Progressive Agriculture 28 (3): 174-183, 2017 ISSN: 1017 - 8139

Progressive Agriculture
Journal homepage:http://www.banglajol.info/index.php/PA

Effect of number of seedlings per hill, rate and time of nitrogen application on the growth and yield of late transplant *Aman* rice

NAMY Ali[2], MAR Sarkar[1], SK Sarkar[1], SK Paul[1*]

[1]Department of Agronomy, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh
[2]Urban Partnership for Poverty Reduction Project, United Nations Development Programme, Mymensingh paurashava, Mymensingh 2200, Bangladesh

Abstract

A field experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh to examine the influence of number seedlings hill^{-1}, rate and time of nitrogen application on the growth parameters of late transplant *Aman* rice (cv. BR23). The study, laid out in a RCBD with three replications, was comprised of three levels of number of seedlings hill^{-1} *viz*. 2, 4 and 6 seedlings hill^{-1}, three nitrogen rates *viz.* 0, 60 and 120 kg N ha^{-1} and three levels of time of nitrogen application *viz.* nitrogen application in two equal splits at 15 DAT and early tillering stage (ET); nitrogen application in three equal splits at 15 DAT, ET and panicle initiation stages (PI); and nitrogen application in four equal splits at 15 DAT, ET, PI and flowering stages (F). The highest plant height (101.04 cm) was found at 80 DAT from 6 seedlings hill^{-1}. 120 kg N ha^{-1} nitrogen application produced the tallest (104.08 cm) plant and nitrogen application in two equal splits at 15 DAT and ET gave the highest plant height (99.44 cm) at 80 DAT. The maximum number of tillers hill^{-1} (19.45) at 60 DAT and the highest leaf area index (3.08) at 40 DAT were found in the interaction effect among 6 seedlings hill^{-1}, 120 kg N ha^{-1} and three times of nitrogen application at 15 DAT, early tillering and panicle initiation stages. The highest shoot dry matter hill^{-1} (28 g) was obtained as the interaction effect among 6 seedlings hill^{-1}, 120 kg N ha^{-1} and nitrogen application in four equal splits at 15 DAT, early tillering, panicle initiation and flowering stages. The grain yield, although statistically non-significant, was numerically highest in seedlings hill^{-1}, 120 kg N ha^{-1} and nitrogen application in three equal splits at 15 DAT, early tillering and panicle initiation stages. Therefore, transplanting with 6 seedlings hill^{-1} and application of 120 kg N ha^{-1} in 3-4 equal splits could be a better management practice for ensuring proper growth of the late transplant *Aman* rice.

Key words: Late transplanted, *Aman* rice, nitrogen, growth, LAI

***Corresponding Author:** skpaull@gmail.com

Introduction

Now-a-days flash flood has become a matter of concern in Bangladesh because it causes partial or complete damage of transplant *aman* rice. About 20% of the transplant *aman* rice is often suddenly submerged by flash flood every year due to heavy rainfall during wet season. *Aman* rice covers the largest area of 5.53 million hectares with a production of 13.19 million tons of rice (BBS, 2015).Rice cultivar BR23 developed by the Bangladesh Rice Research Institute has good photoperiod sensitivity and it can be transplanted late even up to last week of September, which keeps a high margin in comparison to the indigenous as well as the other modem transplant *Aman* rice cultivars. Inspite of its photoperiod sensitivity and capability to grow under late transplanted condition, BR23 when transplanted late in September has a poor opportunity to produce enough tillers before reaching its reproductive phase. So, it is necessary to compensate yield loss due to late transplanting through proper agronomic management. Number of seedlings hill^{-1}is one of the limiting factors for successful rice production. Excess number of seedlings hill^{-1} may produce higher number of tillers hill^{-1} resulting in mutual shading and lodging and thus favours the production of more straw instead of grain. While the least number of seedlings hill^{-1} may produce insufficient tillers hill^{-1} thus keeping air, space and nutrients unutilized in soils and at the end, total panicles unit^{-1} area will be reduced resulting in poor yield. Nitrogen is a key nutrient element which plays a vital role in vegetative development and yield of rice. Unfortunately, the nitrogen reserve of Bangladesh soil is very low due to warm climate accompanied by centuries of cultivation of same piece of land (Portech and Islam, 1984). Plant growth is seriously hampered when lower dose of N is applied which drastically reduces the yield (Khatab *et al.,* 2013). However, excess amount of N-fertilizer also results in lodging of plants, prolonging growing period, delayed in maturity, increased the susceptibility to insect-pest and diseases and ultimately reduces yield (Uddin, 2003). Under the circumstances, it is essential to find out proper stages of plant growth in relation to its maximum requirement of nitrogen to achieve most efficient utilization of applied nitrogenous fertilizer. Therefore, the present piece of research work was undertaken to determine the optimum number of seedlings hill^{-1}, rate of nitrogen and time of nitrogen application for proper vegetative growth of the late transplant *Aman* rice cv. BR23.

