ISSN2717-7238 | ISPEC Journal of Agricultural Sciences

Splitting of Nitrogen Fertilizer Enhanced Growth, Yield Contributing Parameters and Yield of Aromatic Rice Varieties

M.S. ISLAM
Department of Agronomy, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh (Corresponding authors)
M. Abdul HAKIM
Department of Agril Chemistry, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh
ASM Golam HAFEEZ
Department of Agricultural Finance, Bangladesh Agricultural University, Mymensingh, Bangladesh
A.K.M.A. BARI
Depart of Crop Science and Technology, Faculty of Agriculture, Rajshahi University, Rajshahi, Bangladdesh
M.K. CHOWDHURY
Bangladesh Agricultural Training Institute (Department of Agricultural Extension), Gaibanda, Bangladesh

ABSTRACT

Rice crop demands a heavy fertilization for better growth and yield. But improper timing of nitrogenous fertilizer application is the major constraint achieving higher yield of transplanted aman rice in Bangladesh. To solve this problem, a field experiment was carried out at the Department of Agronomy, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh during aman season (July to December, 2016) to study the effect of different split application of nitrogen (N) fertilizer on yield and yield attributes of aromatic rice. The experiment was laid out in a randomized complete block design with four split levels of N : (N_1= ½ during final land preparation + ½ at 30 DAT, N_2= 1/3 at 15 DAT + 1/3 at 30 DAT + 1/3 at 45 DAT, N_3= 1/4 at 15 DAT + ½ at 30 DAT + 1/4 at 45 DAT and N_4= 2/3 at 15 DAT + 1/3 at 45 DAT) on two popular aromatic rice varieties (Tulsimala and Badshabhog) of Bangladesh. Each treatment of the experiment was repeated four times and fertilizers in each plot were applied as per recommendation. Growth, yield contributing characteristics and yield both the varieties were significantly influenced by the splitting application of nitrogen. Nitrogen splitting influenced the plant height and N_2 produced the longest plant but there was no varietal difference on the plant height. Yield contributing characteristics like tillers (total, effective, non-effective), panicle length, spikelets panicle^{-1}, spikelet sterility, test weight were influenced

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by the treatments, and three equal split application of nitrogen (N_2) showed superiority in almost all the studied traits which positively influenced the grain yield of rice. The variety Badshabhog demonstrated higher performance than the variety Tushimala regarding the growth and yield characteristics. The highest grain was recorded by the N_2 and the lowest was in N_1 treatments, and the variety Badshabhog produced higher grain yield than Tulshimala.

Key words: Nitrogen fertilizer, split application, aromatic rice, yield

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important food crop of the developing world and the staple food of more than half of the world's population (Freeg et al., 2016; Fazaa et al., 2016). More than 3.5 billion people depend on rice for more than 20% of their daily calories. Rice provides 19% of global human per capita energy and 13% of per capita protein in 2009, and Asia accounts for 90% of global rice consumption, and total rice demand continues to rise in there (Tama et al., 2015 and Anis et al., 2016). It is the staple food for major worldwide population and forms the cheapest supply of food, energy and protein (Padmaja et al.2008; Hefena et al., 2016; Abdel-Moneam et al., 2016). Different rice varieties are grown in Bangladesh and each of them possesses some special different characteristics. The grains of some varieties are very small, some are fine, some of them are of different colors and some of them have special appeal for their aroma. Aromatic rice is mainly used by the people for the preparation of palatable dishes and sold at a higher price in the market due to its special appeal for aroma and acceptability. *Tulsimala and Badshabhog*, grown in *aman* season, are highly valued aromatic rice varieties in Bangladesh agricultural trade markets having small grain pleasant aroma with soft texture upon cooking (Islam et al., 2008a). Aromatic rice is used in many ways by the people like polau, khir, finny, jarda etc. In Bangladesh, during 2015-16, rice covered about 11.30 million ha with an average production of 35.06 million tons among which transplanted aman rice covered 5.59 million ha with a yield of 2.43 t/ha which is also lower than the national average of 2.97 t/ha (AIS, 2017). The lower yield of transplanted aman rice has been attributed to several reasons, one of them being poor nitrogen (N) fertilizer management, which is vital as N fertilizer can increase rice yield by 70-90% (Win, 2012) proving that rice plants require more N-based nutrients for higher yield. In addition, N positively influences the production of effective tillers/plant, yield and yield attributes (Islam et al., 2008). Nitrogen (N) plays a key role supporting plants activity and increasing the rice yield (Islam et a*l*., 2008b, Rashid et al.,

