

Effect of Nitrogen Rates and Leaf Clipping on Forage and Grain Yield, and Seed Quality of Transplant Aman Rice

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ABSTRACT

Sustainable fodder production is difficult from limited cultivable land occupied for food grain production. This paper presents the results of the experiment designed to test the hypothesis that forage could be produced along rice grain from the same rice field. The aim of the present study was 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. BRRI dhan41 was used in the experiment. N rates, leaf clipping times and its interaction had significant effects on forage and grain yield, yield components and seed quality except thousand grain weight. The results revealed that forage yield increased with increasing N rates and leaf clipping times. Grain yield was higher in higher N rates and early leaf clippings, however, it was decreased in the late clipping (55 DAT). The highest mean grain yield (5.25 t ha⁻¹) was obtained from the treatment combination of 115 kg N ha⁻¹ (N_4) and no leaf clipping (N_4C_0) which was statistically similar (5.18 t ha⁻¹) to N_3C_0 (5.18 t ha⁻¹), N_3C_1 (5.10 t ha⁻¹) and N_4C_1 (5.06 t ha⁻¹). The lowest mean grain yield (3.17 t ha⁻¹) was obtained from N_1C_3 . Grain yield was reduced by 3, 6 and 24% in C_1 , C_2 and C_3 , respectively compared to C_0 (No leaf clipping). Qualitative characters (germination and vigour index) of seed increased with increased N rates, however it decreased in the delayed leaf cuttings. Application of 92 to 115 kg N ha⁻¹ with early leaf clipping (25 to 40 DAT) might be allowed to attain moderate forage yield, higher grain yield, and quality seed of transplant Aman rice.

Key words: Leaf clipping, forage yield, grain yield, harvest index, vigour index.

INTRODUCTION

The population of Bangladesh is increasing at an alarming rate and the cultivable land is reducing @ 0.4% as it is converting to non-cultivable land due to urbanization and industrialization (Hasan *et al.*, 2013; Karmakar and Ali, 2019). Thus, it is an urgent need to increase rice production through maximization of yield for sustainable food security. For maximizing yield and quality of rice seed, proper agronomic management is required. N-fertilization is an important factor which considerably affects yield, yield components and seed quality of transplant Aman rice and

its deficiency impairs the growth and yield of rice (Ahmed *et al.*, 2001a). Enormous efforts are, therefore, needed to formulate nitrogen recommendation for high yielding rice varieties that will technically be feasible, economically viable, socially acceptable and environmentally sound. Moreover, vegetative growth and development of rice is generally highly affected by N-fertilization (Ahmed *et al.*, 2001b).

Livestock is an integral part of agriculture in Bangladesh and plays an important role in agriculture (Ahmed *et al.*, 2001a). Conversely, severe shortage of fodder and feeds, is the biggest constraint of livestock

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production in the country. Farmers use their land for crop production to fulfill the requirement of human consumption. Therefore, they could not be able to leave enough land for fodder production due to high pressure on land for crop production for human consumption. So, farmers have limited opportunity to grow fodder crop in single field. Non-availability of fallow land and pasture for green grass due to high pressure on land for crop production for human consumption create problem for the improvement of livestock sector in Bangladesh. The farmers are not interested to grow fodder crop in these lands because most of the farmers of our country are small holders and they do not show interest to use their land for fodder crop instead of food crop. Severe crisis of green leaf for livestock consumption occurs during August to October, when entire fields are occupied by transplant Aman rice. Moreover, there is a deficit of straw of that time for livestock. To overcome the scarcity of green forage, it is necessary to explore the feasibility of using green leaves of rice as forage without affecting grain yield. It is probable that rice leaves could be used as green fodder to meet fodder deficit because most of the area is covered by rice plants in year round. In rainy season when most of the fields are under water, rice plants remain above water. To overcome the scarcity of food-cum forage, crop like rice seems to be one of the most feasible and economically viable practice to serve the needs of human, cash income and animal feed, particularly for those who have limited resources (Topark-Ngram *et al.*, 1988).