Materials and Methods

The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh. The experimental site belongs to the Old Brahmaputra Floodplain. (AEZ-9) having non-calcareous dark grey floodplain soil (UNDP and FAO, 1988). The land was medium high with silt loam texture. The land was flat, well drained and above the flood level. The pH value of the soil ranged from 5.9 to 6.5.The experiment consisted of three levels of seedlings hill^{-1} viz., 2, 4 and 6 seedlings hill^{-1}, three rate of nitrogen viz., 0, 60 and 120 kg N ha^{-1} and four levels of time of nitrogen application viz., nitrogen application in two equal splits at 15 DAT and early tillering stage (ET), nitrogen application in three equal splits at 15 DAT, early tillering (ET) and panicle initiation stages (PI) and nitrogen application in four equal splits at 15 DAT, early tillering (ET), panicle initiation (PI) and flowering stages (F). The experiment was laid out in a randomized complete block design with three replications. The size of unit plot was 4.0 m x 2.5m. The experimental plot was fertilized with phosphatic, potassic, sulphur and zinc fertilizers @ 125, 67, 60 and 10 kg ha^{-1} in the form of triple super phosphate, muriate of potash, gypsum and zinc sulphate, respectively. Total amount of these fertilizers except urea were applied as basal, dose. Urea was applied as per experimental treatments. Thirty-day old seedlings were transplanted in the field. Intercultural operations such as gap filling, weeding, water management and pest management were done as and when necessary. Growth study continued at 20 day intervals beginning 20 DAT up to 80 DAT. Five sample hills were selected randomly, uprooted, washed properly and dried in an electric oven at 70°C for 72 hours to determine the shoot dry matter production.

The leaf area was calculated from the same hills meant for measuring plant height and tiller counting. The leaf non-removing technique (IRRI, 1972) was followed for this purpose the number of tillers hill^{-1} was counted and the length and maximum width of each leaf of the middle tiller were measured. Area of each leaf blade was than determined on the basis of length-width method as outlined below.

Leaf area=K × L ×W

Where, K is the adjustment factor

L is the length of leaf and

W is the width of leaf

The value of K varied with the slope of the leaf which in turn was affected by the growth stage of the leaf. The value of 0.75 was used for all the stages of growth except for seedling and maturity stages for which the value of 0.67 was used. At maturity (when 90 % of the seeds became golden yellow in color) one square meter area from each plot was selected from the central portion and was cut manually from the ground level to take grain and straw yields. The harvested crops were threshed manually. The grain was cleaned and dried to a moisture content of 14 %, finally yields plot^{-1} were recorded and converted to t ha^{-1}. All data were analyzed using the "Analysis of Variance" technique and the mean differences were adjudged by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

Results and Discussion

Plant height: Plant height was significantly affected by the number of seedlings $hill^{-1}$ at all dates of sampling (Table 1). At 20 DAT, the tallest plant (59.97cm) was found when 6 seedlings were transplanted $hill^{-1}$ (Table 1). Plant height showed a decreasing trend as the number of seedlings $hill^{-1}$ decreased and became the shortest at 2 seedlings $hill^{-1}$.This trend of plant height was found at 40, 60 and 80 DATs (Table 1). .Competition among seedlings for reception of solar radiation was probably the main reason for the elongation growth of plants when 6 seedlings were transplanted $hill^{-1}$.Plant height was significantly increased with the increase of nitrogen rate (Table 1). The tallest plants were obtained when the crop was fertilized with 120 kg N ha^{-1}. The shortest plants were found when the crop was not fertilized with nitrogen. Plant height exhibited increasing trend with the increase of nitrogen rate. This trend was noticeable up to 80 DAT. Nitrogen enhanced the vegetative growth in terms of plant height in the crop fertilized with 60 or 120 kg N ha^{-1} in comparison to the crop not fertilized with nitrogen. Application of nitrogen increased plant height was reported elsewhere (Zannat *et al.,* 2014; Jisan *et al.,* 2014; and Kirtannia *et al*., 2013). The plant height was significantly influenced due to application of nitrogen level irrespective growth stages as stated by Paul *et. al.,* 2016. Plant height was also significantly affected by time of nitrogen application (Table 2). At 60 DAT, the tallest plant (93.14cm) was found when whole amount of nitrogen was applied in four equal splits at 15 DAT, early tillering, panicle initiation and flowering stages which was statistically similar to three equal splits at 15 DAT, early tillering and panicle initiation stages (Table 2). At 80 DAT the tallest plant (99.44cm) was found when whole amount of nitrogen was applied in two equal splits at 15 DAT and early tillering stage. The shortest (97.33cm) was produced when four equal splits of nitrogen application at 15 DAT, early tillering, panicle initiation and flowering stages. The results are in conformity with that of Akanda *et al.* (1986) and Sharma *et al.* (1995). Plant height was significantly affected by the interaction between number of seedling $hill^{-1}$ and nitrogen rate at 20, 60 and 80 DAT (Table 3). At 20 DAT, the tallest plants were observed in 6 seedlings $hill^{-1}$ fertilized with 120 kg N ha^{-1}. The crop of 4 seedlings $hill^{-1}$in combination with 120 kg N ha^{-1} exhibited similar behavior at that of the crop grown from 6 seedlings $hill^{-1}$and fertilized with 120 kg N ha^{-1} The shortest plants were produced when either 4 or 6 seedlings $hill^{-1}$in control nitrogen (Table 3).