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2016). Furthermore, different varieties may have varying responses to N fertilizer depending on their agronomic traits. N content is directly proportional to the variation in the organic carbon of the soils. Considering 0.12% as the critical level of total N content (FRG, 2012) all the soils were found to be deficient in total N. Portch and Islam (1984) reported that 100% soils studied in Bangladesh contained available N below the critical level. Nitrogen is the most important limiting nutrient in rice production and has heavy system losses when applied as inorganic sources in puddle field (Fillery et al., 1984). Optimum timing of nitrogen fertilizer application plays a vital role in growth and development of rice plant. Synchrony of N supply with crop demand is essential in order to ensure adequate quantity of uptake and utilization and optimum yield. Fageria and Baligar (2005) reported that nitrogen rate and timing are important crop management practices for improving N use efficiency and crop yields. In addition, improving N use efficiency can reduce cost of crop production as well as environmental pollution. So, by applying proper dose we can save money and can also keep our environment secure. Because the heavy use of fertilizer affects the soil and also the environment through the residual effect of fertilizer, and urea can be applied in different ways. Therefore, it is essential to find out the optimum timing of nitrogen application for efficient utilization of this element by the plants for better yield. Excessive nitrogen fertilization encourages excessive vegetative growth which makes the plant susceptible to insects, pests and diseases which ultimately reduces yield. Judicious and proper use of fertilizers can markedly increase the yield and quality of rice (Matheiu, 1979). Generally 50% of the applied nitrogen is used by rice plant and the rest of it is lost through volatilization, de-nitrification and/or leaching, and thereby resulting in very low N-use efficiency (Bonki et al., 1996). Nitrogen use efficiency may be increased through its appropriate level and split application (Hussain, 1984). Like-wise, Bacon (1980) observed that split application of N fertilizer at sowing, tillering and panicle emergence produced the highest paddy yield. Since proper and judicious use of fertilizer contributes a lot to improve rice yield and grain quality, there is a need to find out a proper fertilizer application technique to minimize N losses and to improve its use efficiency. It is reported that lower yield of rice obtained with modern technology, over traditional methods, could be attributed to a single factor viz., fertilizer material used or applied at a wrong time or in appropriate application method adopted. To meet this challenge of increased food demand, the productivity per unit area per unit time has to be necessarily increased while all other approaches are obviously static. Considering the

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above facts the present study was, therefore, undertaken to determine the response of split application of nitrogen at different growth stages of rice cv. *Tulshimala and Badshabhog*.

MATERIALS and METHODS

Location and duration

A field experiment was conducted at the Agronomy Research Filed, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh. Geographically the experimental site is located at 25°38" N latitude and 88°41" E longitude at an elevation of 37.5 m above the mean sea level. The Agro Ecological Zone (AEZ) of the area is the Old Himalayan Piedmont Plain (AEZ-1) (FRG, 2012). The experiment was carried out during the Aman season, 2016.

Soil characteristics in the experimental field

The topography of the soil is medium low, loamy in texture and moderately fertile. The soil of the experimental sites was analyzed before transplanting of rice. The pre-transplanting total soil nitrogen (N) was 0.08%, indicating a deficiency in soil N. Soil available K was 0.10 meq $100g^{-1}$ soil, and available P, S, and Zn were 11.2, 6.29, and 0.55 ppm, respectively. Based on the critical levels of these plant nutrients, N, S, and Zn were low; but P and K were high. Soil pH was 5.41 and organic matter was 1.03%. The physical, and chemical properties of the soil are presented in Table 1.

Table 1. Physio-chemical properties of the soil of the experimental field with the critical value

Traits	Value	Critical value
pH	5.41	-
Organic matter (%)	1.03	-
Total nitrogen (%)	0.08	0.12
Available phosphorus (ppm)	11.20	8.0
Exchangeable potassium (meq %)	0.10	0.08
Available sulphur (ppm)	6.29	8.0
Available Zn (ppm)	0.55	0.60

Weather information

The experimental area possesses subtropical climatic conditions. The means of methodological information, like temperature (maximum, minimum and average temperature, °C), rainfall (mm), and relative humidity (%) of the experimental site during the crop growing period are exposed in the Figure 1. The monthly mean maximum temperatures ranged from 33.7 (August)

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to 26.4 ^{0}C (December) with an average of 31.3 ^{0}C, while, the monthly mean minimum temperatures ranged from 12.2 (December) to 24.8 ^{0}C (July) with an average of 21.1 ^{0}C. The mean relative humidity ranged from 81 to 91% with an average of 87%. A total rainfall of 1418mm with an average of 202.57 mm was received during normal growth period.

