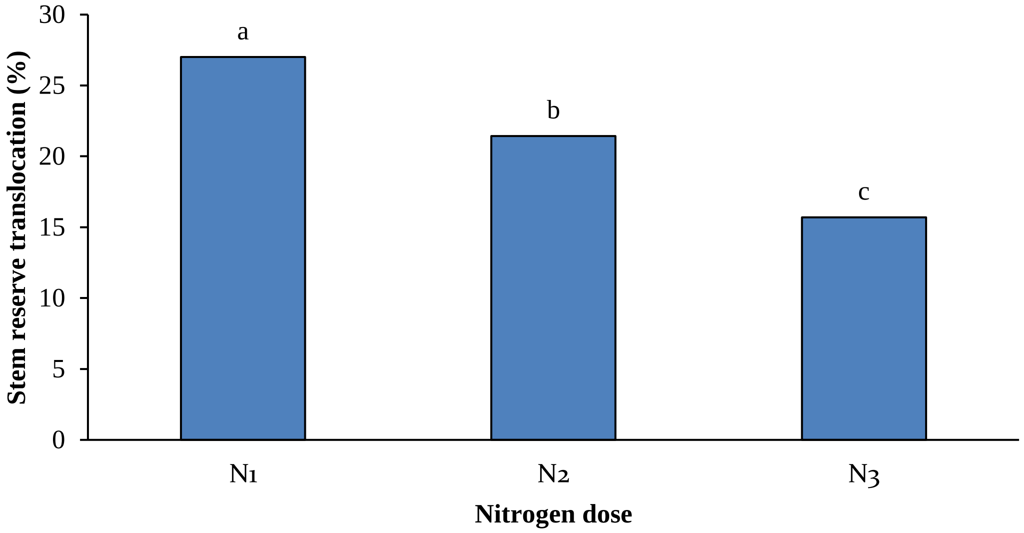
C_2 = Leaf cutting at 40 DAT

C_3 = Leaf cutting at 55 DAT

4.2.4 Stem reserve translocation (%)

4.2.4.1 Effect of nitrogen dose

Different nitrogen dose significantly effect on stem reserve translocation (%) of BRRI dhan29 (Fig. 11, Appendix XI). Experiment result showed that maximum stem reserve translocation (27.01 %) was recorded in N_1 treatment whereas minimum stem reserve translocation (15.71 %) was recorded in N_3 treatment.

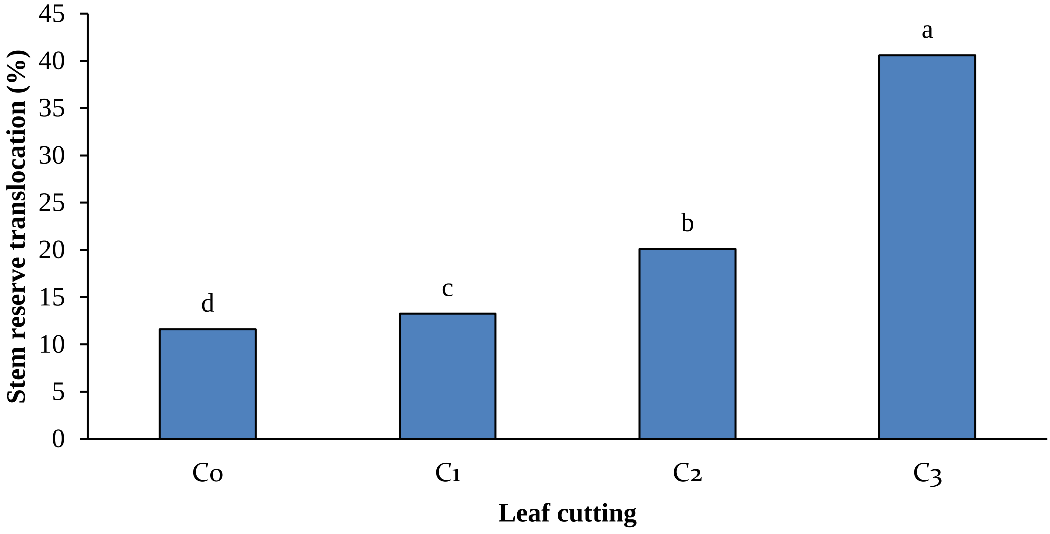


Note: Here, N_1 = 138 kg nitrogen ha^{-1} (Recommended), N_2= 163 kg nitrogen ha^{-1} and N_3= 183 kg nitrogen ha^{-1}

Fig. 11. Effect of nitrogen dose on stem reserve translocation (%) of BRRI dhan29 ($LSD_{(0.05)}$= 0.33)

4.2.4.2 Effect of leaf cutting

Leaf cutting of BRRI dhan29 showed significantly effect on stem reserve translocation (%) (Fig. 12, Appendix XI). From the experiment result showed that the maximum stem reserve translocation was recorded in C_3 (40.57 %) treatment. While the minimum stem reserve translocation was observed in C_0 (11.60 %) treatment.



Note: Here, C_0= No leaf cutting (Control), C_1 = Leaf cutting at 25 DAT, C_2 = Leaf cutting at 40 DAT and C_3 = Leaf cutting at 55 DAT

Fig. 12. Effect of leaf cutting on stem reserve translocation (%) of BRRI dhan29 ($LSD_{(0.05)}$= 0.83)

4.2.4.3 Interaction effect of nitrogen dose and leaf cutting

Application of different nitrogen dose along with leaf cutting showed significant variation in respect of stem reserve translocation (%) of BRRI dhan29 (Table 6, Appendix XI). Experiment result showed that the maximum stem reserve translocation (41.63 %) was recorded in N_3C_3 treatment combination which was statistically similar with N_2C_3 (40.49 %) treatment combination whereas the minimum stem reserve translocation (6.13) was recorded in N_3C_0 treatment combination which was statistically similar with N_3C_2 (6.46 %) treatment combination.

Table 6. Interaction effect of nitrogen dose and leaf cutting on stem reserve translocation of BRRI dhan29

Treatment Combinations	Stem reserve translocation
N_1C_0	20.76 d
N_1C_1	21.07 d
N_1C_2	26.63 c
N_1C_3	39.59 b
N_2C_0	7.92 f
N_2C_1	10.11 e
N_2C_2	27.25 c
N_2C_3	40.49 ab
N_3C_0	6.13 g
N_3C_1	8.61 f
N_3C_2	6.46 g
N_3C_3	41.63 a
$LSD_{(0.05)}$	1.43
CV(%)	3.91

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

Notes viz:

N_1 = 138 kg nitrogen ha^{-1} (Recommended)

N_2= 163 kg nitrogen ha^{-1}

N_3= 183 kg nitrogen ha^{-1}

C_0= No leaf cutting (Control)

C_1 = Leaf cutting at 25 DAT

C_2 = Leaf cutting at 40 DAT

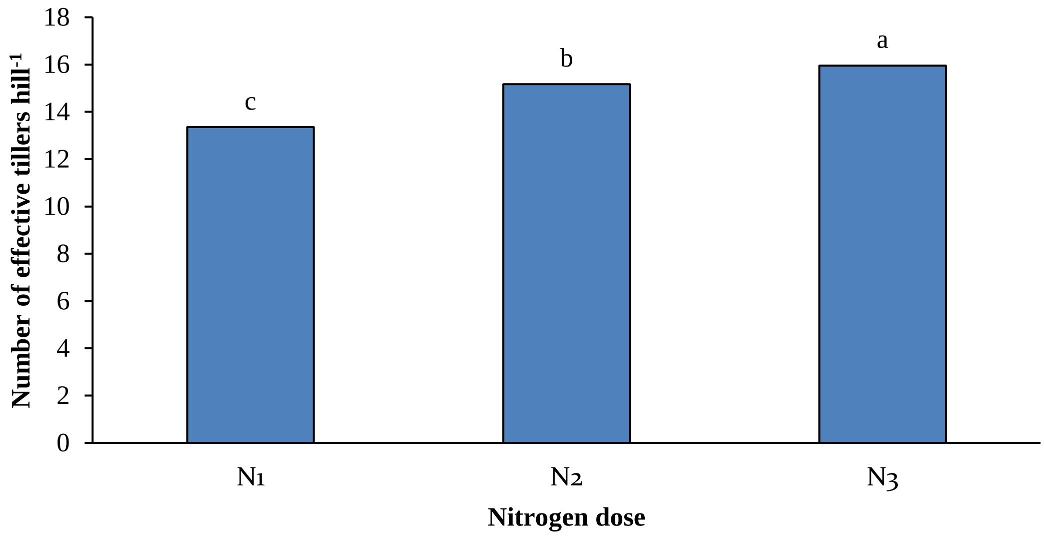
C_3 = Leaf cutting at 55 DAT

4.3. Yield contributing characters

4.3.1 Number of effective tillers hill^{-1}

4.3.1.1 Effect of nitrogen dose

Application of different nitrogen dose significantly effect on number of effective tillers hill^{-1} of BRRI dhan29 (Fig.13, Appendix X). The maximum number of effective tillers hill^{-1} (15.96) was recorded in N_3 treatment whereas minimum number of effective tillers hill^{-1} (13.35) was recorded in N_1 treatment. Puteh *et al.* (2014) and Pandey *et al.* (2008)found similar results with the present study and reported that highest number of effective tillers hill^{-1} with increasing nitrogen doses.

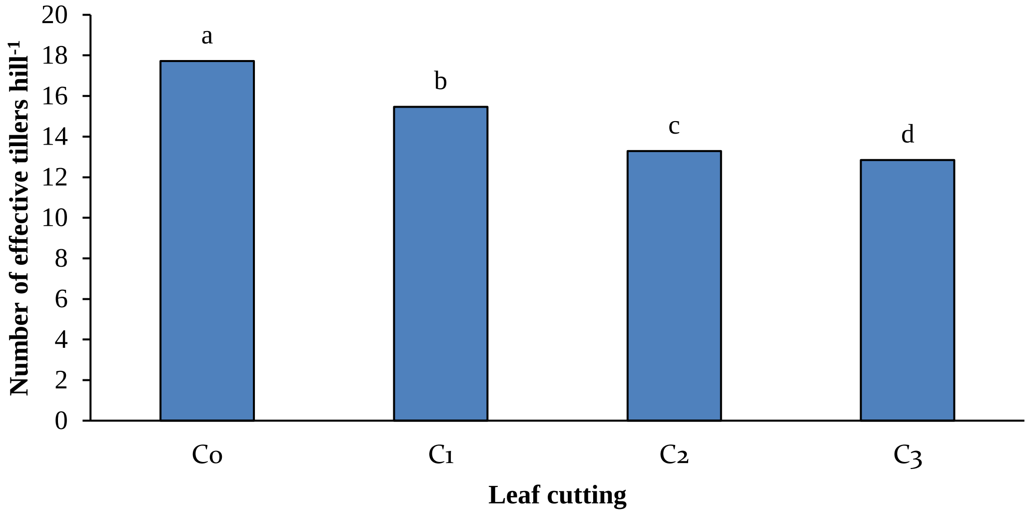


Note: Here, N_1 = 138 kg nitrogen ha^{-1} (Recommended), N_2= 163 kg nitrogen ha^{-1} and N_3= 183 kg nitrogen ha^{-1}

Fig. 13. Effect of nitrogen dose on number of effective tillers hill^{-1} of BRRI dhan29 ($LSD_{(0.05)}$= 0.36)

4.3.1.2 Effect of leaf cutting

Leaf cutting of BRRI dhan29 showed significantly effect on number of effect tillers hill^{-1} (Fig. 14, Appendix X). From the experiment result showed that the maximum number of effect tillers hill^{-1} was observed in C_0 (17.72) treatment. While the minimum number of effective tillers hill^{-1} was observed in C_3 (12.84) treatment. Fatima *et al.* (2019) reported that the highest number of effective tillers hill^{-1} was recorded from Heera 4 under control (without leaf cutting) condition. On the other hand, the dissimilar result was reported by Marsom (2015) He found that cutting of leaves had no significant effect on tiller number plant^{-1}.



Note: Here, C_0= No leaf cutting (Control), C_1 = Leaf cutting at 25 DAT, C_2 = Leaf cutting at 40 DAT and C_3 = Leaf cutting at 55 DAT

Fig. 14. Effect of leaf cutting on number of effective tillers hill^{-1} of BRRI dhan29 (LSD$_{(0.05)}$= 0.32)

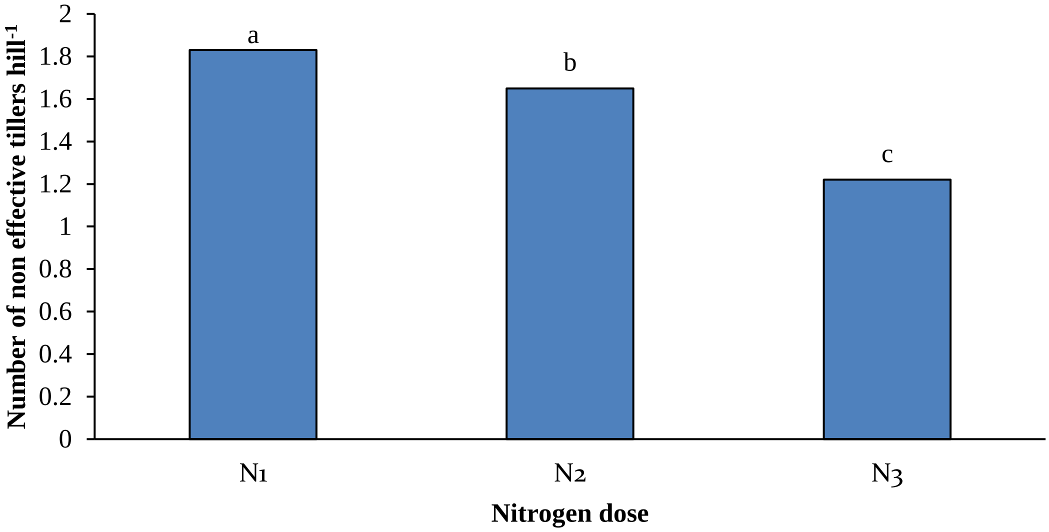
4.3.1.3 Interaction effect of nitrogen dose and leaf cutting

Application of different nitrogen dose along with leaf cutting showed significant variation in respect of number of effective tillers hill^{-1} of BRRI dhan29 (Table 7, Appendix X). Experiment result showed that the maximum number of effective tillers hill^{-1} (19.10) was recorded in N_3C_0 treatment combination whereas the minimum number of effective tillers hill^{-1} (11.33) was recorded in N_1C_3 treatment combination.

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

4.3.2.1 Effect of nitrogen dose

Increasing nitrogen dose reduces non effective tillers hill^{-1}. Different nitrogen dose significantly effect on number of non effective tillers hill^{-1} of BRRI dhan29 (Fig. 15, Appendix X). Experiment result showed that maximum number of non effective tillers hill^{-1} (1.83) was recorded in N_1 treatment whereas minimum number of non effective tillers hill^{-1}(1.22) was recorded in N_3 treatment. The variation of non effective tillers hill^{-1} due to reason that higher nitrogen application available plant to uptake more nitrogen. As the amount of nitrogen absorbed by the crop increases, there is an increase in the number of productive tillers per hill which ultimately reduced less non productive tillers per hill.