Flag leaf plays an imperative role on grain yield through synthesis and translocation of photo-assimilates to the rice grain (Das *et al.*, 2017; Fatima *et al.*, 2019). The rice crop at vegetative stage may be used as forage, then further allowed for regrowth; and finally it could be harvested for grain at maturity. Use of rice as forage at the vegetative

phase of the plant may encourage small farmers to raise more animals on farm. Usually, excess leaf growth of long duration rice plants is grazed at the early vegetative stage. In some deep-water areas of Bangladesh, a traditional deep-water rice variety is grown as fodder (Magor, 1986). If leaf cutting really has no injurious effect on grain production, it may become one of the most economical ways of increasing the total productivity of land by providing additional green feeding materials for the animals. The success of rice cultivation as dual purpose crop, is mostly dependent on different improved agronomic techniques like leaf clipping time, application of N-fertilizer etc. Therefore, the present study was undertaken to investigate the effect of N-rates, leaf clipping timings and their interaction on forage and grain yield of transplant Aman rice.

MATERIALS AND METHODS

The experiment was conducted at the Agronomy Field and Laboratory (24°75'N latitude, 90°50'E longitude and 18 meter above from sea level) of the Bangladesh Agricultural University, Mymensingh, which belongs to the Sonatola soil series under Old Brahmaputra Floodplain (AEZ 9), characterized by medium high silty loam soil with pH 6.5 (BARC, 2012). BRRI dhan41, a high yielding modern rice variety of Aman season (wet season) developed by Bangladesh Rice Research Institute (BRRI) was used in the experiment. Four nitrogen (N) rates, N₁ = 46, N₂ = 69, N₃ = 92, N₄ = 115 kg N ha⁻¹ and four times of leaf clipping (cutting) viz C₀ = 0 (No leaf clipping), C₁ = leaf clipping at 25 DAT (Days after transplanting), C₂ = leaf clipping at 40 DAT, and C₃ = leaf clipping at 55 DAT. In the clipping treatments, all the leaves (100%) were removed from rice plant and the leaves were cut from 12 hills selected diagonally of each plot. Experiment was laid out in split-plot design with three replications, assigning N

rates in the main plots and leaf clipping times in the sub plots. Unit plot size was 3 m × 4 m. Seedbed management was done according to the traditional farm practice (BRRI, 2011). Land preparation was conducted according to the common practice of wetland soil preparation with puddling. Thirty-day-old seedlings were transplanted with 25 × 15 cm spacing using three seedlings hill⁻¹. Fertilizers containing P, K, S and Zn were applied @ 15, 38, 10.6 and 2.7 kg ha⁻¹, respectively using TSP, MOP, gypsum and zinc sulfate. The full amount of TSP, MOP, gypsum and zinc sulfate were applied basally during the final land preparation and incorporated into the soil. Urea fertilizer was top-dressed according to the treatments at three equal splits at 25, 40 and 55 DAT, respectively synchronizing to immediate after every leaf clipping. Due to frequent rains occurred during cropping period, no irrigation was needed. The crop was protected from pest infestation according to standard management practices. Furadan 10G was applied at panicle initiation stage of the crop to protect from stem borer infestation. Green and dry fodder yield data were collected from 6 m² area of each plot and converted into t ha⁻¹. From the center of each plot, 6 m² area was harvested for determination of grain yield when 85% of the grains appeared yellowish (IRRI, 2014). Grain yield was adjusted to 14% moisture content, and expressed in t ha⁻¹. Yield component data were collected following recommended procedures (IRRI, 1994). Harvest index was calculated by using the following formula (Fageria *et al.*, 2011; Karmakar and Sarkar, 2015):

$$\text{Harvest index} = \frac{\text{Grain yield}}{\text{Grain yield} + \text{Straw yield}}$$

Germination test was conducted following the rules and procedures of ISTA (ISTA, 1976). Germinated seeds were counted on 7, 10 and 14th days after placement of seed vigour index of seedling was calculated using the following formula of Maguire (1962):

$$\text{Vigour Index} = \frac{\text{No. of seeds germinated at first count}}{\text{Duration of first count}} + \dots + \frac{\text{No. of seeds germinated at last count}}{\text{Duration of last count}}$$

Analysis of variance was conducted using the statistical software MStatC. Mean differences among the treatments were tested using Duncan's Multiple Range Test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Plant height