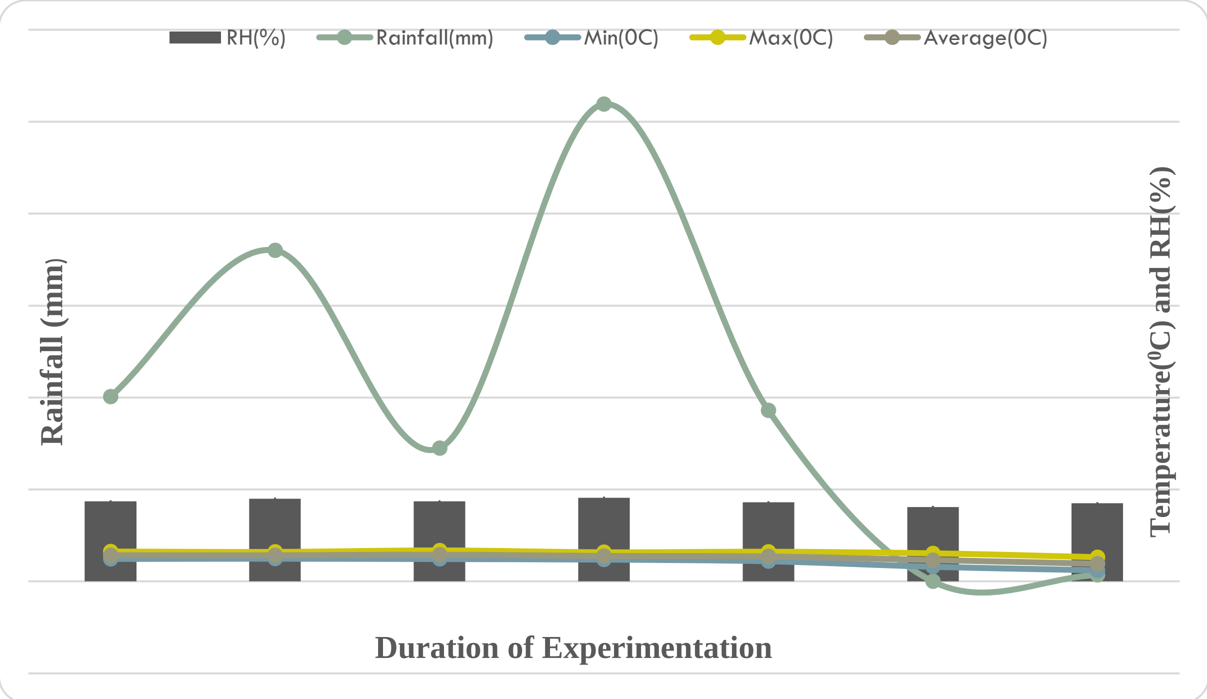

Figure 1. Monthly temperature (^{0}C), relative humidity (%) and rainfall (mm) of the experimental site during the period from June to December, 2016

Plant materials

The aim of the experiment was to study the effects of split application of four nitrogen levels on two rice varieties (*Tulshimala and Badshabhog*). The varieties were grown as transplant aman rice, major native varieties of Bangladesh.

Treatments

The four split nitrogen treatments were N_1 (at two equal splits, ½ during final land preparation + ½ at 30 DAT), N_2 (at three equal splits, $^{1}/_{3}$ 15 DAT + $^{1}/_{3}$ at 30 DAT + $^{1}/_{3}$ at 45 DAT), N_3 ($^{1}/_{4}$ at 15 DAT + $^{1}/_{2}$ at 30 DAT + $^{1}/_{4}$ at 45 DAT) and N_4 (at two splits, $^{2}/_{3}$ at 15 DAT + $^{1}/_{3}$ at 45 DAT).

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Experimental design and layout

The experiment was carried out in a Randomized Complete Block Design (RCBD) with three replications as factorial arrangement. The size of the each experimental pot was 4 m × 2.5 m. Layout of the experiment

was done with inter-plot spacing 0.75 m and inter-block spacing 1.0 m.

Seedlings raising and up rooting

Pre-germinated seeds were sown in wet nursery bed and proper care was taken to raise the seedlings in seedbed. Thirty (30) day old seedlings were uprooted carefully for transplanting in the main field.