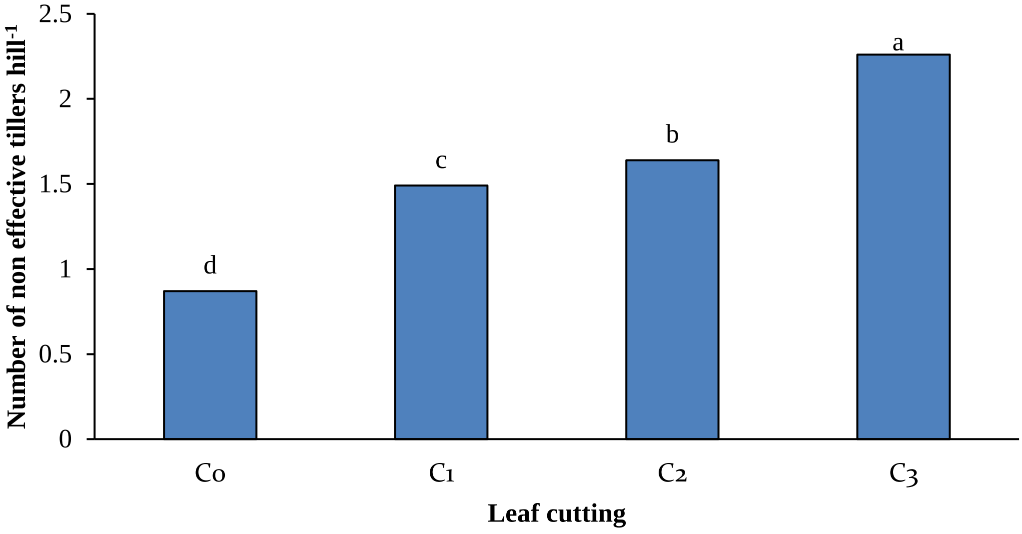


Note: Here, N_1 = 138 kg nitrogen ha^{-1} (Recommended), N_2= 163 kg nitrogen ha^{-1} and N_3= 183 kg nitrogen ha^{-1}

Fig. 15. Effect of nitrogen dose on number of non effective tillers hill^{-1} of BRRI dhan29 (LSD$_{(0.05)}$= 0.14)

4.3.2.2 Effect of leaf cutting

Leaf cutting of BRRI dhan29 showed significantly effect on number of non effect tillers hill^{-1}. (Fig. 16, Appendix X). From the experiment result showed that the maximum number of non effect tillers hill^{-1} was recorded in C_3 (2.26) treatment. While the minimum number of non effective tillers hill^{-1} was recorded in C_0 (0.87) treatment Dissimilar result was reported by Ahmed *et al.* (2001). He reported that the greatest number of non-bearing turners hill^{-1} was recorded from no leaf cutting treatment, which was genuinely like leaf cutting at 21 DAT and the minimum was seen in leaf cutting at 49 DAT.



Note: Here, C_0= No leaf cutting (Control), C_1 = Leaf cutting at 25 DAT, C_2 = Leaf cutting at 40 DAT and C_3 = Leaf cutting at 55 DAT

Fig. 16. Effect of leaf cutting on number of non effective tillers hill^{-1} of BRRI dhan29 (LSD$_{(0.05)}$= 0.11)

4.3.2.3 Interaction effect of nitrogen dose and leaf cutting

Application of different nitrogen dose along with leaf cutting showed significant variation in respect of number of non-effective tillers hill^{-1} of BRRI dhan29 (Table 7, Appendix X). Experiment result showed that the maximum number of non-effective tillers hill^{-1} (2.77) was recorded in N_1C_3 treatment combination whereas the minimum number of non-effective tillers hill^{-1} (0.50) was recorded in N_3C_0 treatment combination.

Table 7. Interaction effect of nitrogen dose and leaf cutting on effective andnon-effective tillers hill^{-1} of BRRI dhan29

Treatment Combinations	Effective tillers hill^{-1} (no.)	Non-effective tillers hill^{-1} (no.)
N_1C_0	15.87 d	1.10 e
N_1C_1	14.20 ef	1.33 d
N_1C_2	12.00 h	2.10 b
N_1C_3	11.33 i	2.77 a
N_2C_0	18.20 b	1.00 e
N_2C_1	15.43 d	1.80 c
N_2C_2	13.53 g	1.90 c
N_2C_3	13.53 g	1.90 c
N_3C_0	19.10 a	0.50 f
N_3C_1	16.77 c	1.33 d
N_3C_2	14.30 e	0.93 e
N_3C_3	13.67 fg	2.10 b
$LSD_{(0.05)}$	0.55	0.18
CV(%)	2.17	6.88

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

Notes viz:

N_1 = 138 kg nitrogen ha^{-1} (Recommended)

N_2= 163 kg nitrogen ha^{-1}

N_3= 183 kg nitrogen ha^{-1}

C_0= No leaf cutting (Control)

C_1 = Leaf cutting at 25 DAT

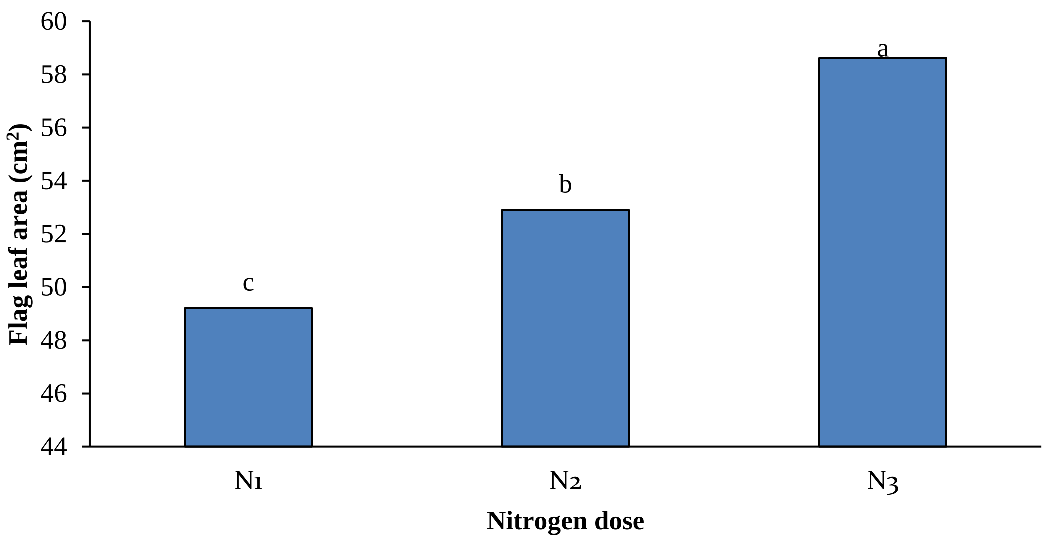
C_2 = Leaf cutting at 40 DAT

C_3 = Leaf cutting at 55 DAT

4.3.3 Flag leaf area (cm^2)

4.3.3.1 Effect of nitrogen dose

The uppermost leaf below the panicle is the flag leaf that provides the most important source of photosynthetic energy during reproduction. In this experiment different nitrogen dose significantly effect on flag leaf area of BRRI dhan29 (Fig. 17, Appendix XI). Experiment result showed that maximum flag leaf area (58.62 cm^2) was recorded in N_3 treatment whereas minimum flag leaf area (49.21 cm^2) was recorded in N_1treatment. Nitrogen is a very important and needed for plant growth. It is found in healthy soils, and give plants the energy to grow, and produce fruit or vegetables. The increase in leaf area was due to adequate N nutrition is explainable in terms of possible increase in nutrient mining capacity of plant as a result of better root development and increased translocation of carbohydrates from source to growing points in higher fertilized application plots.

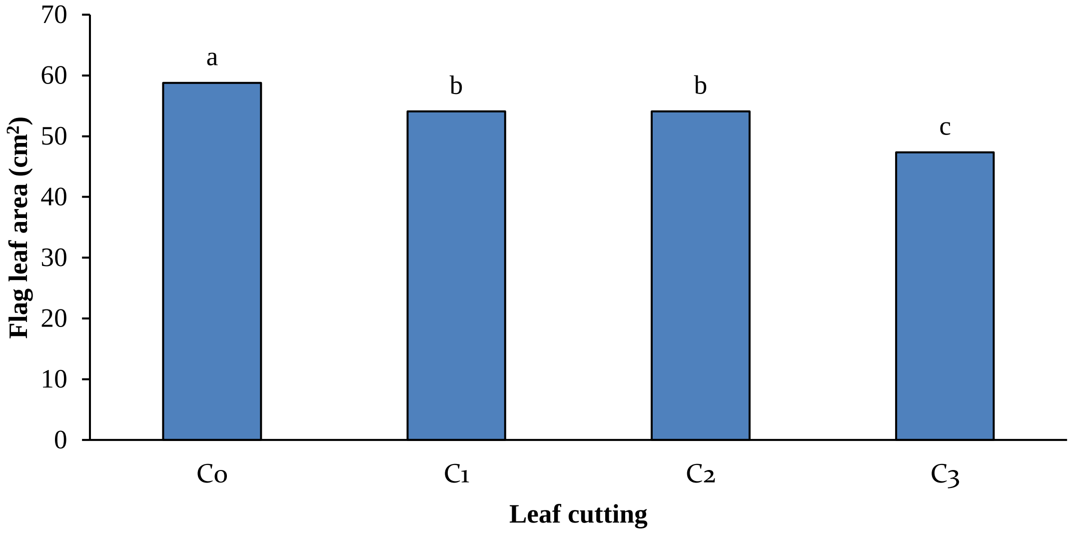


Note: Here, N_1 = 138 kg nitrogen ha^{-1} (Recommended), N_2= 163 kg nitrogen ha^{-1} and N_3= 183 kg nitrogen ha^{-1}

Fig. 17. Effect of nitrogen dose on flag leaf area of BRRI dhan29 ($LSD_{(0.05)}$= 1.73)

4.3.3.2 Effect of leaf cutting

Different leaf cutting at different DAT significantly effect on flag leaf area of BRRI dhan29 (Fig.18, Appendix XI). Experiment result showed that the maximum flag leaf area (58.79 cm^2) was recorded in C_0 treatment whereas minimum flag leaf area (47.35 cm^2) was recorded in C_3 treatment. The differences of flag leaf area for leaf cutting at different DAT was due to reason that leaf cutting reduced the leaf area which ultimately impact on photosynthesis activities of the plant as a results its impacts on growth, development and grain yield in rice.



Note: Here, C_0= No leaf cutting (Control), C_1 = Leaf cutting at 25 DAT, C_2 = Leaf cutting at 40 DAT and C_3 = Leaf cutting at 55 DAT

Fig. 18. Effect of leaf cutting on flag leaf area of BRRI dhan29 ($LSD_{(0.05)}$= 1.82)

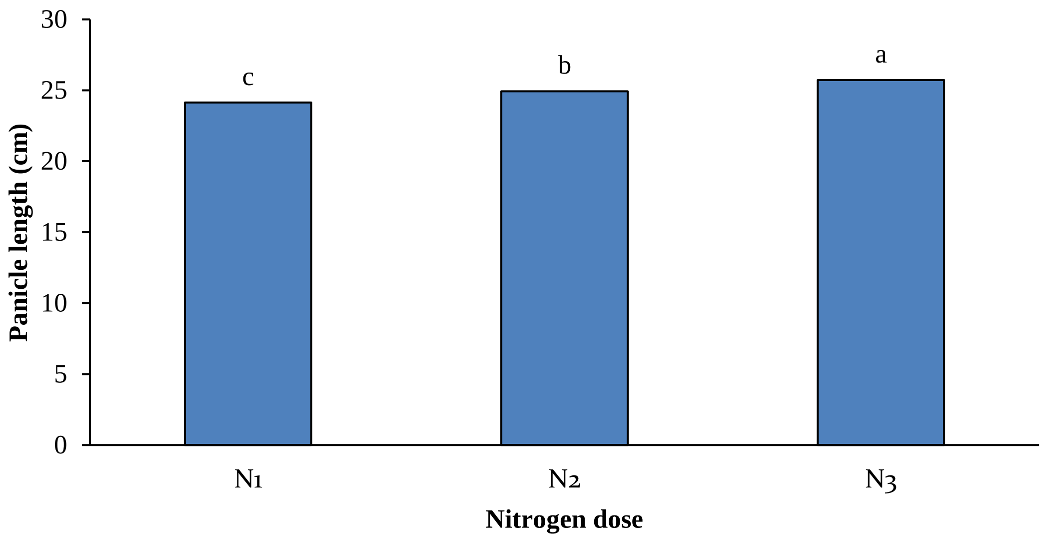
4.3.3.3 Interaction effect of nitrogen dose and leaf cutting

Interaction effect of nitrogen dose and leaf cutting showed significant variation in respect of flag leaf area of BRRI dhan29 (Table 8, Appendix XI). Experiment result showed that the maximum flag leaf area (63.22 cm^2)was recorded in N_3C_0 treatment combination which was statistically similar with N_3C_1 (60.89 cm^2)and N_3C_2 (60.70 cm^2) treatment combination whereas the minimum flag leaf area (44.41 cm^2)was recorded in N_1C_3 treatment combination which was statistically similar with N_1C_1 (47.23 cm^2) treatment combination.

4.3.4 Panicle length (cm)

4.3.4.1 Effect of nitrogen dose

BRRI dhan29 rice showed significant variation in respect of panicle length due to the effect of different nitrogen dose (Fig. 19, Appendix XI). The maximum panicle length (24.94 cm) was recorded in N_3 treatment while minimum panicle length (24.13 cm) was recorded in N_1 treatment. The role of nitrogen in the stimulation of cell division may have led to increasing panicle length during the productive stage in rice. Yoseftabar (2013) also found similar result which supported the present finding and reported that panicle length increased with increasing N fertilizer application the maximum panicle length at highest level of nitrogen application. Lar *et al*.(2007) concluded that nitrogen application up to 150 kg ha^{-1} significantly increased the panicle length of rice.

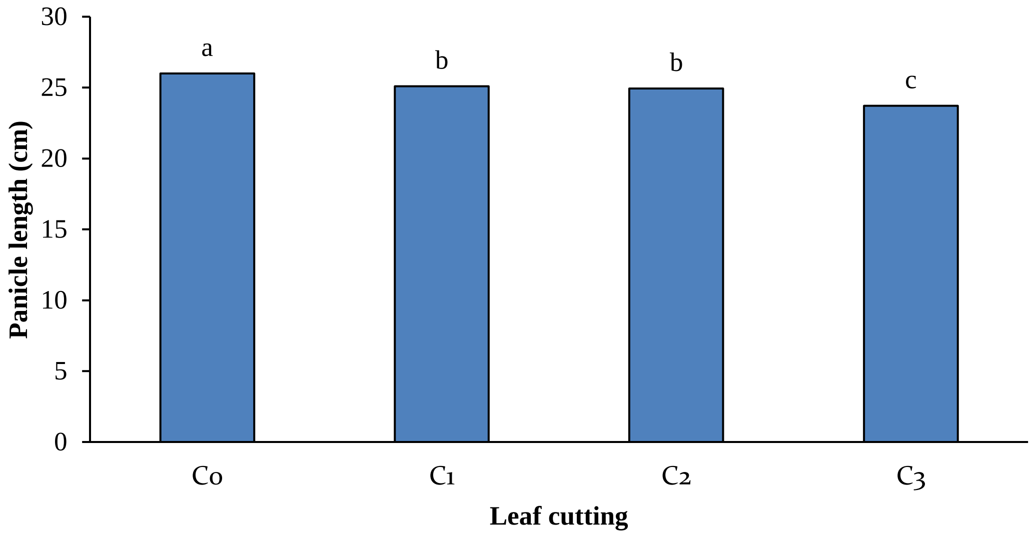


Note: Here, N_1 = 138 kg nitrogen ha^{-1} (Recommended), N_2= 163 kg nitrogen ha^{-1} and N_3= 183 kg nitrogen ha^{-1}

Fig. 19. Effect of nitrogen dose on panicle length of BRRI dhan29 ($LSD_{(0.05)}$= 0.65)

4.3.4.2 Effect of leaf cutting

Leaf Cutting of BRRI dhan29 showed significant effect on panicle length (Fig. 20, Appendix XI). From the experiment result showed that the maximum panicle length was recorded in C_0 (25.99 cm) treatment. While the minimum panicle length was observed in C_3 (23.71 cm) treatment. Dissimilar result was reported by DAS *et al.* (2017) and Boonreund and Marsom (2015). They reported that cutting of leaves had no significant effect on panicle length of rice. Rahman *et al.* (2013) reported that flag leaf increasing the panicle length in some extent which supported the present finding.