Plant height was significantly affected by N rates, leaf clipping times and their interaction (Table 1). Plant height was significantly increased with increasing nitrogen rates which is corroborating with Fageria *et al.* (2011). The highest plant height (130.10 cm) at harvest was recorded from 115 kg N ha⁻¹ (N₄) followed by 92 kg N ha⁻¹ (126.90 cm). The lowest plant height (121.22 cm) was found from 46 kg N ha⁻¹ (N₁). This result indicates that plant height increased significantly with increased N application. These results are in confirmation of the findings of Fageria *et al.* (2011); Awan *et al.* (1984) and Mannan *et al.* (2010). The highest plant height (128.95 cm) was recorded at C₀ (No leaf clipping) and the lowest plant height (116.83 cm) was found C₃ (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. Similar results were found by Bandyopadhyay *et al.* (1998). The plant height at harvest ranged from 113.20 to 137.60 cm in the interaction of nitrogen rates and leaf clipping timings. The longest plant (137.60 cm) was observed in the interaction of 92 kg N ha⁻¹ with leaf clipping at 40 DAT (N₃C₂) at harvest and the shortest plant (113.20 cm) was recorded in 92 kg N ha⁻¹ with leaf clipping at 55 DAT (N₃C₃).

Table 1. Effect of nitrogen rates, leaf clipping times and their interactions on plant height of transplant Aman rice cv. BRR1 dhan41 at different dates after transplanting (DAT).

Treatment	Plant height (cm) at different DAT			
	25 DAT	40 DAT	55 DAT	At Harvest
<i>N rates (kg ha⁻¹)</i>				
N ₁ = 46	42.79c	60.66b	78.54c	121.22d
N ₂ = 69	45.85b	62.90a	80.84bc	124.45c
N ₃ = 92	47.03a	62.05a	81.18b	126.90b
N ₄ = 115	47.76a	62.97a	82.94a	130.10a
LSD _{0.05}	0.94	1.66	1.09	2.24
F-test	**	**	**	**
<i>Leaf clipping times (DAT)</i>				
C ₀ = 0	47.15	64.43a	81.72a	128.32a
C ₁ = 25	48.35	63.78b	79.37b	125.57b
C ₂ = 40	47.21	59.58d	79.32b	123.95bc
C ₃ = 55	48.22	60.75c	78.09c	116.83c
LSD _{0.05}	0.81	1.53	0.99	1.65
F-test	ns	**	*	**
<i>Interaction effect of N rates and leaf clipping times</i>				
N ₁ ×C ₀	45.87c	63.97b	84.07a	124.73bcdef
N ₁ ×C ₁	47.13bc	61.32	78.47de	126.33bcde
N ₁ ×C ₂	47.40b	56.73f	75.53efg	119.20efg
N ₁ ×C ₃	46.75bc	60.60def	76.10ef	114.60fg
N ₂ ×C ₀	46.73bc	63.60bc	80.73c	128.93abcde
N ₂ ×C ₁	49.20a	67.47a	82.40b	131.67abcd
N ₂ ×C ₂	47.17bc	61.53de	60.88g	125.40bcdef
N ₂ ×C ₃	42.10d	59.00e	79.40cd	121.60defg
N ₃ ×C ₀	48.47a	64.13c	81.17bc	124.27bcdef
N ₃ ×C ₁	47.41b	61.07de	76.67ef	122.73cdefg
N ₃ ×C ₂	46.27bc	61.85	79.73cd	137.60a
N ₃ ×C ₃	45.93c	61.13de	79.11cd	113.20g
N ₄ ×C ₀	47.53bc	66.00ab	80.93c	135.33ab
N ₄ ×C ₁	49.40a	65.27ab	79.93c	133.53abc
N ₄ ×C ₂	48.00a	58.20e	81.17bc	133.60abc
N ₄ ×C ₃	46.10bc	62.40cd	77.73ef	117.93efg
LSD _{0.05}	1.63	3.06	1.98	3.30
F-test	*	**	**	**

Ns=Not significant, * = Significant at the 5% level of probability and ** = Significant at the 1% level of probability.