Fertilization and transplanting

Fertilizers in each plot were applied as urea, triple super phosphate (TSP), muriate of potash (MP) and gypsum @ 150, 100 and 70, 60 kg ha^{-1}, respectively. All fertilizers except urea were applied at final land preparation and urea was applied as per treatments specification like. Three healthy seedlings in each hill were transplanted maintaining spacing of 20 cm × 15 cm.

Intercultural operations

Intercultural operations gap-filling, weeding and pests management were done properly and as necessary.

Data collection

At maturity stage, five sample hills were harvested from ach plot and traits of yield quantity and yield were analyzed. Yield quantity traits include the plant height, total tiller number, effective tillers, panicle lengths, number of spikelets per panicle, spikelet sterility (%), test weight, and grain yield.

Filled and unfilled (sterile) spikelets were counted separately from five sample hills in each plot and per cent spikelet sterility was calculated by using the following formula.

$$\text{Spikelet sterility (\%)} = \frac{\text{Number of sterile spikelets panicle}^{-1}}{\text{Total number of spikelets panicle}^{-1}\text{ (filled + non filled)}} \times 100$$

Grain from the net plot of each treatment was dried in sun till a constant weight was arrived. The grain from the five labeled hills was included to the net plot yields before expressing the final grain yield in t ha^{-1}. Grain yields were recorded plot-wise on sundry basis. Grain yield was expressed on 12-14 % moisture basis.

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Statistical analysis

Data were analyzed statistically using 'analysis of variance' technique and differences among treatments were adjudged by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

Results and Discussion

Plant height

Nitrogen application in different splits significantly increased the plant height of Tulshimala and Badshabhog in this study (Table 2). The tallest plant (148.65 cm) was observed at the N_2 treatment which was statistically similar to N_3 treatment (144.74 cm) and the shortest plant height (139.18 cm) was recorded at N_1 treatment, which statistically identical with N_4 treatment. Three equal splits of application (N_2) might have provided nitrogen uniformly at phenological stages resulting enhanced plant height of 6.82% compare to N_1. These results explicitly confirm of the results obtained by Islam et al. (2009); Hasanuzzaman et al. (2009). Availability of nitrogen at early growth stages caused to increasing of plant height (Manzoor et al., 2006). Three splits of nitrogen application were better than two splits. The increase in plant height due to application of three split of nitrogen might be associated with the increasing nitrogen use efficiency of rice. There was no significant variation regarding the plant height between the two varieties of Tulshimala and Badshabhog although the previous one produced the higher plant height than the later one (Table 3). Similar result was also recorded with the interaction effect of between the split application of nitrogen and the studied varieties (Table 4). However, the longest plant height (152.63 cm) was recorded with the N_3V_1 treatment and the shortest (139.71cm) was observed with the N_4V_2 treatment. Plant height is a genetical characteristic which is varied with the nature of variety. But within the variety plant height is influenced by the fertilizer management practices. Biloni and Bocchi (2003) observed that the plant height was significantly affected by nitrogen application in splits and N applied at pre-sowing and tillering stage performed better. Our result is also in agreement with the findings of Mahjoobeh et al. (2013) who reported that splits application of nitrogen remarkably increased the plant height of rice.

Number of tillers

The number of tillers (total, effective and non-effective) hill^{-1} of rice plant was also significantly influenced by the split application of nitrogen, variety and their interaction treatments (Table 2,