Note: Here, C_0= No leaf cutting (Control), C_1 = Leaf cutting at 25 DAT, C_2 = Leaf cutting at 40 DAT and C_3 = Leaf cutting at 55 DAT

Fig. 20. Effect of leaf cutting on panicle length of BRRI dhan29 ($LSD_{(0.05)}$= 0.76)

4.3.4.3 Interaction effect of nitrogen dose and leaf cutting

Application of different nitrogen dose along with leaf cutting showed significant variation in respect of panicle length of BRRI dhan29 (Table 8, Appendix XI). The maximum panicle length (27.67 cm) was recorded in N_3C_0 treatment combination whereas the minimum panicle length (22.07) was recorded in N_1C_3 treatment combination.

Table 8. Interaction effect of nitrogen dose and leaf cutting on flag leaf area and panicle length of BRRI dhan29

Treatment Combinations	Flag leaf area	Panicle length (cm)
N_1C_0	54.60 c	25.10 b
N_1C_1	47.23 fg	24.63 b
N_1C_2	50.61 e	24.73 b
N_1C_3	44.41 g	22.07 c
N_2C_0	58.56 b	25.20 b
N_2C_1	54.06 cd	25.03 b
N_2C_2	51.00 de	24.80 b
N_2C_3	47.97 ef	24.73 b
N_3C_0	63.22 a	27.67 a
N_3C_1	60.89 ab	25.60 b
N_3C_2	60.70 ab	25.26 b
N_3C_3	49.66 ef	24.33 b
$LSD_{(0.05)}$	3.15	1.31
CV(%)	3.43	3.06

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

Notes viz:

N_1 = 138 kg nitrogen ha^{-1} (Recommended)

N_2= 163 kg nitrogen ha^{-1}

N_3= 183 kg nitrogen ha^{-1}

C_0= No cutting (Control)

C_1 = Leaf cutting at 25 DAT

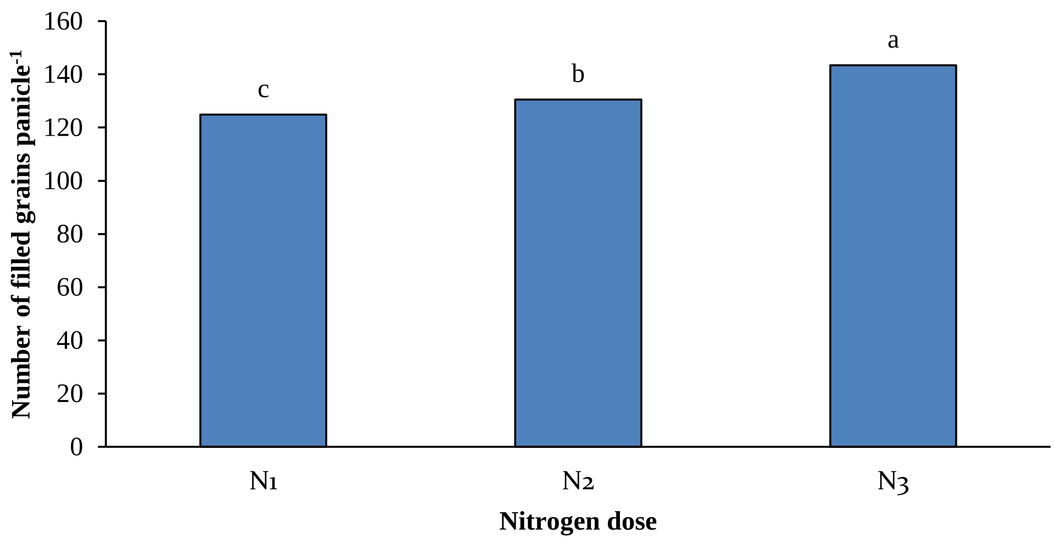
C_2 = Leaf cutting at 40 DAT

C_3 = Leaf cutting at 55 DAT

4.3.5 Number of filled grains panicle^{-1}

4.3.5.1 Effect of nitrogen dose

Filled grains panicle^{-1} is an important yield contributing characters which influences the yield of the plant. Application of different dose of nitrogen showed significant variation in respect of filled grains panicle^{-1} of BRRI dhan29 (Fig 21, Appendix XII). The experiment result revealed that the maximum number of filled grains panicle^{-1} (143.45) was observed in N_3 treatment while the minimum number of filled grains panicle^{-1} (124.86) was observed in N_1 treatment.The result obtained from the present study was similar with the findings of Gewaily *et al.* (2018). Metwally *et al.* (2010) also reported that plants which fertilized with 150 kg N/ha produced the highest number of filled grain per panicle, followed by plants which received 75 kg N/ha. It could be concluded that nitrogen fertilization resulted in an increase in the amount of metabolites synthesized by rice plant and this, in turn, might account much for the superiority of number of filled grains per panicle.

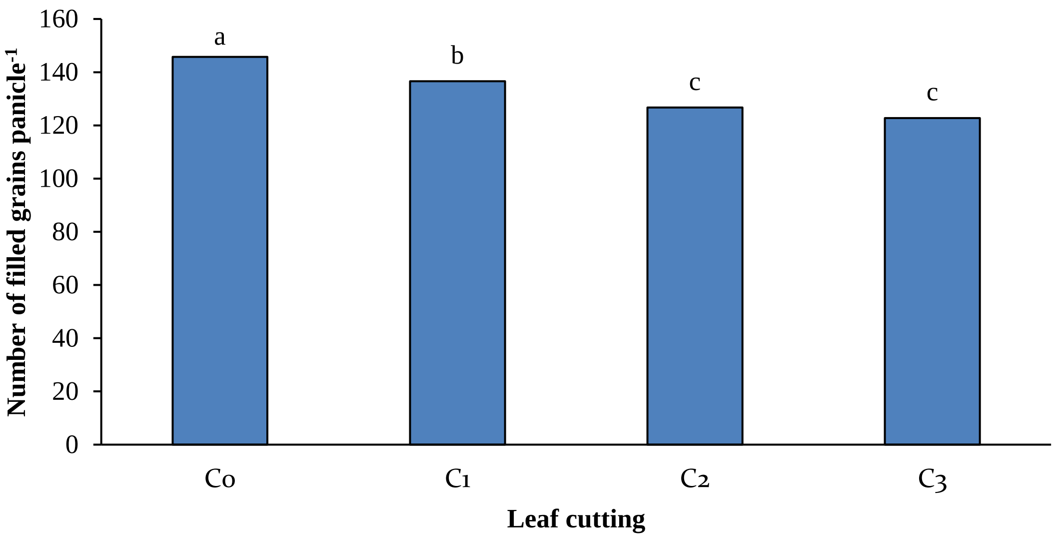


Note: Here, N_1 = 138 kg nitrogen ha^{-1} (Recommended), N_2= 163 kg nitrogen ha^{-1} and N_3= 183 kg nitrogen ha^{-1}

Fig. 21. Effect of nitrogen dose on number of filled grains panicle^{-1}of BRRI dhan29 (LSD$_{(0.05)}$= 4.58)

4.3.5.2 Effect of Leaf cutting

Leaf cutting of BRRI dhan29 showed significant effect on number of filled grains panicle^{-1} (Fig. 22, Appendix XII). The maximum number of filled grains panicle^{-1} was observed in C_0 (145.75) treatment. While the minimum number of filled grains panicle^{-1} was observed in C_3 (122.80) treatment which was statistically similar with C_2 (126.69) treatment.The result obtained from the present study was similar with the findings of Das *et al.* (2017) and Usman *et al.* (2007). Das *et al.* (2017) reported that the reduction in filled grains takes place by flag leaf cut (35.14%), flag leaf with 2nd leaf cut (62.62%) and flag leaf with 2nd and 3rd leaf cut (51.83 %). Usman *et al.* (2007) reported that the highest number of filled grains panicle^{-1} (90) were obtained from control (no detopping) treatment.



Note: Here, C_0= No leaf cutting (Control), C_1 = Leaf cutting at 25 DAT, C_2 = Leaf cutting at 40 DAT and C_3 = Leaf cutting at 55 DAT

Fig. 22. Effect of leaf cutting on number of filled grains panicle^{-1}of BRRI dhan29 (LSD$_{(0.05)}$= 4.11)

4.3.5.3 Interaction effect of nitrogen dose and leaf cutting

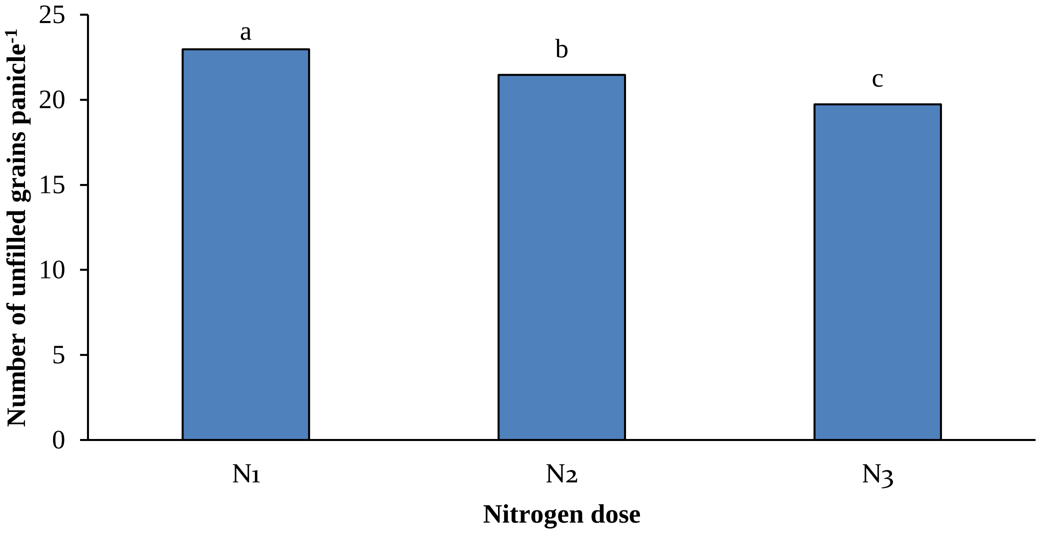
Application of different nitrogen dose along with leaf cutting showed significant variation in respect of filled grains panicle^{-1} of BRRI dhan29 (Table 9, Appendix XII). Experiment result showed that the maximum filled grains panicle^{-1} (154.63) was recorded in N_3C_0 treatment combination which was statistically similar with N_3C_0

(149.43) treatment combination whereas the minimum filled grains panicle^{-1} (110.90) was recorded in N_1C_3 treatment combination.

4.3.6 Number of unfilled grains panicle^{-1}

4.3.6.1 Effect of nitrogen dose

Application of different dose of nitrogen showed significant variation in respect of unfilled grains panicle^{-1} of BRRI dhan29 (Fig 23, Appendix XII). From the experiment result revealed that the maximum number of unfilled grains panicle^{-1} (22.97) was observed in N_1 treatment while the minimum number of unfilled grains panicle^{-1} (19.74) was observed in N_3 treatment.



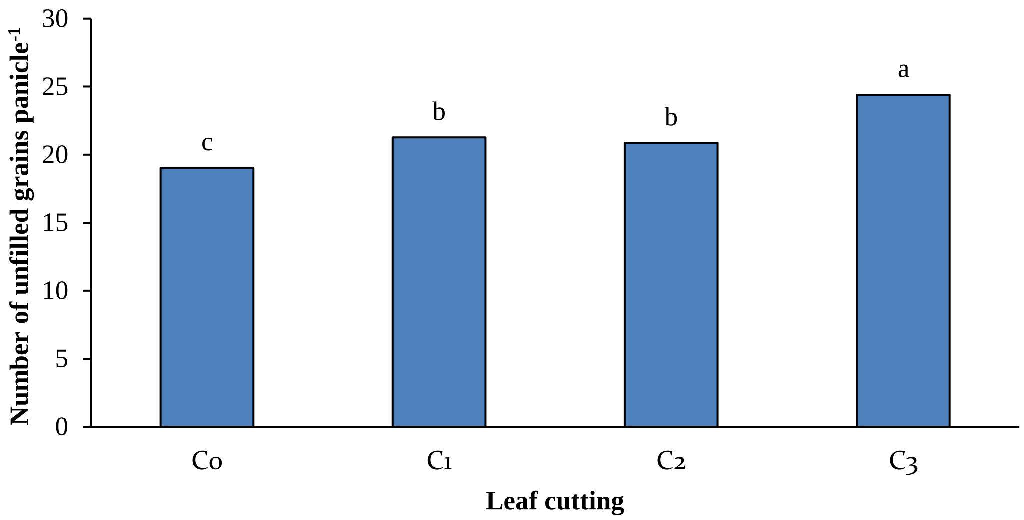
Note: Here, N_1 = 138 kg nitrogen ha^{-1} (Recommended), N_2= 163 kg nitrogen ha^{-1} and N_3= 183 kg nitrogen ha^{-1}

Fig. 23. Effect of nitrogen dose on number of unfilled grains panicle^{-1}of BRRI dhan29 (LSD$_{(0.05)}$= 1.03)

4.3.6.2 Effect of leaf cutting

Leaf cutting of BRRI dhan29 showed significant effect on number of unfilled grains panicle^{-1} (Fig. 24, Appendix XII). From the experiment result showed that the maximum number of unfilled grains panicle^{-1} was observed in C_3 (24.41) treatment. While the minimum number of unfilled grains panicle^{-1} was observed in C_0 (19.03) treatment. The result obtained from the present study was similar with the findings of

Das *et al.* (2017) and reported that unfilled grain number increased with higher intensity of leaf cutting and was the highest (79.40) in flag leaf with 3rd leaf cut, which was similar with flag leaf with 2nd leaf cut (65.91). The lowest unfilled grain was observed in the control (33.99) treatment.