Green forage yield

Green forage yield of BRR1 dhan41 was significantly affected by the nitrogen rates, leaf clipping timings and their interaction (Table 2). Green forage yield increased with increasing N rates. The highest green forage yield (14.5 t ha⁻¹) was recorded from 115 kg N ha⁻¹ at 55 DAT and the lowest green forage yield (1.1 t ha⁻¹) was

obtained from 46 kg N ha⁻¹ (N₁) at 25 DAT (Table 2). In case of leaf clipping timings, the highest green forage yield (53.6 t ha⁻¹) was observed from leaf clipping time at 55 DAT (C₃) and the lowest green forage yield (6.5 t ha⁻¹) was observed from leaf clipping time at 25 DAT (C₁). The difference in green forage yield was mainly due to difference in duration of cuts from the

transplanting times. Forage yield increased with delayed leaf cutting which was also reported previously by Ahmed *et al.* (2001b). This indicated that leaf clipping time at 55 DAT could produce a large amount of green leaves for animals. The crops were allowed to grow further for seed production. The highest green forage yield (57.8 t ha⁻¹) was found from 115 kg N ha⁻¹ and clipping time at 55 DAT (N₄C₃) and the lowest (6.0 t ha⁻¹) was found from 46 kg N ha⁻¹ and clipping time at 25 DAT (N₁C₁).

Dry forage yield

Dry forage yield of rice was significantly affected by the nitrogen fertilizer and the clipping time (Table 2). Dry forage yield increased with increasing N rates. The highest dry forage yield (0.990 t ha⁻¹) was recorded from 115 kg N ha⁻¹ collected at 55 DAT while the lowest dry forage yield (0.421 t ha⁻¹) was noticed from 46 kg N ha⁻¹ (N₁) collected at 25 DAT. In case of leaf cutting timings, the highest dry forage yield (3.764 t ha⁻¹) was observed from leaf clipping time at 55 DAT (C₃) while the lowest dry forage yield (2.127

Table 2. Forage yield of BRR1 dhan41 as affected by N rates, leaf clipping times and their interactions.

Treatment	Green and dry forage yield (t ha ⁻¹) at different DAT					
	25 DAT		40 DAT		55 DAT	
	Green FY ¹ (t ha ⁻¹)	Dry FY (t ha ⁻¹)	Green FY (t ha ⁻¹)	Dry FY (t ha ⁻¹)	Green FY (t ha ⁻¹)	Dry FY (t ha ⁻¹)
	<i>N rates (kg ha⁻¹)</i>					
N ₁ = 46	1.1c	0.421c	4.8d	0.532c	11.0d	0.720d
N ₂ = 69	1.4b	0.500b	5.4c	0.561c	12.5c	0.839c
N ₃ = 92	1.6a	0.535ab	5.9b	0.650b	13.7ab	0.905b
N ₄ = 115	1.7a	0.542a	6.3a	0.767a	14.5a	0.990a
LSD _{0.05}	0.02	0.19	0.04	0.61	0.18	0.39
F-test	*	*	*	*	**	**
	<i>Leaf clipping times (DAT)</i>					
C ₀ = 0	0.0b	0.000b	0.00b	0.000b	0.0b	0.000b
C ₁ = 25	6.5a	2.127a	0.00b	0.000b	0.0b	0.000b
C ₂ = 40	0.0b	0.000b	24.0a	2.835a	0.0b	0.000b
C ₃ = 55	0.0b	0.000b	0.00b	0.000b	53.6a	3.764a
LSD _{0.05}	0.01	0.23	0.04	0.39	0.07	0.62
F-test	**	**	**	*	**	**
	<i>Interaction effect of N rates and leaf clipping times</i>					
N ₁ ×C ₀	-	-	-	-	-	-
N ₁ ×C ₁	6.0b	2.014d	-	-	-	-
N ₁ ×C ₂	-	-	22.7d	2.600c	-	-
N ₁ ×C ₃	-	-	-	-	52.0d	3.680d
N ₂ ×C ₀	-	-	-	-	-	-
N ₂ ×C ₁	6.7ab	2.149b	-	-	-	-
N ₂ ×C ₂	-	-	24.5b	2.744b	-	-
N ₂ ×C ₃	-	-	-	-	54.0b	3.722c
N ₃ ×C ₀	-	-	-	-	-	-
N ₃ ×C ₁	6.5b	2.140c	-	-	-	-
N ₃ ×C ₂	-	-	23.7c	2.930ab	-	-
N ₃ ×C ₃	-	-	-	-	50.7c	3.756b
N ₄ ×C ₀	-	-	-	-	-	-
N ₄ ×C ₁	7.0a	2.267a	-	-	-	-
N ₄ ×C ₂	-	-	25.0a	3.067a	-	-
N ₄ ×C ₃	-	-	-	-	57.8a	3.996a
LSD _{0.05}	0.03	0.06	0.08	0.09	0.14	0.11
F-test	*	*	**	**	*	**