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3 and 4). Application of nitrogen with three equal splits produced the highest number of total tillers and effective tillers than other three nitrogen treatments. However, the highest number of total tillers (10.73), effective tillers (8.64) hill^{-1} were recorded at N_2 which was statistically similar to N_3 (9.83 and 7.65) while, the lowest (8.92) was recorded at the N_4 treatment which was at par with N_1 treatment. On the other hand, the least number of non-effective tillers was observed with the N_2 treatment which was statistically similar with the N_3 and the highest of the same was recorded at N_1 which was as like N_4 treatment. Our results designated that continuous supply of nitrogen up to the maximum tillering stage enhanced the total- and effective tillers hill^{-1} which is more essential for producing the maximum tillers of the crop. Three equal splits proved superiority compared to other splits, indicating equal splits (N_2) might have delivered the required quantity of nitrogen at the maximum tillering stage of rice plants, encouraged more nitrogen uptake, and discouraged the nitrogen loss. These results were accordance with the findings of Singh and Singh (1998), Singh et al. (2006), Islam et al. (2009), Kamruzzaman et al. (2013). Three splits of nitrogen application were better than two splits. Sahoo et al. (1989) and Rao et al. (1997) cited that three splits application of nitrogen showed better response than two splits. Rana et al. (1989), Islam et al. (2008), and Hasanuzzaman (2009) observed the similar results. The variety Tulshimala produced higher number of total tillers but less number of effective tillers hills^{-1} than the variety Badshabhog which ensured less number of non-effective tillers hills^{-1} in Badshabhog (Table 3). Less number of non-effective tillers was found in Badshabhog than Tulshimala which is more yield contributing trait. The interaction of nitrogen and variety influenced the total-, effective- and non-effective tillers hill^{-1} of aromatic rice. The highest number of total-, effective-, and non-effective tillers hill^{-1} (12.17, 8.65 and 4.87) were recorded at the treatment combination of N_1V_1, N_2V_2 and N_1V_1, while the lowest numbers (8.67, 6.01 and 1.95) hill^{-1} were recorded at N_4V_2, N_4V_1 and N_2V_2, respectively (Table 4). Effective tillers hill^{-1} is an important yield trait which directly influenced the yield of rice. In this study, the treatment combination of N_2V_2 produced the highest number of effective as well as less non number of non-effective tillers hill^{-1}.

Panicle length

The length of spikelet bearing panicle is a vital yield trait which influences the grain yield of cereal crops. Splits application of nitrogen significantly influenced the panicle length of rice. The highest panicle length (27.13 cm) was found at N_2 treatment which was statistically similar to N_3 and N_4 treatments, and the lowest value (23.05 cm) was obtained at the treatment of N_1.

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Three splits of nitrogen (N_2 and N_3) produced significantly higher panicle length than the rest two splits (N_1 and N_4). Similar result was also observed by Hasanuzzaman et al. (2009), Rashid et al. (2016) in T. aman rice. Kaushal et al. (2010) reported that three splits of ½ basal, ¼ at tillering, ¼ at panicle initiation produced the highest panicle length. Raza et al. (2003) claimed the panicle length was significantly higher in N applied in two splits i.e. 1/2 at tillering and 1/2 at panicle initiation. Incase of variety, the longer panicle length tillers^{-1} (28.11 cm) was obtained in Badshabhog than Tulshimala (26.26 cm) (Table 3). The interaction effect of nitrogen split application and variety was significant. However, the longest panicle length (31.33 cm) was observed at the treatment combination of N_2V_2 which was statistically similar to V_2N_3 and V_1N_2 and V_1N_2, whereas the lowest value (23.49 cm) was recorded at V_1N_1 which was statistically similar (24.73 cm) to N_1V_2 treatment combination (Table 4).

Spikelets panicle^{-1}

The spikelet number panicle^{-1} is influenced by the different splits application of nitrogen which largely determines the yield of rice. The highest number of grains panicle^{-1} (88.91) was observed with N_2 that was statistically identical with N_3 treatment, and the lowest value (75.16) was found at N_1 treatment. This result is in agreement with the findings of Kenzo (2004), Islam et al. (2008), Kaushal et al. (2010), Kamruzzaman et al. (2013), Rashid et al. (2016). In the varietal performance, Badshabhog performed remarkably better that Tushimala regarding the number of spikelets panicle^{-1} (Table 3). The significant interaction between the nitrogen split application and variety on the spikelets panicle^{-1} was recorded in this study (Table 4). However, the highest number of spikelets panicle^{-1} (97.84) was recorded with the treatment combination of N_2V_2which was at par with N_3V_2, and the lowest value (70.55) was at the N_1V_1 combination. The number of spikelets panicle^{-1} is correlated with panicle length which was recorded the highest value with the treatment combination of N_2V_2 in this study.