Note: Here, C_0= No leaf cutting (Control), C_1 = Leaf cutting at 25 DAT, C_2 = Leaf cutting at 40 DAT and C_3 = Leaf cutting at 55 DAT

Fig. 24. Effect of leaf cutting on number of unfilled grains panicle^{-1}of BRRI dhan29 (LSD$_{(0.05)}$= 1.14)

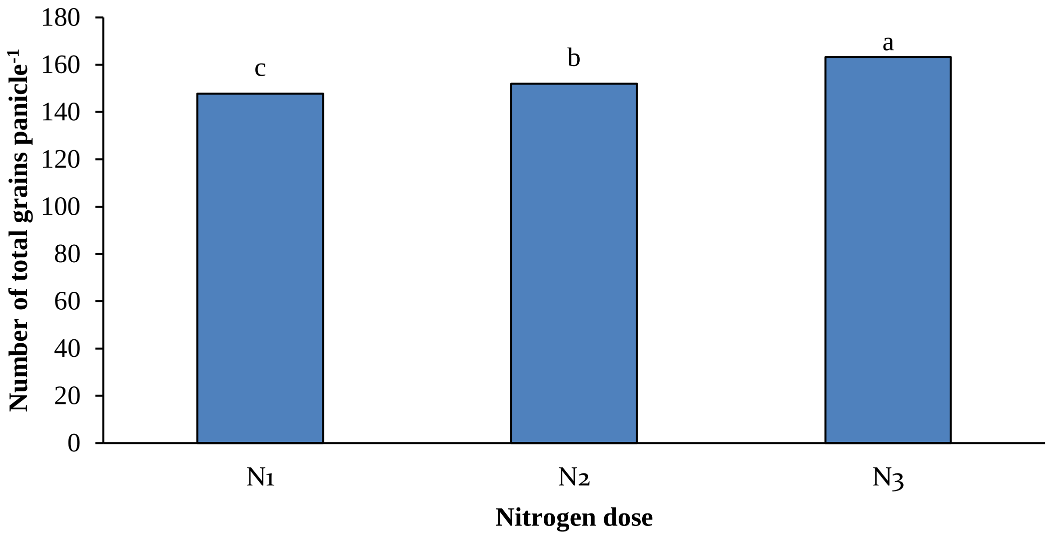
4.3.6.3 Interaction effect of nitrogen dose and leaf cutting

Application of different nitrogen dose along with leaf cutting showed significant variation in respect of unfilled grains panicle^{-1} of BRRI dhan29 (Table 9, Appendix XII). The maximum unfilled grains panicle^{-1} (27.50) was recorded in N_1C_3 treatment combination whereas the minimum unfilled grains panicle^{-1} (17.20) was recorded in N_3C_0 treatment combination.

4.3.7 Number of total grains panicle^{-1}

4.3.7.1 Effect of nitrogen dose

BRRI dhan29 rice showed significant variation in respect of number of total grains panicle^{-1}due to the effect of different nitrogen dose (Fig. 25, Appendix XII). The maximum number of total grains panicle^{-1}(163.19) was recorded in N_3 treatment while minimum number of total grains panicle^{-1}(147.82) was recorded in N_1 treatment. The result obtained from the present study was similar with the findings of Gill and Walia (2013), and they reported that increasing nitrogen dose increasing number of grain panicle^{-1}, with application of 125% of recommended dose of nitrogen recorded the height grain panicle^{-1} comparable to others treatment.

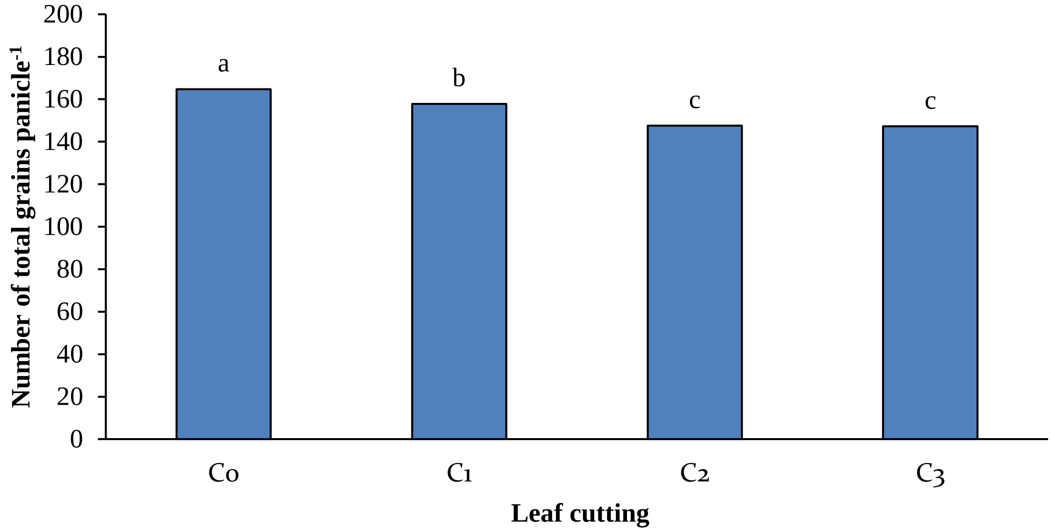


Note: Here, N_1 = 138 kg nitrogen ha^{-1} (Recommended), N_2= 163 kg nitrogen ha^{-1} and N_3= 183 kg nitrogen ha^{-1}

Fig. 25. Effect of nitrogen dose on number of total grains panicle^{-1}of BRRI dhan29 (LSD$_{(0.05)}$= 3.74)

4.3.7.2 Effect of leaf cutting

Leaf cutting of BRRI dhan29 showed significant effect on number of total grains panicle^{-1} (Fig. 26, Appendix XII). The maximum number of total grains panicle^{-1} was recorded in C_0 (164.78) treatment. While the minimum number of total grains panicle^{-1} was recorded in C_3 (147.21) treatment which was statistically similar with C_2 (147.54) treatment. Usman *et al.* (2007) reported that the highest number of spikelets panicle$^{–1}$ (106.8) was obtained from control (no detopping) treatment. Aktar-uz-zaman (2006) also reported that the defoliation of flag leaf caused significant decrease on spikelets per panicle by 17.34 %. Likewise, the expulsion of penultimate leaf caused decrease of 10.98 % for spikelets per panicle. Similarly, the defoliation of third leaf caused decrease of 7.20 % for spikelets per panicle. Likewise, the defoliation of flag leaf, penultimate leaf and third at a time caused reduction of 29.20 % for spikelets per panicle.



Note: Here, C_0= No leaf cutting (Control), C_1 = Leaf cutting at 25 DAT, C_2 = Leaf cutting at 40 DAT and C_3 = Leaf cutting at 55 DAT

Fig. 26. Effect of leaf cutting on number of total grains panicle^{-1}of BRRI dhan29 (LSD$_{(0.05)}$= 3.14)

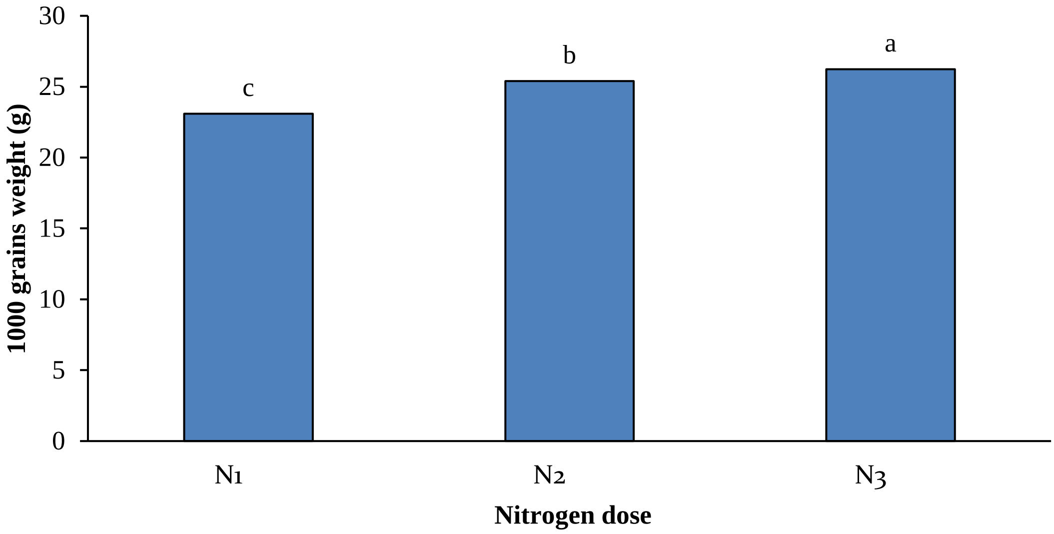
4.3.7.3 Interaction effect of nitrogen dose and leaf cutting

Application of different nitrogen dose along with leaf cutting showed significant variation in respect of number of total grains panicle^{-1} of BRRI dhan29 (Table 9, Appendix XII). Experiment result showed that the maximum number of total grains panicle^{-1} (171.83) was recorded in N_3C_0 treatment combination which was statistically similar with N_3C_1 (169.36) treatment combination whereas the minimum number of total grains panicle^{-1} (138.40) was recorded in N_1C_3 treatment combination which was statistically similar with N_1C_2 (141.64) treatment combination.

4.3.8 1000 grains weight (g)

4.3.8.1 Effect of nitrogen dose

BRRI dhan29 rice showed significant variation in respect of 1000 grains weight, due to the effect of different nitrogen dose (Fig. 27, Appendix XII). The maximum 1000 grains weight (26.24 g) was recorded in N_3 treatment while minimum 1000 grains weight (23.10 g) was recorded in N_1 treatment. Similar result with the present study also observed by Gewaily *et al.* (2018) who reported that, The maximum 1000 grains weight (28.52 and 28.91)in 2016 and 2017 respectively was observed in 220 kg N ha^{-1} fertilizer application. The possible reason behind this may be due to production of higher number of spikelets per panicle in the plants fertilized by nitrogen. Manzoor *et al.* (2015) also found that 1000 grain weight increased with application of nitrogen from 0 to 133 N kg ha^{-1}.



Note: Here, N_1 = 138 kg nitrogen ha^{-1} (Recommended), N_2= 163 kg nitrogen ha^{-1} and N_3= 183 kg nitrogen ha^{-1}

Fig. 27. Effect of nitrogen dose on 1000 grains weight of BRRI dhan29

($LSD_{(0.05)}$= 0.83)

4.3.8.2 Effect of leaf cutting

Leaf cutting of BRRI dhan29 showed significant effect in respect of 1000 grains weight (Fig. 28, Appendix XII). From the experiment result showed that the maximum 1000 grains weightwas recorded in C_0 (28.39 g) treatment. While the minimum 1000 grains weightwas recorded in C_3 (22.51 g) treatment. The result obtained from the present study was similar with the findings of Fatima *et al.* (2019). Hossain (2017) also found similar result which supported the present finding and reported that The yield and yield contributing characters was diminished by leaf cutting when compared with the control. 1000-grains weight was significantly reduced in plants those had the leaves cut compared with the plant in control treatment.

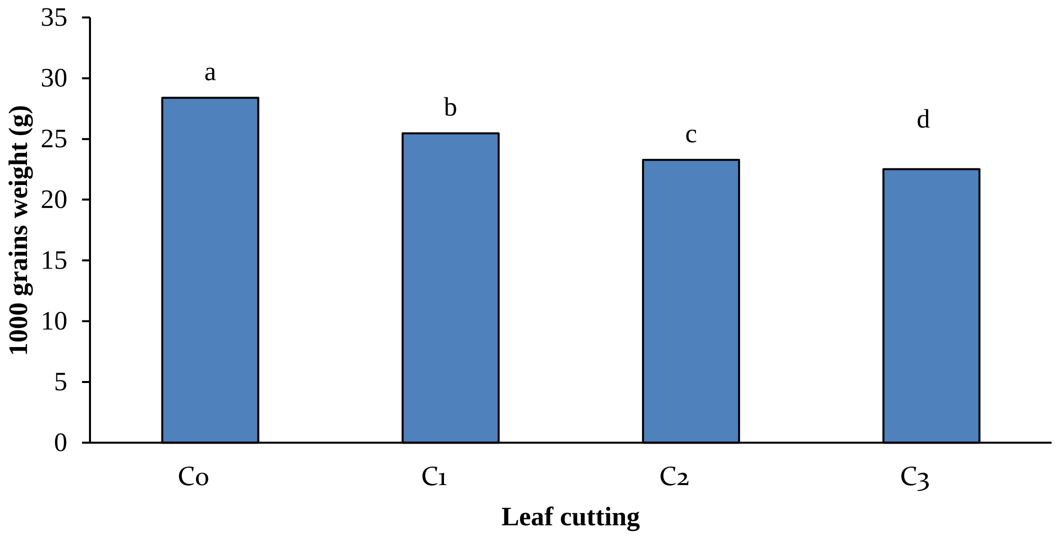


Fig. 28. Effect of leaf cutting on 1000 grains weight of BRRI dhan29 ($LSD_{(0.05)}$= 0.56)

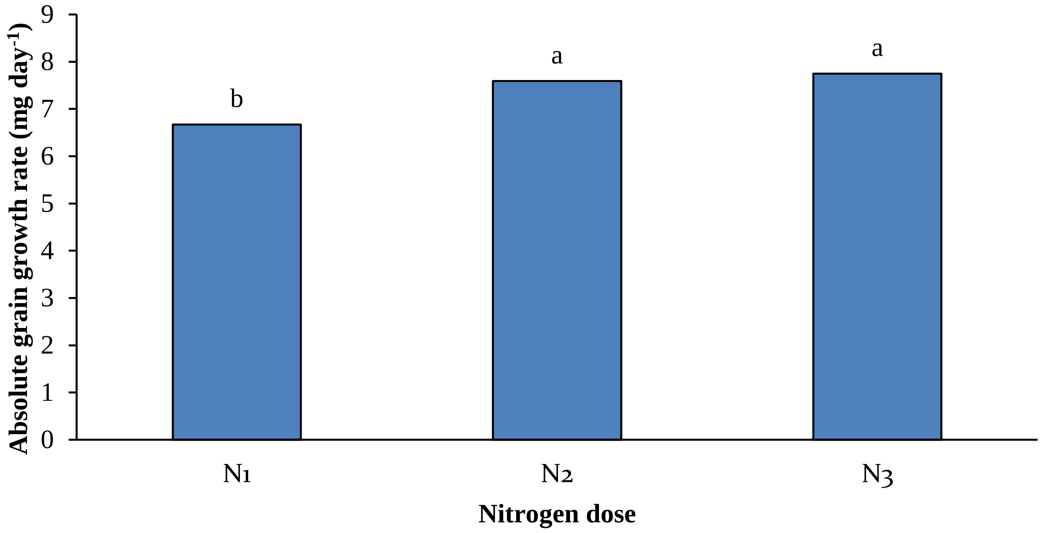
4.3.8.3 Interaction effect of nitrogen dose and leaf cutting

Application of different nitrogen dose along with leaf cutting showed significant variation in respect of 1000 grains weight of BRRI dhan29 (Table 9, Appendix XII). Experiment result showed that the maximum 1000 grains weight (30.20 g) was recorded in N_3C_0 treatment combination which was statistically similar with N_2C_0 (29.10 g) treatment combination whereas the minimum number 1000 grains weight (20.33 g) was recorded in N_1C_3 treatment combination.