¹FY=Forage yield, * Significant at the 5% and ** Significant at the 1% level of probability.

t ha⁻¹) was observed from leaf cutting at 25 DAT (C₁). These results are in good harmony with Ahmed *et al.* (2001a). Interaction of 115 kg N ha⁻¹ (N₄) and leaf cutting at 55 DAT (C₃) produced the highest dry forage yield (3.996 t ha⁻¹) followed by N₃C₃ (2.930 t ha⁻¹) and the lowest dry forage yield (2.014 t ha⁻¹) was found from 46 kg N ha⁻¹ and clipping time at 25 DAT (N₁C₁). These results are corroborating with findings of Abou-khalifa *et al.*, 2008.

Grain yield

Grain yield was influenced significantly by nitrogen rates, leaf clipping times and their interaction (Table 3). Results revealed that, the highest grain yield (4.88 t ha⁻¹) was recorded from 115 kg N ha⁻¹ (N₄) that was statistically similar (4.75 t ha⁻¹) with 92 kg N ha⁻¹ (N₃). The lowest grain yield (3.35 t ha⁻¹) was recorded when the crop was fertilized with 46 kg N ha⁻¹ (N₁). Nevertheless, grain yield increased with increased nitrogen rates. The results confirmed the findings of Fageria *et al.* (2011), Prudente *et al.* (2008), Karmakar *et al.* (2002) and Oo *et al.* (2007) who reported that grain yield increased significantly with increasing N levels. In respect of leaf clipping, the highest grain yield (4.36 t ha⁻¹) was observed in control plot (C₀=leaf was not clipped) and the lowest grain yield (3.33 t ha⁻¹) was obtained from the delayed leaf cutting C₃ (at 55 DAT). Grain yield of C₁ (Leaf clipping at 25 DAT) and C₂ (at 40 DAT) was statistically similar, however it was statistically higher than C₃. These findings indicated that leaf clipping in early stage of crop did not reduce yield significantly. These results are in alignment with Das *et al.*, (2017) and Das and Mukherjee, (1992). Moreover, grain yield was reduced by 3, 6 and 24% in C₁, C₂ and C₃, respectively compared to C₀ (No leaf cutting). The results were consistent with reports by Ros *et al.* (2003) who found that pruning 30% of leaves depressed grain yield by 20%. Grain yield was highly influenced by the interaction of N rates and leaf clipping times at the 1%

level of probability. 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 (N₄C₀) which was statistically similar to N₃C₀ (5.18 t ha⁻¹), N₃C₁ (5.10 t ha⁻¹) and N₄C₁ (5.06 t ha⁻¹). The lowest mean grain yield (3.17 t ha⁻¹) was obtained from N₁C₃. The results indicated that moderate forage yield and higher grain yield could be obtained from higher N rates (92 to 115 kg N ha⁻¹) with early leaf clippings (25 DAT).

Harvest index

Harvest index was significantly influenced by nitrogen rates, leaf clipping timings, and their interaction (Table 3). In case of N application rates, harvest index varied from 0.42 to 0.46. Harvest index increased with increased N rates which was similar to the findings of Fageria *et al.* (2011). The highest harvest index (0.46) was obtained from the interaction effect of N₄C₀ and N₃C₀ that was statistically similar with N₃C₁ and N₁C₀ (0.45); and the lowest (0.38) was found in N₁C₃.