Table 2. Effect of split application of nitrogen on the yield contributing characteristics of aromatic rice

Treatments	Plant height (cm)	Total tillers hill^{-1}	Effective tillers hill^{-1}	Non-effective tillers hill^{-1}	Panicle length (cm)	Spikelets panicle^{-1}	Test weight (g)
N_1	139.18b	9.47bc	7.02b	2.45a	23.05b	75.16c	16.70ab
N_2	148.65a	10.73a	8.64a	2.09b	27.13a	88.91a	17.53a
N_3	144.74a	9.83ab	7.65ab	2.18b	27.03a	86.29ab	16.10b
N_4	142.41b	8.92c	6.49b	2.43a	26.68a	79.54b	15.47bc
CV	3.45	9.56	8.12	4.32	5.78	7.15	10.39
Sx	3.65	0. 92	0.63	0.27	1.45	1.19	0.54

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N_1 = ½ as basal + ½ at 30 DAT, N_2 = $^1/_3$ at 15 DAT +$^1/_3$ at 30 DAT + $^1/_3$ at 45 DAT, N_3 = $^1/_4$ at 15 DAT +½ at 30 DAT + $^1/_4$ at 45 DAT, N_4 = $^2/_3$ at 15 DAT + $^1/_3$ at 45 DAT, NS = Non significant

Table 3. Effect of variety on the yield contributing characteristics of aromatic rice

Treatments	Plant height (cm)	Total tillers hill^{-1}	Effective tillers hill^{-1}	Non-effective tillers hill^{-1}	Panicle length (cm)	Spikelets panicle^{-1}	Test weight (g)
V_1	150.58	11.29a	6.75b	4.54a	26.26b	75.40b	14.29b
V_2	144.33	9.87b	7.29a	2.58b	28.11a	93.85a	17.16a
CV	4.23	10.54	10.74	7.69	5.44	10.04	11.07
Sx	NS	0.292	0.231	0.073	0.404	2.119	0.526

The figures in a column having the same letter do not differ significantly as per DMRT
V_1 = Tulsimala; V_2 = Badshabhog; NS = Non significant

Table 4. Yield contributing characteristics of fine rice as influenced by the interaction between split applications of nitrogen and variety

Treatment combination	Plant height cm)	Total tillers hill^{-1}	Effective tillers hill^{-1}	Non-effective tillers hill^{-1}	Panicle length (cm)	Spikelets panicle^{-1}	Test weight (g)
N_1V_1	144.54	12.17a	7.30b	4.87a	23.49c	70.55d	14.64c
N_2V_1	150.27	11.13b	7.40b	3.73b	30.73a	78.23c	19.34a
N_3V_1	152.63	10.67b	7.20b	3.47b	30.21a	73.10d	17.75a
N_4V_1	154.88	9.53c	6.01c	3.52b	26.61bc	71.71d	15.38b
N_1V_2	141.20	9.70c	7.00bc	2.70c	24.73c	83.85bc	14.80c
N_2V_2	149.96	10.60b	8.65a	1.95d	31.33a	97.84a	16.65ab
N_3V_2	146.40	9.50c	7.40ab	2.10cd	31.23a	94.85ab	16.72ab
N_4V_2	139.71	8.67d	6.37c	2.30c	27.33b	89.98b	13.47c
CV (%)	4.23	10.54	10.74	7.69	5.44	10.04	11.07
Sx	NS	0.583	0.462	0.147	0.808	7.78	3.65

The figures in a column having the same letter do not differ significantly as per DMRT; V_1 = Tulsimala, V_2 = Badshabhog;
N_1 = ½ as basal + ½ at 30 DAT, N_2 = $^1/_3$ at 15 DAT +$^1/_3$ at 30 DAT + $^1/_3$ at 45 DAT, N_3 = $^1/_4$ at 15 DAT +½ at 30 DAT + $^1/_4$ at 45 DAT, N_4 = $^2/_3$ at 15 DAT + $^1/_3$ at 45 DAT, NS = Non significant

Test weight

The test weight is a steady varietal character because the grain size rigidly controlled by the hull. In this study, the test weight was significantly influenced due to application of nitrogen in different splits. However, the highest test weight was recorded with the N_2 treatment which was statistically identical with the N_1 treatment but different with other nitrogen split treatments,

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while the lowest was found at N_4 treatment. Raza et al. (2003), Islam et al. (2008), Hirzel et al. (2011) claimed that 1000-grain weight was highly significant due to the split application of nitrogen, where nitrogen applied in three equal splits i.e. 1/3 at transplanting + 1/3 at tillering + 1/3 at panicle initiation produced the highest test weight. The variety Badshabhog produced significantly higher test weight than the variety Tulshimala (Table3). The 1000-grain weight varied due to the rice varieties as reported by Shamsuddin et al. (1988), Rashid et al. (2016). Yoshida (1981) concluded that the 1000-grain weight is the stable character. The interaction between split application of nitrogen and variety was significant in respect of test weight. Nonetheless, the highest test weight (19.34 g) was opined at N_2V_1 followed N_2V_2, N_3V_2, and lowest (13.47 g) was recorded at V_2N_4 which was at par with N_1V_1 and N_4V_1 treatment combinations.