4.3.9 Absolute grain growth rate (mg day^{-1})

4.3.9.1 Effect of nitrogen dose

Different nitrogen dose significantly effect on absolute grain growth rate of BRRI dhan29 (Fig. 29, Appendix XII). The maximum absolute grain growth rate (7.75 mg day^{-1}) was recorded in N_3 treatment which was statistically similar with N_2 (759) treatment. Whereas the minimum absolute grain growth rate (6.67 mg day^{-1}) was recorded in N_1 treatment. The differences of absolute grain growth rate of BRRI dhan29 was due to production of higher number of spikelets per panicle in the plants fertilized by nitrogen. This caused the high sink capacity as compared to limited respective source, therefore, the grain filling was more and consequently the grain of weight was high.

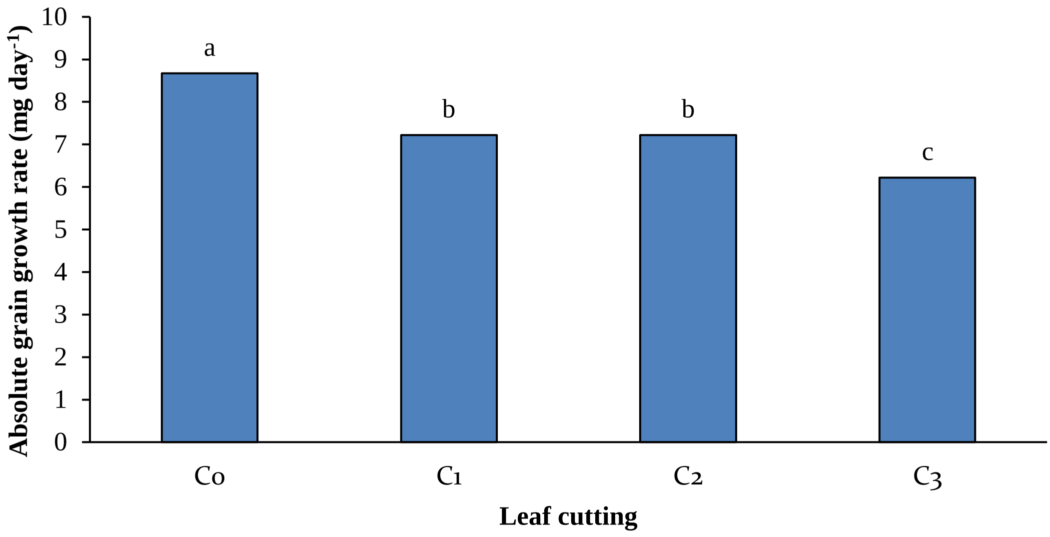


Note: Here, N_1 = 138 kg nitrogen ha^{-1} (Recommended), N_2= 163 kg nitrogen ha^{-1} and N_3= 183 kg nitrogen ha^{-1}

Fig. 29. Effect of nitrogen dose on absolute grain growth rate of BRRI dhan29 ($LSD_{(0.05)}$= 0.26)

4.3.9.2 Effect of leaf cutting

Leaf cutting of BRRI dhan29 showed significant effect on absolute grain growth rate (Fig. 30, Appendix XII). From the experiment result showed that the maximum absolute grain growth rate was recorded in C_0 (8.67 mg day^{-1}) treatment. While the minimum absolute grain growth rate was recorded in C_3 (6.22 mg day^{-1}) treatment.The main function of a leaf is to produce food for the plant by photosynthesis. Chlorophyll, the substance that gives plants their characteristic green colour, absorbs light energy. cutting leaves gradually decreasing leaf area which ultimately impact on absorbs light energy and photosynthesis causing slow grain growth rate.



Note: Here, C_0= No leaf cutting (Control), C_1 = Leaf cutting at 25 DAT, C_2 = Leaf cutting at 40 DAT and C_3 = Leaf cutting at 55 DAT

Fig. 30. Effect of leaf cutting on absolute grain growth rate of BRRI dhan29 ($LSD_{(0.05)}$= 0.27)

4.3.9.3 Interaction effect of nitrogen dose and leaf cutting

Interaction effect of nitrogen dose and leaf cutting showed significant variation in respect of absolute grain growth rateof BRRI dhan29 (Table 9, Appendix XII). The maximum absolute grain growth rate(9.67 mg day^{-1}) was recorded in N_3C_0 treatment combination whereas the minimum absolute grain growth rate(5.33 mg day^{-1}) was recorded in N_1C_3 treatment combination.

Table 9. Interaction effect ofnitrogen dose and leaf cutting on filled, unfilled, total grains panicle^{-1}, 1000 grains weight and absolute grain growth rate of BRRI dhan29

Treatment Combinations	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Total grains panicle^{-1} (no.)	1000 grains weight (g)	Absolute grain growth rate
N_1C_0	140.04 c	20.33 d-f	160.37 b	25.87 bc	7.67 c
N_1C_1	129.21 e	21.67 c-e	150.88 c	24.20 e	6.67 e
N_1C_2	119.27 f	22.37 bc	141.64 ef	22.00 f	7.00 de
N_1C_3	110.90 g	27.50 a	138.40 f	20.33 g	5.33 f
N_2C_0	142.57 bc	19.57 f	162.14 b	29.10 a	8.67 b
N_2C_1	131.10 de	22.17 cd	153.27 c	25.43 cd	7.67 c
N_2C_2	128.46 e	19.80 ef	148.26 cd	23.53 e	7.33 cd
N_2C_3	120.10 f	24.30 b	144.40 de	23.53 e	6.67 e
N_3C_0	154.63 a	17.20 g	171.83 a	30.20 a	9.67 a
N_3C_1	149.43 ab	19.93 ef	169.36 a	26.77 b	7.33 cd
N_3C_2	132.33 de	20.40 c-f	152.73 c	24.30 de	7.33 cd
N_3C_3	137.40 cd	21.43 c-f	158.83 b	23.67 e	6.67 e
$LSD_{(0.05)}$	7.11	1.98	5.43	1.16	0.47
CV(%)	3.12	5.40	2.05	2.26	3.71

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

Notes viz:

N_1 = 138 kg nitrogen ha^{-1}
N_2= 163 kg nitrogen ha^{-1}
N_3= 183 kg nitrogen ha^{-1}

C_0= No cutting (Control)
C_1 = Leaf cutting at 25 DAT
C_2 = Leaf cutting at 40 DAT
C_3 = Leaf cutting at 55 DAT

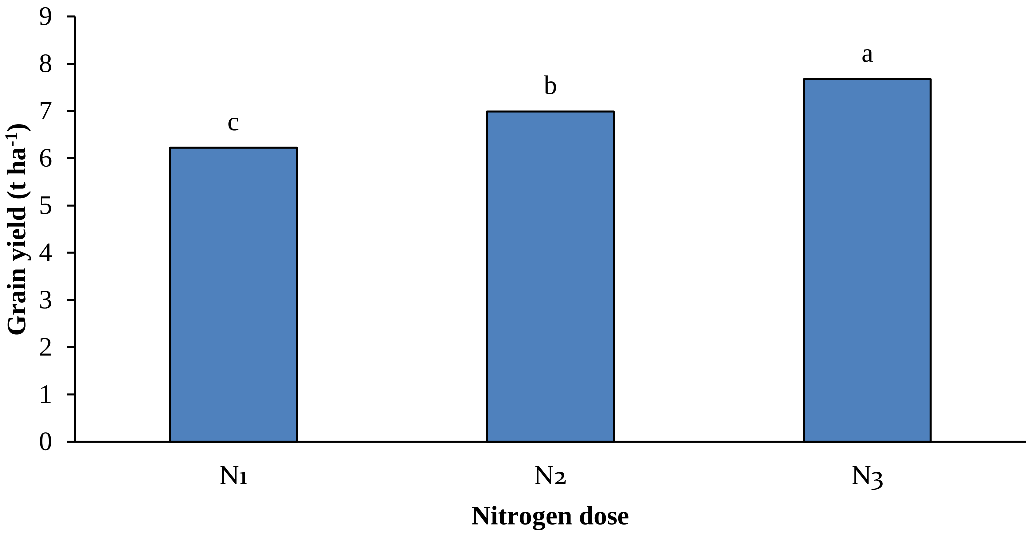
4.4 Yield characters

4.4.1 Grain yield (t ha^{-1})

4.4.1.1 Effect of nitrogen dose

Application of different nitrogen dose significantly effect on grain yield of BRRI dhan29 (Fig. 31, Appendix XIII). Experiment result showed that the maximum grain yield (7.67 t ha^{-1}) was recorded in N_3 treatment whereas the minimum grain yield

(6.22 t ha^{-1}) was recorded in N_1 treatment. The increase in grain yield might be due to higher nitrogen application enhancing the dry matter production, effective tillers number hill^{-1}, filled grains panicle^{-1}, 1000 grains weight and increasing grains growth rate. The result obtained from the present study was similar with the findings of Hirzel *et al.* (2021) who reported that yield increased with increasing N rates. Narayan *et al.* (2017) reported that with the application of 125 kg N ha^{-1}, a significant higher grain (6498.53 kg ha^{-1}) was observed. Fageria *et al.* (2008) reported that Grain yield increased significantly in a quadratic fashion, when N rate was increased in the range of 0 to 400 mg kg^{-1}.

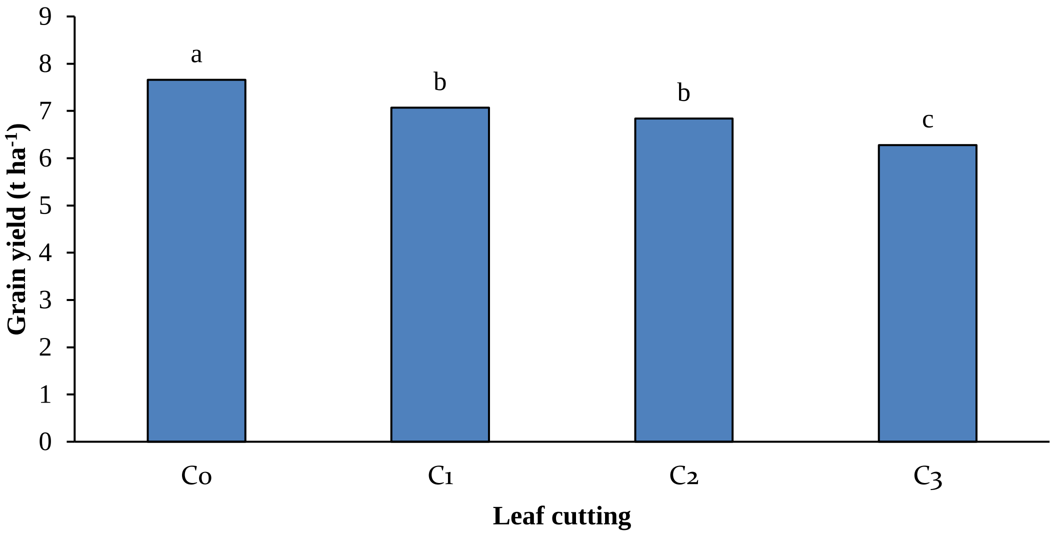


Note: Here, N_1 = 138 kg nitrogen ha^{-1} (Recommended), N_2= 163 kg nitrogen ha^{-1} and N_3= 183 kg nitrogen ha^{-1}

Fig. 31. Effect of nitrogen dose on grain yield of BRRI dhan29 ($LSD_{(0.05)}$= 0.44)

4.4.1.2 Effect of leaf cutting

Leaf cutting showed significant effect on grain yield (t ha^{-1}) of BRRI dhan29 (Fig. 32, Appendix XIII). From the experiment result showed that the maximum grain yield of BRRI dhan29 was recorded in C_0 (7.66 t ha^{-1}) treatment. While the minimum grain yield of BRRI dhan29 was recorded in C_3 (6.28 t ha^{-1}) treatment. Fatima *et al.* (2019) also found similar result which supported the present finding. Karmaker and Karmakar (2019) reported that the highest mean grain yield (5.25 t ha^{-1}) was obtained from the treatment combination of 115 kg N ha^{-1} and no leaf clipping (N_4C_0) comparable to other treatment. Hossain (2017) observed that the reduction of grain yield was minimum (10%) in BRRI dhan39 (control 5.75 t ha^{-1}, treated 5.15 t ha^{-1}) with leaf cutting than that of the rest varieties. Ros *et al.* (2003) found that pruning 30% of leaves depressed grain yield by 20%.



Note: Here, C_0= No leaf cutting (Control), C_1 = Leaf cutting at 25 DAT, C_2 = Leaf cutting at 40 DAT and C_3 = Leaf cutting at 55 DAT

Fig. 32. Effect of leaf cutting on grain yield of BRRI dhan29 ($LSD_{(0.05)}$= 0.34)

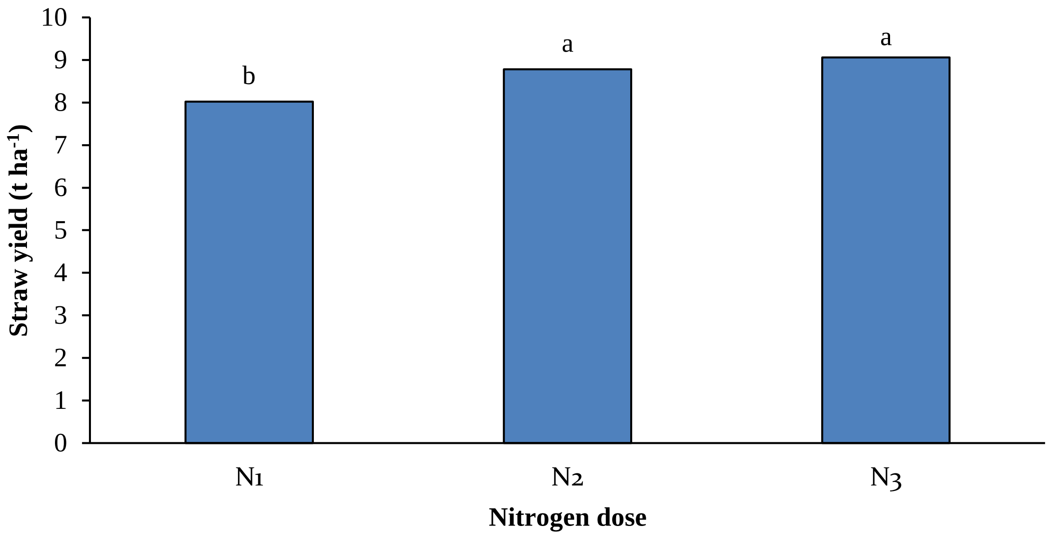
4.4.1.3 Interaction effect of nitrogen dose and leaf cutting

Interaction effect of nitrogen dose and leaf cutting showed significant variation in respect of grain yield (t ha^{-1}) of BRRI dhan29 (Table10, Appendix XIII). Experiment result showed that maximum grain yield (8.54 t ha^{-1}) was recorded in N_3C_0 treatment combination whereas the minimum grain yield (5.04 t ha^{-1}) was recorded in N_1C_3 treatment combination.