Panicle production

N rates, leaf clipping times and their interaction had significant effect on panicle production (Table 3). The highest mean number of panicles hill⁻¹ was produced (8.7) when 115 kg N ha⁻¹ (N₄) was applied and that was statistically similar (8.5) with N₃ (92 kg N ha⁻¹) and the lowest (7.8) was in 46 kg N ha⁻¹ (N₁). Panicle production increased with increased nitrogen rates. Leaf clipping timings had also remarkable effect on panicle production. Panicles hill⁻¹ ranged from 7.3 to 8.3 across the leaf cutting treatments. The maximum number of effective tillers hill⁻¹ (9.2) was performed from the interaction of 115 kg N ha⁻¹ with no leaf clipping (N₄C₀) and the lowest number of panicles hill⁻¹(6.3) was obtained from N₁C₃.

Grains per panicle

Number of grains panicle⁻¹ was significantly

influenced by the nitrogen rates, leaf clipping times and their interaction (Table 3). The highest mean number of grains panicle⁻¹ (122) was recorded from 115 kg N ha⁻¹ (N₄). The lowest number of grains panicle⁻¹ (112) was observed from 46 kg N ha⁻¹ (N₁). In case of leaf clipping timings, the highest mean number of grains panicle⁻¹ (118) was found in C₀ (no leaf clipping) and the lowest (106) was obtained from C₃ when leaf clipped at 55 DAT (Table 3). This indicated that leaf clipping negatively affected in producing grains panicle⁻¹ which was similar to the findings of Das *et al.* (2017). Without leaf clipping and early clipping produced more grains panicle⁻¹ compared to the delayed leaf clippings. The present results explicitly confirm previous results obtained by Ghosh and Sharma (1998) who reported higher number of grains panicle⁻¹ from early leaf clipping time than late leaf clipping. This might be attributed due to the fact that forage removal at later stages of crop growth did not produce sufficient photosynthetic leaf area. The lesser amount of dry matter production in the late leaf cut plants failed to supply sufficient amount of carbohydrates. The highest number of grains panicle⁻¹ (124) was recorded from the interaction of 115 kg N ha⁻¹ and no leaf clipping (N₄C₀) followed by N₃C₀ (123), and the lowest (90) was in the combination of N₁ × C₃.

Thousand grain weight (TGW)

Nitrogen rates, leaf clipping times and the interaction had no significant effect on 1000-grain weight (Table 3). It might be that the grain weight is genetical and stable varietal character, and the management practices has less effect on its variation (Yoshida, 1981). The results are in agreement with the findings of Mannan *et al.* (2010); Karmakar *et al.* (2002) who reported that nitrogen has no significant effect on TGW. Moreover, DAS *et al.* (2017)

reported that leaf clipping had non-significant effect on TGW of modern variety while it was significant in local variety. On the contrary, Fagerial *et al.* (2011) found that TGW was significantly influenced by N fertilization. The highest TGW (23.16 g) was recorded in the interaction of 92 kg N ha⁻¹ fertilizer (N₃) with no leaf clipping (C₀). Although treatments had no significant effect, however it varied in some extent across the treatments.

Seed germination

Germination of seed was significantly affected by N rates, leaf clipping times and their interaction (Table 3). The highest germination percentage (91.0%) was observed in N₃ (92 kg N ha⁻¹) followed by N₄ (89.8%). However, the lowest germination percentage (85.6%) was recorded in 46 kg N ha⁻¹. Ahmed *et al.* (2001b) also reported that leaf cutting timings had significant effect on seed germination. The highest seed germination (89.0%) was found in C₀ followed by C₁ when leaves were cut at 25 DAT. Seed germination ranged from 80 to 93% in the interaction of N rates and leaf cutting timings.

Vigour index

Nitrogen rates, leaf clipping timings and their interaction had significant effect on vigour index of seedlings (Table 3). Among the N rates, seedling of N₃ (92 kg N ha⁻¹) performed the highest vigour (10.77) and the lowest (9.14) was in N₁ (46 kg N ha⁻¹). Seeds without leaf cutting treatment (C₀) showed the highest vigour index (10.33) while the lowest (9.60) was in C₃ (Leaf clipping at 55 DAT). The highest vigour index (11.78) was found in the interaction of 92 kg N ha⁻¹ (N₃) with C₀ (no leaf cutting) that was followed by N₃C₁, N₂C₀ and the lowest vigour index was (6.17) for N₄C₃, respectively.