Spikelet sterility (%)

The spikelet sterility percentage (SP) of grain is a significant yield contributing characteristic which negatively related with the grain yield. Two equal splits of nitrogen as ½ at basal and ½ at 30 DAT (N_1) increased the SP of grains followed by another two splits of $^2/_3$ at 15 DAT + $^1/_3$ at 45 DAT (N_4), resulting their lower corresponding yield (Fg. 2). Our result is in agreement with the findings of Lampayan *et al*. (2010) who noted that equal application of nitrogen throughout the growing period (tillering to reproductive stages) increased the fertile spikelets by reducing the sterile spikelets. On the other hand, the lower SP was achieved at three splits of nitrogen application (N_2 and N_3), and three equal splits of nitrogen (N_2) produced the least SP in both the varieties. However, the variety Badshabhog demonstrated the lesser SP than Tulshimala at all the nitrogen splits except N_1 (½ at basal and ½ at 30 DAT).

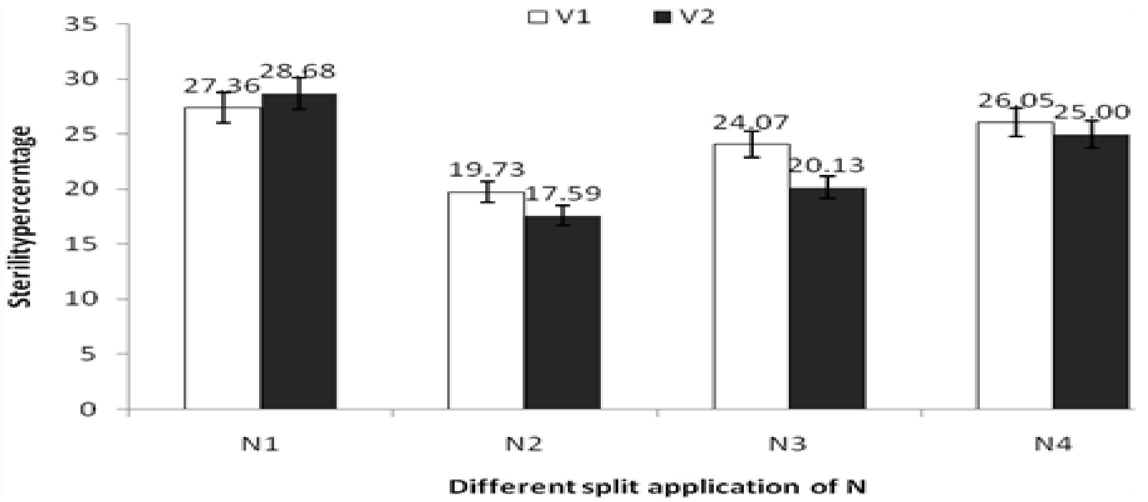

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Fig. 2. Effect of different split application of nitrogen on the spikelet sterility percentages of aromatic rice varieties (cv. Tulshimala and Badshabhog)

Grain yield

Split application of nitrogen had significant effect on the grain yield of aromatic rice (Fig. 3). The highest grain yield (2.69 tha^{-1}) was achieved from the three equal split application of nitrogen (N_2) and the lowest grain yield (1.58 tha^{-1}) was obtained from nitrogen application as ½ at basal + ½ at 30 DAT (N_1). The increased grain yield was contributed by the higher number of effective tillers $hill^{-1}$, higher number of grains $panicle^{-1}$ and maximum weight of 1000-grains. Splits application maintained continuous supply of nutrients (N) which might have favored the crop for good growth, yield attributes and finally the yield of rice. It was revealed that the highest grain yield was mainly contributed by its higher number of panicles $hill^{-1}$ and grains $panicle^{-1}$ and higher test weight in the plants treated with three split application of N fertilizer. Application of three equal split of nitrogen met up of appropriate quantity of nitrogen as the crop demand and enhanced the growth, yield contributing characteristics and yield of aromatic rice. Our result regarding grain is supported by Hirzel et al. (2011) who depicted that split N fertilization with 33% N at sowing, 33% at tillering, and 34% at panicle initiation significantly produced the highest grain yield than any other methods. Similar result was reported by Krishnan and Nayak (2000), Jing (2007), Islam et al. (2008), Kaushal et al. (2011), Kamruzzaman et al. (2013) and Rashid et al. (2016). Ida et al. (2009) indicated that N applications in the heading stage increased rice grain yield through more N accumulation in the panicles. Incase of variety, the variety Badshabhog yielded significantly higher grain than the variety Tulshimala (Fig. 3). Shorter plant of Badshabhog variety (Table 3) might be harvested more light which influenced more number of effective tillers, grains $panicle^{-1}$, 1000-grains weight than the plants of Tulshimala. Similar observations were also noted by Kabaki (1993), Yamauchi (1994), Abou-Khalifa et al. (2007). However, continuous and balanced supply of nitrogen throughout the crop growth period might have increased the yield traits, consequently augmented the highest grain yield.