4.4.2 Straw yield (t ha^{-1})

4.4.2.1 Effect of nitrogen dose

Application of different nitrogen dose significantly effect on straw yield of BRRI dhan29 (Fig. 33, Appendix XIII). The maximum straw yield (9.06 t ha^{-1}) was recorded in N_3 treatment which was statistically similar with N_2 (8.78 t ha^{-1}) treatment whereas the minimum straw yield (8.02 t ha^{-1}) was recorded in N_1 treatment. Nitrogen is an element which enhances vegetative growth of plants. Therefore, with the positive physiological effects the growth and yield increased with the increase in nitrogen dose. The result obtained from the present study was similar with the findings of Narayan *et al.* (2017) who reported that with the application of 125 kg N ha^{-1}, a significant higher straw yield (7689.50 kg ha^{-1}) was achieved. Dubey *et al.* (2016) reported that maximum straw yield of 86.58 q ha^{-1} was recorded at 180 kg N ha^{-1}.

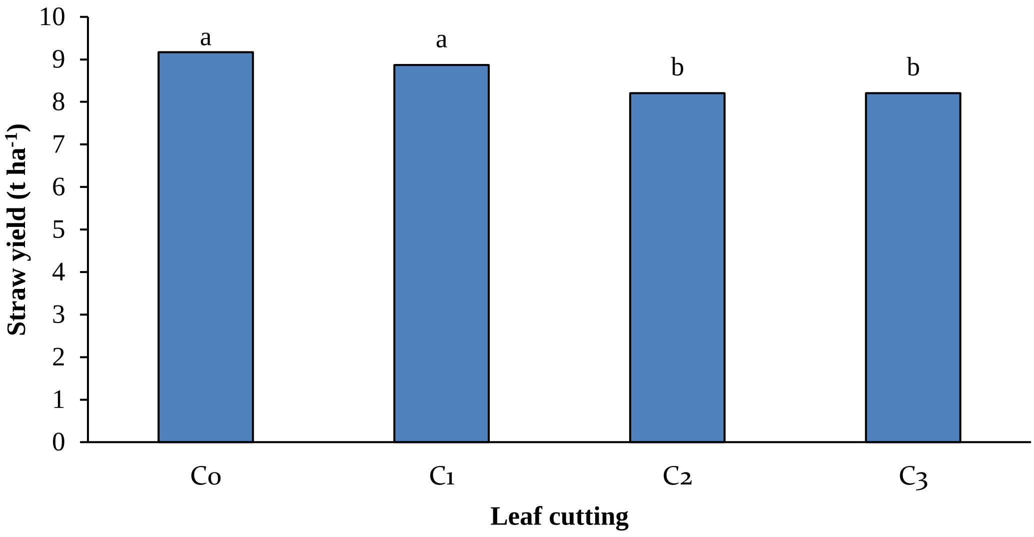


Note: Here, N_1 = 138 kg nitrogen ha^{-1} (Recommended), N_2= 163 kg nitrogen ha^{-1} and N_3= 183 kg nitrogen ha^{-1}

Fig. 33. Effect of nitrogen dose on straw yield of BRRI dhan29 ($LSD_{(0.05)}$= 0.34)

4.4.2.2 Effect of leaf cutting

Leaf cutting showed significant effect on straw yield (t ha^{-1}) of BRRI dhan29 (Fig. 34, Appendix XIII). The maximum straw yield of BRRI dhan29 was recorded in C_0 (9.17 t ha^{-1}) treatment which was statistically similar with C_1 (8.87 t ha^{-1}). While the minimum straw yield of BRRI dhan29 was recorded in C_3 (8.21 t ha^{-1}) treatment which was statistically similar with C_2 (8.21 t ha^{-1}) treatment. Hossain (2017) reported that irrespective of all the varieties under study, the highest straw yield was obtained in no leaf cutting (control).



Note: Here, C_0= No leaf cutting (Control), C_1 = Leaf cutting at 25 DAT, C_2 = Leaf cutting at 40 DAT and C_3 = Leaf cutting at 55 DAT

Fig. 34. Effect of leaf cutting on straw yield of BRRI dhan29 ($LSD_{(0.05)}$= 0.29)

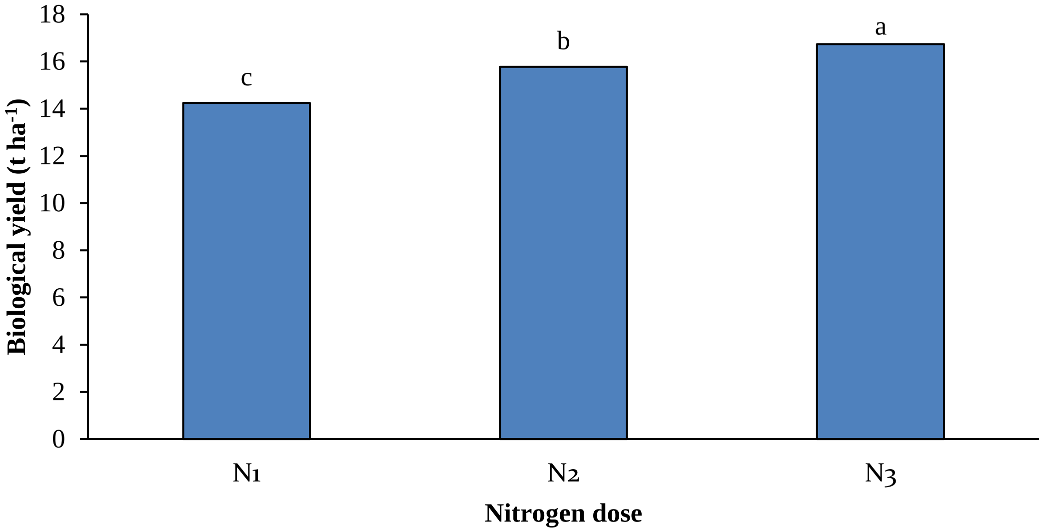
4.4.2.3 Interaction effect of nitrogen dose and leaf cutting

Application of different nitrogen dose along with leaf cutting showed significant variation in respect of straw yield (t ha^{-1}) of BRRI dhan29 (Table10, Appendix XIII). Experiment result showed that the maximum straw yield (9.62 t ha^{-1}) was recorded in N_3C_0 treatment combination which was statistically similar with N_3C_1 (9.61 t ha^{-1}) and N_2C_0 (9.40 t ha^{-1}) treatment combination whereas the minimumstraw (7.63 t ha^{-1}) was recorded in N_1C_3 treatment combination which was statistically similar with N_1C_1 (7.97 t ha^{-1}).

4.4.3 Biological yield (t ha^{-1})

4.4.3.1 Effect of nitrogen dose

BRRI dhan29 rice significantly varied on biological yield due to effect of different nitrogen doses (Fig. 35, Appendix XIII).The maximum biological yield (16.73 t ha^{-1}) was recorded in N_3 treatment whereas the minimum biological yield (14.24 t ha^{-1}) was recorded in N_1 treatment. Increasing nitrogen dose result in production of higher dry matter accumulation, tillers numbers, grain and straw yield which ultimately help in increasing biological yield. Lar *et al*.(2007) also found similar result which supported the present finding and reported that, the maximum biological yield (20.63 t ha^{-1}) was recorded with 150 kg N ha^{-1}.

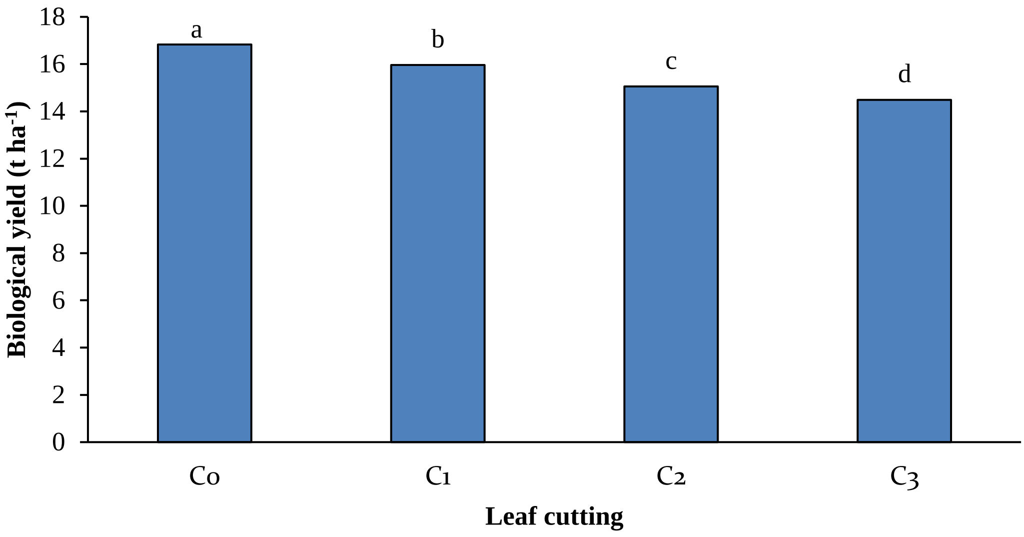


Note: Here, N_1 = 138 kg nitrogen ha^{-1} (Recommended), N_2= 163 kg nitrogen ha^{-1} and N_3= 183 kg nitrogen ha^{-1}

Fig. 35. Effect of nitrogen dose on biological yield of BRRI dhan29 ($LSD_{(0.05)}$= 0.54)

4.4.3.2 Effect of leaf cutting

Different leaf cutting of BRRI dhan29 showed significant effect on biological yield (Fig. 36, Appendix XIII). From the experiment result showed that the maximum biological yield of BRRI dhan29 was recorded in C_0 (16.83 t ha^{-1}) treatment. While the minimum biological yield of BRRI dhan29 was recorded in C_3 (14.49 t ha^{-1}) treatment .Fatima *et al.* (2019) and Usman *et al.* (2007) alsofound similar results with the present study. They reported that the highest biological yield was obtained from no leaf cutting treatment.



Note: Here, C_0= No leaf cutting (Control), C_1 = Leaf cutting at 25 DAT, C_2 = Leaf cutting at 40 DAT and C_3 = Leaf cutting at 55 DAT

Fig. 36. Effect of leaf cutting on biological yield of BRRI dhan29 ($LSD_{(0.05)}$= 0.51)

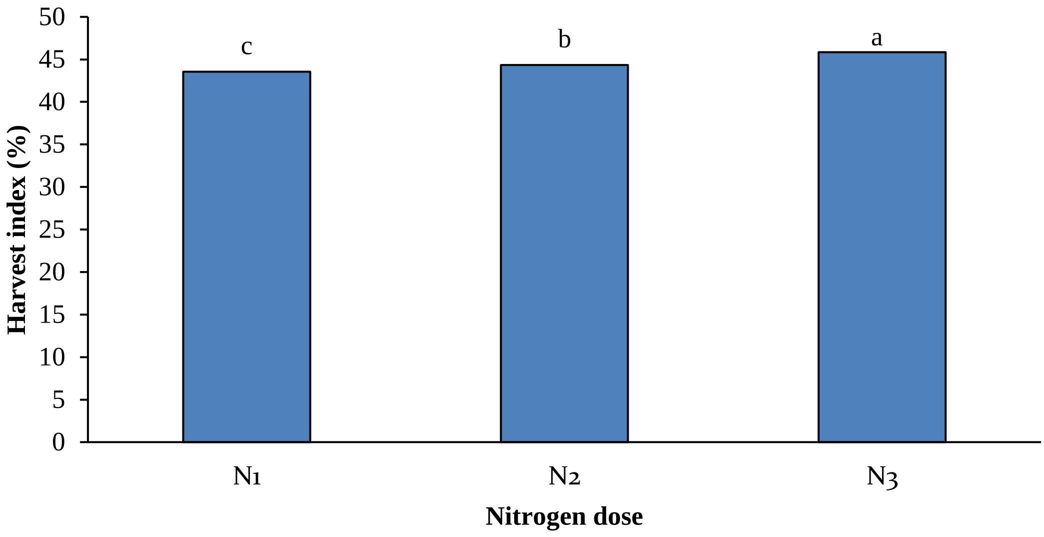
4.4.3.2 Interaction effect of nitrogen dose and leaf cutting

Application of different nitrogen dose along with leaf cutting showed significant variation in respect of biological yield (t ha^{-1}) of BRRI dhan29 (Table10, Appendix XIII). Experiment result showed that the maximum biological yield (18.16 t ha^{-1}) was recorded in N_3C_0 treatment combination which was statistically similar with N_3C_1 (17.48 t ha^{-1}) treatment combination whereas the minimum biological yield (12.67 t ha^{-1}) was recorded in N_1C_3 treatment combination.

4.4.4 Harvest index (%)

4.4.4.1 Effect of nitrogen dose

Harvest index (%) of BRRI dhan29 showed significant variation due to effect of different nitrogen dose (Fig 37, Appendix XIII) From the experiment result revealed that the maximum harvest index (45.83 %) was recorded in N_3 treatment. Whereas the minimum harvest index (43.54 %) was recorded in N_1 treatment. Different nitrogen doses influence grain and biological yield which ultimately impact on harvest index. The result obtained from the present study was similar with the findings of Karmaker and Karmakar (2019) and reported that in case of N application rates, harvest index varied from 0.42 to 0.46 and harvest index increased with increased N rates.



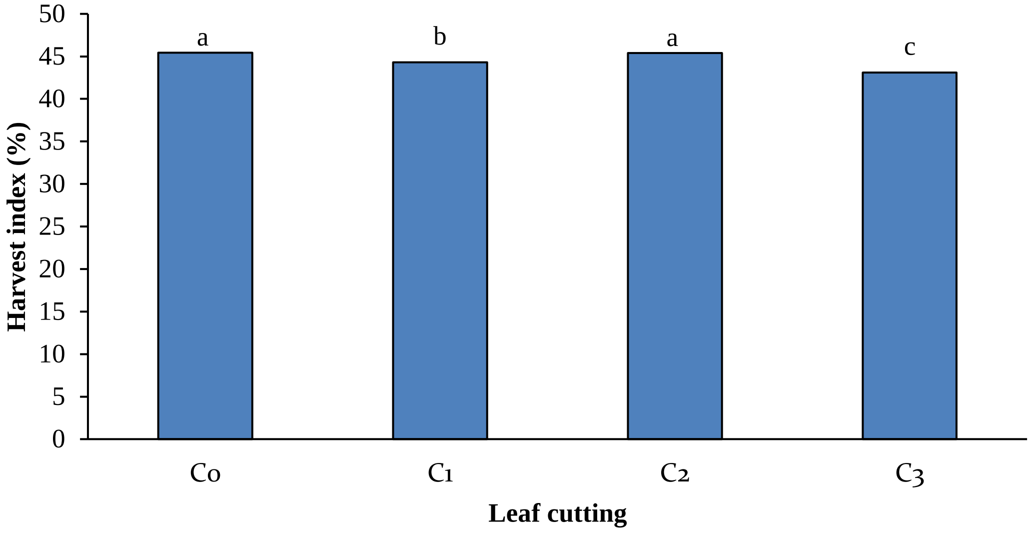
Note: Here, N_1 = 138 kg nitrogen ha^{-1} (Recommended), N_2= 163 kg nitrogen ha^{-1} and N_3= 183 kg nitrogen ha^{-1}

Fig. 37. Effect of nitrogen dose on harvest index of BRRI dhan29

($LSD_{(0.05)}$= 0.49)

4.4.4.2 Effect of leaf cutting

Leaf cutting of BRRI dhan29 showed significant effect on harvest index (%) (Fig. 38, Appendix XIII). From the experiment result showed that the maximum harvest index of BRRI dhan29 was recorded in C_0 (45.45 %) treatment which was statistically similar with C_2 (45.40 %). While the minimum harvest index was observed in C_3 (43.11c %) treatment. Karmaker and Karmakar (2019) reported that the highest mean harvest index (46%) was obtained from the treatment combination of 115 kg N ha^{-1} and no leaf clipping (N_4C_0) comparable to others treatment combinations. Usman *et al.* (2007) also reported that the highest harvest index (42.70%) were obtained from control (no detopping) treatment.