Table 3. Effect of nitrogen (N) rates, leaf clipping times and their interaction on yield and yield components of transplant Aman rice cv. BRR1 dhan41 .

Treatment	Panicle hill ⁻¹ (no.)	Grain panicle ⁻¹	1000-grain wt (g)	Grain yield (t ha ⁻¹)	Harvest index	Germination (%)	Vigour index
<i>N rates (kg ha⁻¹)</i>							
N ₁ = 46	7.8c	112d	22.41	3.35c	0.42d	85.6d	9.14d
N ₂ = 69	8.2b	117c	22.81	4.52b	0.44c	86.5c	9.91c
N ₃ = 92	8.5ab	120b	22.74	4.75a	0.45b	91.0a	10.77a
N ₄ = 115	8.7a	122a	22.50	4.88a	0.46a	89.8b	10.33b
LSD _{0.05}	0.3	1	0.42	0.15	0.01	0.1	0.02
F-test	*	**	ns	**	**	**	**
<i>Leaf clipping times (DAT)</i>							
C ₀ = 0	8.3a	118a	22.72	4.36a	0.44b	89.0a	10.33a
C ₁ = 25	7.8b	115b	22.70	4.21ab	0.44a	88.0b	10.22ab
C ₂ = 40	7.5c	110c	22.54	4.10b	0.43b	87.3ab	10.10b
C ₃ = 55	7.3d	106d	22.64	3.33c	0.41c	86.0b	9.60c
LSD _{0.05}	0.2	2	0.27	0.13	0.01	0.80	0.15
F-test	**	**	ns	*	*	*	*
<i>Interaction effect of N rates and leaf clipping times</i>							
N ₁ ×C ₀	8.3ab	115c	22.05	4.25c	0.45a	81.7g	10.55cd
N ₁ ×C ₁	6.5de	108cde	22.59	4.10cd	0.44b	92.0ab	9.92de
N ₁ ×C ₂	6.8cde	97def	22.37	3.82de	0.40e	84.0f	10.75bc
N ₁ ×C ₃	6.3e	90f	22.61	3.17e	0.38f	89.0d	10.40cd
N ₂ ×C ₀	8.0abc	122ab	22.86	4.65bc	0.43c	87.0ef	11.70a
N ₂ ×C ₁	8.2abc	108ef	23.15	4.17dc	0.42d	92.0ab	10.85bc
N ₂ ×C ₂	7.7bcd	98ef	22.83	3.42e	0.41cd	87.0e	10.09d
N ₂ ×C ₃	6.5de	94ef	22.97	3.30ef	0.41cd	80.0h	7.46g
N ₃ ×C ₀	7.7bcd	123a	23.16	5.18a	0.46a	92.4ab	11.78a
N ₃ ×C ₁	7.7bcd	121ab	22.43	5.10a	0.45a	93.0a	11.71a
N ₃ ×C ₂	7.1bcde	110de	22.60	4.84b	0.44b	92.0ab	10.39cd
N ₃ ×C ₃	6.9cde	97edf	22.36	3.58d	0.42c	89.0bcd	10.57cd
N ₄ ×C ₀	9.2a	124a	22.42	5.25a	0.46a	90.2bc	10.63cd
N ₄ ×C ₁	7.8bcd	122b	22.61	5.06a	0.44b	91.0bc	10.58cd
N ₄ ×C ₂	7.7bcd	111d	22.35	4.75bc	0.43bc	89.5d	9.18e
N ₄ ×C ₃	7.1bcde	93e	22.61	3.92d	0.42c	89.0d	6.17h
LSD _{0.05}	0.40	3	1.15	0.21	.02	0.6	0.10
F-test	**	**	ns	**	**	**	**

ns = Not significant; * = Significant at the 5% and ** = Significant at the 1% level of probability.

CONCLUSION

Application of 92 to 115 kg N ha⁻¹ with leaf clipping at early stage (25 to 40) days after transplanting could be recommended to obtain moderate forage yield, higher grain yield and quality seed of transplant Aman rice BRR1 dhan41. Moreover, further investigation on leaf cutting and nitrogen management is very much important especially for the rainfed lowland rice environment to meet up enormous demand of forage as well as better grain yield with quality seed from same land in Aman season.

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