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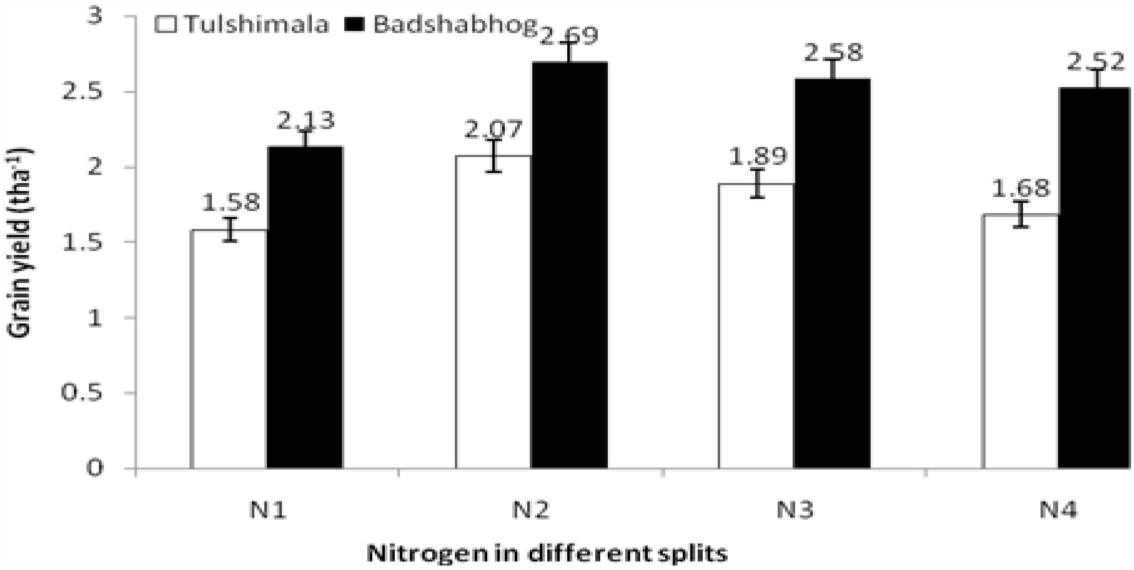

Fig. 3. Effect of different splits application of nitrogen on the yield of aromatic rice (cv. Tushimala and Badshabhog)

Conclusions

Timely nitrogen application (along with optimum level) is another pioneer agronomic technique of overall nitrogen management in rice for efficient utilization of nutrients. Split nitrogen fertilization significantly influenced the growth, yield traits and yield of aromatic rice varieties, and three equal splits of nitrogen as $^1/_3$ at 15 DAT, 1/3 at 30 DAT and $^1/_3$ at 45 DAT (N_2) significantly increased growth, yield traits and yield of rice varieties followed by another three splitting of nitrogen of N_3 ($^1/_4$ at 15 DAT + ½ at 30 DAT + $^1/_4$ at 45 DAT) as compared to two splitting of nitrogen of N_1 (½ during final land preparation + ½ at 30 DAT) and N_4 ($^2/_3$ at 15 DAT + $^1/_3$ at 45 DAT). The variety Badshabhog showed better yield than the variety Tulshimala. Therefore, the application of nitrogen fertilizer at proper time amplified yield of rice to a remarkable extent, and hence proper management of crop nutrition is of immense importance.

Acknowledgements

We thank Professor Dr. Shafiqul Islam Sikder, Chaman, Department of Agronomy, HSTU, for conducting the research. We are also obliged to several colleagues for communicating valuable information. We acknowledge the generous financial support by the University Grants Commission (UGC), Dhaka and also Institute of Research and Training (IRT), HSTU for coordination UGC and us.

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Conflict of interest: The authors declare that they have no competing interests.

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