Note: Here, C_0= No cutting (Control), C_1 = Leaf cutting at 25 DAT, C_2 = Leaf cutting at 40 DAT and C_3 = Leaf cutting at 55 DAT

Fig. 38. Effect of leaf cutting on harvest index of BRRI dhan29

($LSD_{(0.05)}$= 0.93)

4.4.4.3 Interaction effect of nitrogen dose and leaf cutting

Interaction effect of nitrogen dose and leaf cutting showed significant variation in respect of harvest index (%) of BRRI dhan29 (Table10, Appendix XIII). Experiment result showed that the maximum harvest index (47.03 %) was recorded in N_3C_0 treatment combination which was statistically similar with N_3C_2 (45.99 %) and N_2C_2 (45.70 %) treatment combination whereas the minimum harvest index (39.78 %) was recorded in N_1C_3 treatment combination.

Table 10. Interaction effect of nitrogen dose and leaf cutting on grain, straw, biological yield (t ha^{-1}) and harvest index (%) of BRRI dhan29

Treatment Combinations	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
N_1C_0	6.94 c-e	8.49 cd	15.43 cd	44.98 bc
N_1C_1	6.49 e	7.97 ef	14.46 e	44.88 bc
N_1C_2	6.41 e	7.99 d-f	14.40 e	44.51 cd
N_1C_3	5.04 f	7.63 f	12.67 f	39.78 e
N_2C_0	7.49 bc	9.40 ab	16.89 b	44.35 cd
N_2C_1	6.86 c-e	9.08 b	15.94 c	43.04 d
N_2C_2	6.86 c-e	8.15 c-e	15.01 de	45.70 a-c
N_2C_3	6.75 de	8.50 c	15.25 c-e	44.26 cd
N_3C_0	8.54 a	9.62 a	18.16 a	47.03 a
N_3C_1	7.87 ab	9.61 a	17.48 ab	45.02 bc
N_3C_2	7.24 b-d	8.50 c	15.74 cd	45.99 ab
N_3C_3	7.04 c-e	8.50 c	15.54 cd	45.30 bc
$LSD_{(0.05)}$	0.59	0.50	0.88	1.47
CV(%)	4.91	3.37	3.32	2.10

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

Notes viz:

N_1 = 138 kg nitrogen ha^{-1}

N_2= 163 kg nitrogen ha^{-1}

N_3= 183 kg nitrogen ha^{-1}

C_0= No cutting (Control)

C_1 = Leaf cutting at 25 DAT

C_2 = Leaf cutting at 40 DAT

C_3 = Leaf cutting at 55 DAT

CHAPTER V

SUMMARY AND CONCLUSION

The present piece of work was carried out at the Research Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during December-2020 to may 2021, to examine the response of BRRI dhan29 to different doses of nitrogen and leaf cutting. The experimental field belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28. The soil of the experimental field belongs to the General soil type, Deep Red Brown Terrace Soils under Tejgaon soil series. The experiment consisted of two factors, and followed split plot design.Factor A: Different nitrogen doses (3) *viz:*N_1 = 138 kg nitrogen ha^{-1}, N_2= 163 kg nitrogen ha^{-1}, N_3= 183 kg nitrogen ha^{-1} andFactor B: Leaf cutting at different DAT (4) *viz:* C_0 = No cutting (Control), C_1 = Leaf cutting at 25 DAT, C_2 = Leaf cutting at 40 DAT and C_3 = Leaf cutting at 55 DAT. The total numbers of unit plots were 36. The size of unit plot was 5.76 m^2 (2.4 m × 2.4 m). Data on different growths, yield contributing characters and yield were recorded to find out the response of BRRI dhan29 to different doses of nitrogen and leaf cutting.

Different nitrogen dose and leaf cutting either individually or interaction showed significant variations in respect of various parameters of BRRI dhan29.

In respect of different nitrogen dose, the maximum plant height (25.63, 45.81, 75.11 and 92.61 cm) at 25, 40, 55 DAT and at harvest respectively, tillers number $hill^{-1}$ (3.50, 14.33, 22.20 and 17.18) at 25, 40, 55 DAT and at harvest respectively, maximum leaf area index (0.25, 2.96 and 8.00) at 25, 40 and 55 DAT, maximum SPAD value (38.94, 46.82 and 43.20) at 35, 50 and 66 DAT, maximum dry matter weight $plant^{-1}$ (18.92, 25.87 and 50.09 g) at 40, 55 DAT and at harvest respectively, effective tillers $hill^{-1}$ (15.96) were recorded in N_3 treatment. The maximum number of non effective tillers $hill^{-1}$ (1.83) and stem reserve translocation (27.01 %) were recorded in N_1 treatment. The maximum flag leaf area (58.62 cm^2), panicle length (24.94 cm), filled grains $panicle^{-1}$ (143.45) were recorded in N_3 treatment. The maximum number of unfilled grains $panicle^{-1}$ (22.97) was observed in N_1 treatment. The maximum number of total grains $panicle^{-1}$(163.19),1000 grains weight (26.24 g), absolute grain growth rate (7.75 mg day^{-1}), grain yield (7.67 t ha^{-1}), straw yield (9.06 t ha^{-1}), biological yield (16.73 t ha^{-1}) and harvest index (45.83 %) were recorded in

N_3 treatment. Whereas the minimum plant height (23.07 cm) was recorded in N_2 treatment at 25 DAT. At 40, 55 DAT and at harvest respectively the minimum plant height (42.56, 71.49 and 86.91 cm) was recorded in N_1 treatment. The minimum tillers number hill^{-1} (2.92, 10.66, 16.85 and 15.18 cm) at 25, 40, 55 DAT and at harvest respectively, leaf area index (0.17, 2.55 and 5.05) at 25, 40, 55 DAT,

SPAD value (36.67, 39.72 and 37.79) at 35, 50 and 65 DAT, dry matter weight plant^{-1} (14.66, 22.84 and 42.72 g) was recorded in N_1 treatment at 40, 55 DAT and at harvest respectively, minimum number of effective tillers hill^{-1} (13.35) were recorded in N_1 treatment. The minimum number of non effective tillers hill^{-1} (1.22) stem reserve translocation (15.71 %) were recorded in N_3 treatment. The minimum flag leaf area (49.21 cm^2), panicle length (24.13 cm), number of filled grains panicle^{-1} (124.86), were recorded in N_1 treatment. The minimum number of unfilled grains panicle^{-1} (19.74) was observed in N_3 treatment. The minimum number of total grains panicle^{-1} (147.82),1000 grains weight (23.10 g), absolute grain growth rate (6.67 mg day^{-1}), grain yield (6.22 t ha^{-1}), straw yield (8.02 t ha^{-1}), biological yield (14.24 t ha^{-1}) and harvest index (43.54 %) were recorded in N_1 treatment.

In respect of different leaf cutting, the maximum plant height (25.33, 46.76, 75.98 and 92.96 cm) at 25, 40, 55 DAT and at harvest respectively, number of tillers hill^{-1} (4.10, 15.59, 21.54 and 18.59) at 25, 40, 55 DAT and at harvest respectively, leaf area index (0.30, 3.46 and 8.69) at 25, 40 and 55 DAT were recorded in C_0 treatment. At 35 DAT the maximum SPAD value (40.00) was recorded in C_0 treatment. At 50 DAT maximum SPAD value (44.65) was recorded in C_2 treatment and at 65 DAT maximum SPAD value (42.67) was recorded in C_0. The maximum above ground dry matter weight plant^{-1} (19.04, 26.41 and 49.72 g) at 40, 55 DAT and at harvest respectively, number of effect tillers hill^{-1} (17.72) were recorded in C_0 treatment. The maximum number of non effect tillers hill^{-1} (2.26) and stem reserve translocation were recorded in C_3 (40.57 %) treatment. The maximum flag leaf area (58.79 cm^2), panicle length (25.99 cm), filled grains panicle^{-1} (145.75) were recorded in C_0 treatment. The maximum number of unfilled grains panicle^{-1} was observed in C_3 (24.41) treatment. The maximum number of total grains panicle^{-1} (164.78), 1000 grains weight(28.39 g), absolute grain growth rate (8.67 mg day^{-1}), grain yield (7.66 t ha^{-1}), straw yield (9.17 t ha^{-1}), biological yield (16.83 t ha^{-1}) and harvest index (45.45

%) were recorded in C_0 treatment. Whereas the minimum plant height (22.95, 43.24, 72.29 and 86.40 cm) at 25, 40, 55 DAT and at harvest respectively, number of tillers hill^{-1} (2.53, 10.51 and 17.05) at 25, 40 and 55 DAT were recorded in C_3 treatment. The minimum leaf area index (0.17and 2.39) was recorded in C_2 treatment at 25 and 40 DAT. And at 55 DAT minimum leaf area index (4.23) was recorded in C_3 treatment. The minimum above ground dry matter weight plant^{-1} (14.83, 23.35 and 43.57 g), at 40, 55 and at harvest respectively, number of effective tillers hill^{-1} (12.84) were recorded in C_3 treatment. The minimum number of non effective tillers hill^{-1} (0.87), and stem reserve translocation (11.60 %) treatment were recorded in C_0 treatment. The minimum flag leaf area (47.35 cm^2), panicle length (23.71 cm), number of filled grains panicle^{-1} (122.80) were recorded in C_3 treatment. The minimum number of unfilled grains panicle^{-1} was observed in C_0 (19.03) treatment. The minimum number of total grains panicle^{-1} (147.21),1000 grains weight(22.51 g) absolute grain growth rate (6.22 mg day^{-1}), grain yield (6.28 t ha^{-1}), straw yield (8.21 t ha^{-1}), biological yield (14.49 t ha^{-1}) and minimum harvest index (43.11c %) were recorded in C_3 treatment.

In case of interaction effect, the maximum plant height (27.00, 49.05, 79.30 and 96.95 cm) at 25, 40, 55 DAT and at harvest respectively, number of tillers hill^{-1} (5.00, 17.33, 23.97 and 19.60) at 25, 40, 55 DAT and at harvest respectively, leaf area index (0.40, 3.65 and 11.20) at 25, 40 and 55 DAT, SPAD value (42.00, 48.50, 45.20) at 35, 50 and 65 DAT, above ground dry matter weight plant^{-1} (21.23. 27.57 and 54.09 g) at 40, 55 DAT and at harvest respectively, number of effective tillers hill^{-1} (19.10) were recorded in N_3C_0 treatment. The maximum number of non effective tillers hill^{-1} (2.77) was recorded in N_1C_3 treatment combination. The maximum stem reserve translocation (41.63 %) was recorded in N_3C_3 treatment combination. The maximum flag leaf area (63.22 cm^2), panicle length (27.67 cm), filled grains panicle^{-1} (154.63) were recorded in N_3C_0 treatment combination. The maximum unfilled grains panicle^{-1} (27.50) was recorded in N_1C_3 treatment combination. The maximum number of total grains panicle^{-1} (171.83), 1000 grains weight (30.20 g), absolute grain growth rate(9.67 mg day^{-1}), grain yield (8.54 t ha^{-1}), straw yield (9.62 t ha^{-1}), biological yield (18.16 t ha^{-1}) and harvest index (47.03 %) were recorded in N_3C_0 treatment combination. Whereas the minimum plant height (21.50, 40.09, 68.10 and 82.80 cm) at 25, 40, 55 DAT and at harvest respectively, number of tillers hill^{-1} (2.00, 9.20, 13.86 and 14.10) at 25, 40, 55 DAT and at harvest respectively was recorded in N_1C_3treatment combination. At 34 DAT the minimum leaf area index (0.10) was recorded in N_3C_2 treatment combination. At 40 DAT the minimum leaf area index (1.87) was recorded in N_1C_2 treatment combination and at 55 DAT the minimum leaf area index (3.07) was recorded in N_1C_3 treatment combination. The minimum SPAD value (34.43, 38.53 and 34.06) at 35, 50 and 65 DAT, dry matter weight plant^{-1} (11.12, 21.65 and 38.01 g) at 40, 55 DAT and at harvest respectively, number of effective tillers hill^{-1} (11.33) were recorded in N_1C_3 treatment combination the minimum number of non effective tillers hill^{-1} (0.50), stem reserve translocation (6.13) were recorded in N_3C_0 treatment combination. The minimum flag leaf area (44.41 cm^2), panicle length (22.07), filled grains panicle^{-1} (110.90) were recorded in N_1C_3 treatment combination. The minimum unfilled grains panicle^{-1} (17.20) was recorded in N_3C_0 treatment combination. The minimum number of total grains panicle^{-1} (138.40), 1000 grains weight (20.33 g), absolute grain growth rate(5.33 mg day^{-1}), grain yield (5.04 t ha^{-1}), straw yield (7.63 t ha^{-1}), biological yield (12.67 t ha^{-1}) and harvest index (39.78 %) were recorded in N_1C_3 treatment combination.

Conclusion

Based on above findings of the present experiment, the following conclusion can be drawn:

i. Different doses of nitrogen had a great effect on morpho-physiology and yield character of BRRI dhan 29. The maximum number of effective tillers hill^{-1} (15.96), flag leaf area (58.62 cm^2), panicle length (24.94 cm), filled grains panicle^{-1} (143.45), total grains panicle^{-1}(163.19), 1000 grains weight (26.24 g), absolute grain growth rate (7.75 mg day^{-1}), maximum grain yield (7.67 t ha^{-1}), straw yield (9.06 t ha^{-1}), biological yield (16.73 t ha^{-1}) and harvest index (45.83 %) were recorded in N_3 treatment.

ii. Leaf cutting also influenced the growth and yield of BRRI dhan 29. The maximum number of effect tillers hill^{-1} (17.72), flag leaf area (58.79 cm^2), panicle length (25.99 cm), filled grains panicle^{-1} (145.75), total grains panicle^{-1} (164.78), 1000 grains weight (28.39 g), absolute grain growth rate (8.67 mg day^{-1}), grain yield (7.66 t ha^{-1}), straw yield (9.17 t ha^{-1}), biological yield (16.83 t ha^{-1}) and harvest index (45.45 %) were recorded in C_0 treatment.

iii. The treatment combination N_3C_0 showed better result in the present experiment. N_3 (Application of 183 kg nitrogen ha^{-1}) treatment along with C_0 (No leaf cutting) treatment combination recorded the maximum number of effective tillers $hill^{-1}$ (19.10), flag leaf area (63.22 cm^2), panicle length (27.67 cm), filled grains $panicle^{-1}$ (154.63), total grains $panicle^{-1}$ (171.83), 1000 grains weight (30.20 g), absolute grain growth rate (9.67 mg day^{-1}), grain yield (8.54 t ha^{-1}), straw yield (9.62 t ha^{-1}), biological yield (18.16 t ha^{-1}) and harvest index (47.03 %).

So, finally it may be concluded that the application of 183 kg nitrogen ha^{-1} with no leaf cutting might give higher yield to BRRI dhan29 which was similar with N_3C_1 treatment combination.

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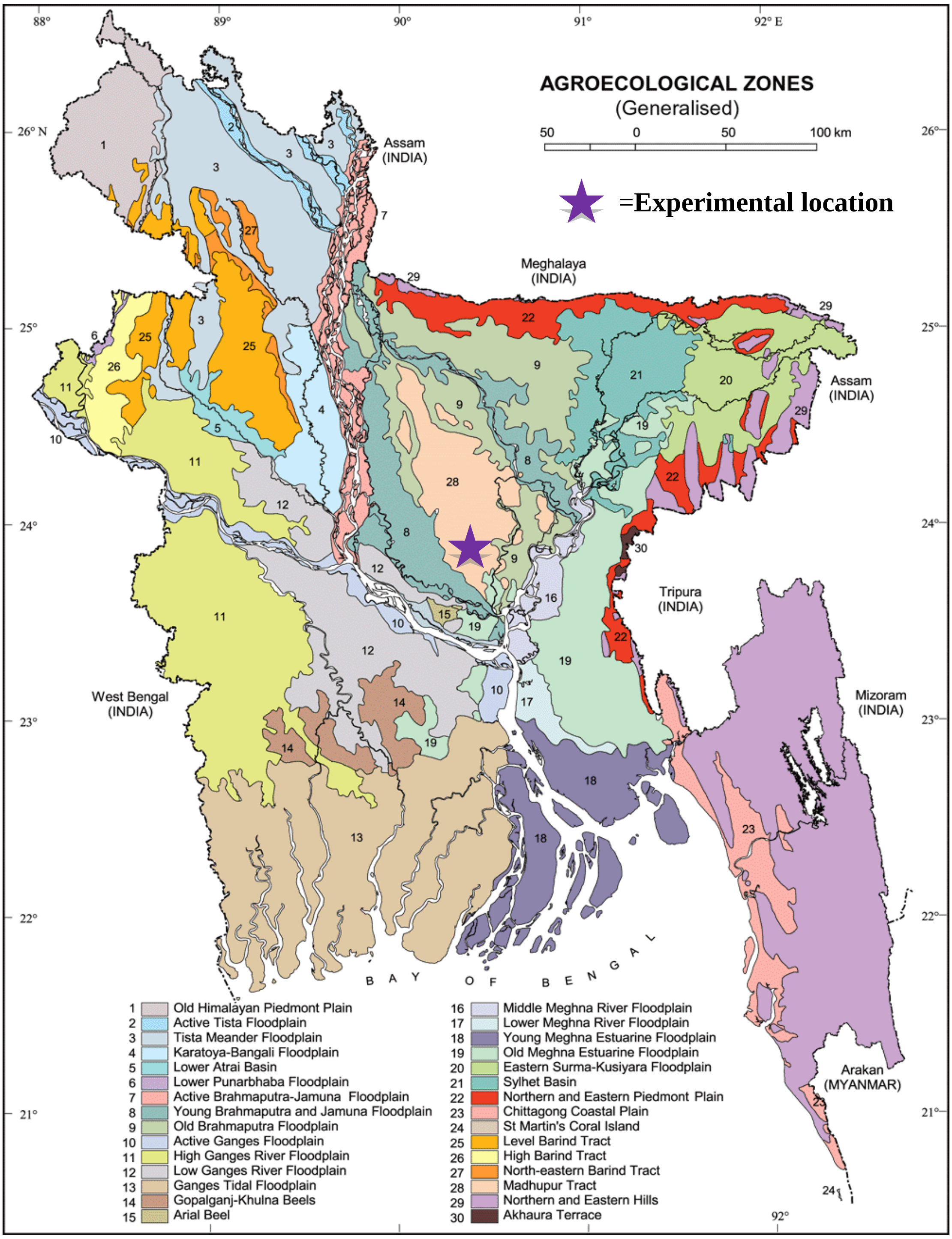
APPENDICES

Appendix I. Map showing the experimental location under study



Appendix II. Soil characteristics of the experimental field

A. Morphological features of the experimental field

Morphological features	Characteristics
Location	Sher-e-Bangla Agricultural University Agronomy research field, Dhaka
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Shallow Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. The initial physical and chemical characteristics of soil of the experimental site (0 - 15 cm depth)

Physical characteristics

Constituents	Percent
Sand	26 %
Silt	45 %
Clay	29 %
Textural class	Silty clay

Chemical characteristics

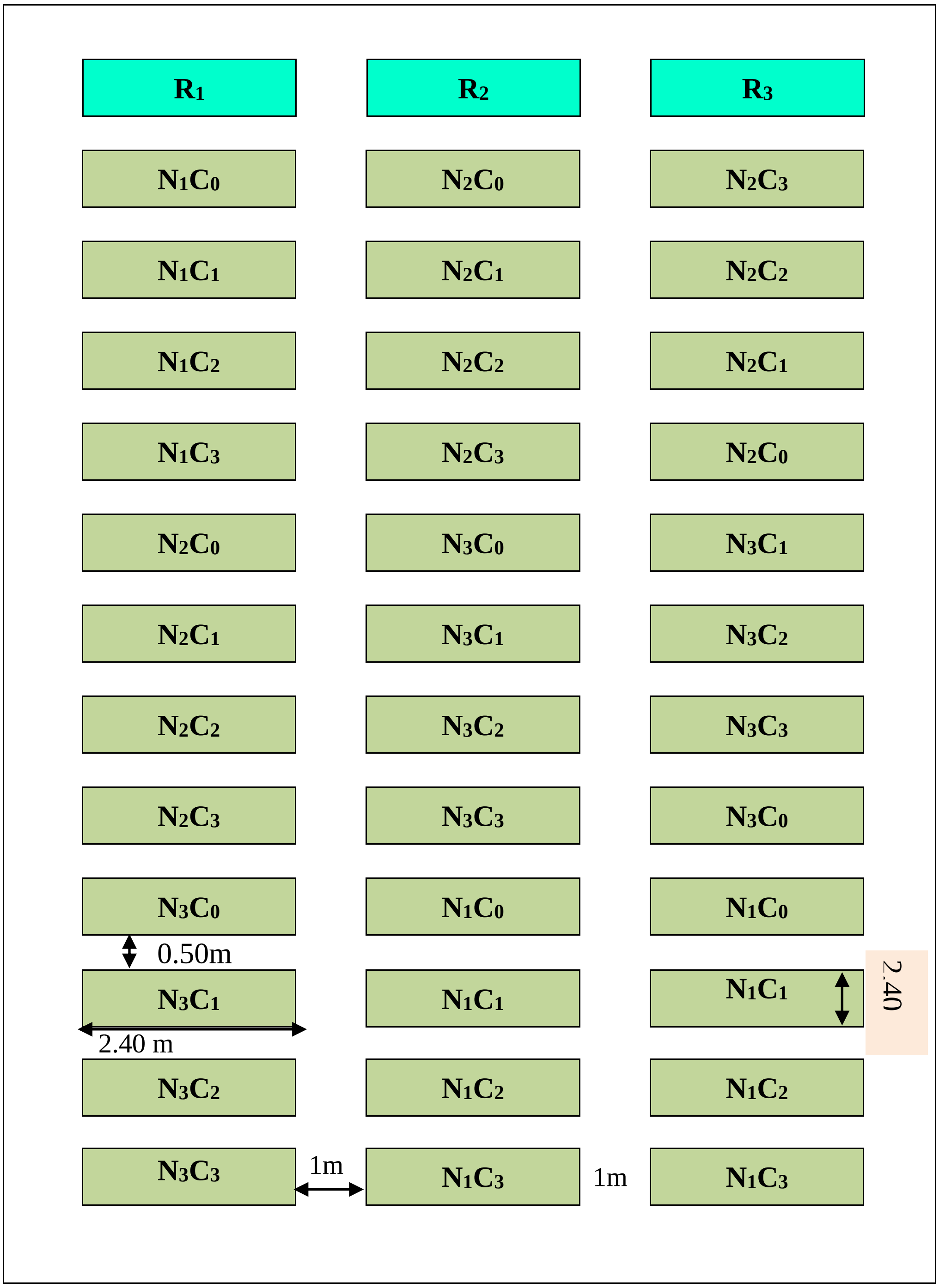
Soil characteristics	Value
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.03
Available P (ppm)	20.54
Exchangeable K (mg/100 g soil)	0.10

Appendix III. Monthly meteorological information during the period from December 2020 to May, 2021

Year	Month	Air temperature (^0C)		Relative humidity (%)	Average rainfall (mm)
		Maximum	Minimum		
2020	December	25.3 °C	14.6 °C	70%	9 mm
2021	January	26.4°C	12.5°C	72%	6 mm
	February	29.1°C	15.3°C	63%	19 mm
	March	32.9°C	20.1°C	61%	54 mm
	April	34.1°C	23.6°C	67%	138 mm
	May	33.4°C	24.7°C	76%	269 mm

Source: Metrological Centre, Agargaon, Dhaka (Climate Division)

Appendix IV. Layout of the experimental field



LEGENDS

N_1 = 138 kg nitrogen ha^{-1}	C_0= No cutting (Control)
N_2= 163 kg nitrogen ha^{-1}	C_1 = Leaf cutting at 25 DAT
N_3= 183 kg nitrogen ha^{-1}	C_2 = Leaf cutting at 40 DAT
	C_3 = Leaf cutting at 55 DAT

Appendix V. Analysis of variance of the data of plant height of BRRI dhan29 at different DAT

Source	Df	Mean square of plant height at			
		25 DAT	40 DAT	55 DAT	At harvest
Replication (R)	2	1.08	9.34	8.58	3.03
Nitrogen dose (N)	2	19.74**	50.02**	48.49**	98.19**
Error (R×N)	4	0.33	2.75	2.33	2.79
Leaf cutting (L)	3	8.97**	18.73**	26.98**	72.81**
N×L	6	4.42**	7.89*	11.75	6.81*
Error (R×N×L)	18	0.58	2.93	4.42	2.44
Total	35				

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

Appendix VI. Analysis of variance of the data of number of tillers hill^{-1} of BRRI dhan29 at different DAT

Source	Df	Mean square of number of tillers hill^{-1} at			
		25 DAT	40 DAT	55 DAT	At harvest
Replication (R)	2	0.01	0.04	0.19	0.10
Nitrogen dose (N)	2	1.13**	43.68**	89.24**	13.68**
Error (R×N)	4	0.01	0.04	0.19	0.08
Leaf cutting (L)	3	4.64**	45.72**	46.69**	26.95**
N×L	6	2.65**	3.24**	1.97*	0.45*
Error (R×N×L)	18	0.03	0.29	0.64	0.12
Total	35				

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

Appendix VII. Analysis of variance of the data of leaf area indexof BRRI dhan29 at different DAT

Source	Df	Mean square of leaf area index at		
		25 DAT	40 DAT	55 DAT
Replication (R)	2	0.00001	0.00303	0.1009
Nitrogen dose (N)	2	0.02010**	0.52803**	26.9043**
Error (R×N)	4	0.00001	0.00453	0.1009
Leaf cutting (L)	3	0.03323**	2.16643**	35.7422**
N×L	6	0.02213**	0.32603**	1.7927**
Error (R×N×L)	18	0.00007	0.00803	0.1989
Total	35			

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

Appendix VIII. Analysis of variance of the data of SPAD value of BRRI dhan29 at different DAT

Mean square of SPAD value at				
Source	**Df**	**35 DAT**	**50 DAT**	**65 DAT**
Replication (R)	2	0.0069	0.083	0.0400
Nitrogen dose (N)	2	18.6910**	153.198**	88.8244**
Error (R×N)	4	1.0069	0.083	0.0500
Leaf cutting (L)	3	30.8926**	17.937**	60.9604**
N×L	6	8.2918**	2.376*	37.2284**
Error (R×N×L)	18	0.8958	0.861	1.0244
Total	35			

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

Appendix IX. Analysis of variance of the data of above ground dry matter weight (g) of BRRI dhan29 at different DAT

Mean square of above ground dry matter weight				
Source	**Df**	**40 DAT**	**55 DAT**	**At harvest**
Replication (R)	2	0.68	0.35	1.64
Nitrogen dose (N)	2	55.03**	30.38**	168.30**
Error (R×N)	4	0.68	0.35	1.64
Leaf cutting (L)	3	27.41**	20.99**	75.97**
N×L	6	3.22	2.15*	9.53*
Error (R×N×L)	18	0.78	0.79	3.03
Total	35			

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

Appendix X. Analysis of variance of the data of effective and non effective tillers hill^{-1}of BRRI dhan29

Mean square of			
Source	**Df**	**Effective tillers hill^{-1} (no.)**	**Non-effective tillers hill^{-1} (no.)**
Replication (R)	2	0.11	0.003
Nitrogen dose (N)	2	21.51**	1.18**
Error (R×N)	4	0.10	0.02
Leaf cutting (L)	3	45.41**	2.94**
N×L	6	0.35*	0.38**
Error (R×N×L)	18	0.10	0.01
Total	35		

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

Appendix XI. Analysis of variance of the data of stem reserve translocation, flag leaf area and panicle length of BRRI dhan29

Source	Df	Mean square of		
		Stem reserve translocation	**Flag leaf area**	**Panicle length (cm)**
Replication (R)	2	0.08	1.69	1.08
Nitrogen dose (N)	2	383.35**	269.50**	7.51**
Error (R×N)	4	0.08	2.32	0.33
Leaf cutting (L)	3	1593.78**	199.61**	7.91**
N×L	6	123.13**	15.29**	1.99*
Error (R×N×L)	18	0.70	3.37	0.58
Total	35			

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

Appendix XII. Analysis of variance of the data of filled, unfilled, total grains panicle^{-1}, 1000 grains weight and absolute grain growth rate of BRRI dhan29

Source	Df	Mean square of				
		Filled grains panicle^{-1} (no.)	**Unfilled grains panicle^{-1} (no.)**	**Total grains panicle^{-1} (no.)**	**1000 grains weight (g)**	**Absolute grain growth rate**
Replication (R)	2	18.86	2.33	8.36	0.54	0.05
Nitrogen dose (N)	2	1088.68**	31.29**	756.88**	31.62**	4.08**
Error (R×N)	4	16.36	0.83	10.86	0.53	0.05
Leaf cutting (L)	3	957.51**	44.93**	654.71	62.54**	9.13**
N×L	6	48.66*	4.64*	28.19*	1.12*	0.53**
Error (R×N×L)	18	17.19	1.33	10.03	0.32	0.07
Total	35					

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

Appendix XIII. Analysis of variance of grain, straw, biological yield (t ha^{-1}) and harvest index (%) of BRRI dhan29

Source	Df	Mean square of Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication (R)	2	0.11	0.07	0.88	0.04
Nitrogen dose (N)	2	6.34**	3.47**	18.94**	16.31**
Error (R×N)	4	0.15	0.09	0.23	0.19
Leaf cutting (L)	3	2.95**	2.12**	9.53**	10.96**
N×L	6	0.40*	0.22*	0.78*	6.96**
Error (R×N×L)	18	0.12	0.08	0.26	0.87
Total	35				

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

PLATE

Plate 1: Photograph showing leaf cutting of young seedling

Plate 2: Photograph showing weeding and thinning of the experiment plot

Plate 3: Photograph showing SPAD value determination

Plate 4: Photograph showing nitrogen fertilizer application in the experiment plot

Plate 5: Photograph showing general view of the experiment plot during maturity stage

Plate 6: Photograph showing collection of various data for the experiment