Table 1. Effect of number of seedlings $hill^{-1}$ on plant height of late transplant *Aman* rice (cv. BR23

Number of seedlings $hill^{-1}$	Plant height (cm)			
	20 DAT	**40 DAT**	**60 DAT**	**80 DAT**
2 seedlings $hill^{-1}$	56.66b	65.62b	91.37c	98.13c
4 seedlings $hill^{-1}$	56.98ab	66.47a	92.44b	98.98b
6 seedlings $hill^{-1}$	59.97a	67.10a	93.79a	101.04a
Level of significance	0.05	0.01	0.01	0.01
Sx	0.364	0.273	0.320	0.375
N rate (kg/ha)				
0	52.65c	61.97c	84.56c	91.99c
60	57.65b	66.32b	93.99b	99.95b
120	61.31a	70.90a	99.95a	104.08a
Level of significance	0.01	0.01	0.01	0.01
S$\underline{x}$	0.364	0.293	0.320	0.375

Number of tillers $\boldsymbol{hill^{-1}}$: Number of seedlings $hill^{-1}$ had significant effect on the number of tillers produced $hill^{-1}$ at all dates of sampling (Figure 1). At all sampling dates the maximum number of tillers $hill^{-1}$ were found with 6 seedlings $hill^{-1}$ and the minimum one was found with 2 seedlings $hill^{-1}$ (Figure 1). It was evident that number of tillers $hill^{-1}$ increased with the increase in the number of seedlings used $hill^{-1}$. Number of tillers $hill^{-1}$ was significantly influenced by nitrogen rate at all sampling dates (Figure 2). At 20 DAT, the maximum number of tillers $hill^{-1}$ (11.50) was produced with 120 kg N ha^{-1} and the minimum number of tillers $hill^{-1}$ (7.57) was produced in control. Similar trend of tiller production was observed at 40, 60 and 80 DAT. Nitrogen encouraged vegetative growth in terms of tiller production and hence the number of tillers hill^{-1} was found to be increased with the increase or nitrogen rate compared to no nitrogen (control) treatment. These results are in conformity with those of Paul *et al.,* (2017). Qurashi *et. al.* (2013) found that number of effective tillers hill^{-1} was significantly influenced by the dose of nitrogen.

Table 2. Effect of time of nitrogen application on plant height, number of tillers hill^{-1}, leaf area index and shoot dry matter hill^{-1}of late transplant *Aman* rice (cv. BR23)

Time of nitrogen application	Plant height (cm)				Number of tillers hill^{-1}				Leaf area index				Shoot dry matter hill^{-1} (g)			
	20 DAT	40 DAT	60 DAT	80 DAT	20 DAT	40 DAT	60 DAT	80 DAT	20 DAT	40 DAT	60 DAT	80 DAT	20 DAT	40 DAT	60 DAT	80 DAT
15 DAT + ET	56.75	66.08	91.94b	99.44a	9.52	11.28b	12.5 1 b	13.01b	0.89b	2.41c	3.59b	2.78a	10.50a	20.25a	26.45b	10.50a
15DAT+ET+PI	57.25	66.49	92.52a	98.36b	9.66	11.72a	13,01a	13.45a	0.92a	2.44b	3.67a	2.85a	10.23b	20.34b	27.06a	10.23b
15DAT+ET+PI+F	57.60	66.62	93.14a	97.33b	9.57	11.03b	12.58b	13.14ab	0.91a	2.46a	3.66a	2.88b	10.02b	21.16c	27.35a	10.02b
Level of sig.	NS	NS	0.05	0.01	NS	0.01	0.05	0.05	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01
Sx	NS	NS	0.320	0.375	NS	0.136	0.135	0.128	0.001	0.001	0.024	0.020	0.049	0.097	0.193	0.049

Table 3. Effect of interaction between number of seedlings hill^{-1} and rate of nitrogen on plant height, number of tillers hill^{-1}and leaf area index of lat

Interactions Number of seedlings hill^{-1} x N rate (kg ha^{-1})	Plant height (cm)				Number of tillers hill^{-1}				Leaf area index			
	20 DAT	40 DAT	60 DAT	80 DAT	20 DAT	40 DAT	60 DAT	80 DAT	20 DAT	40 DAT	60 DAT	80 DAT
2 seedlings hill^{-1}× 0 kg N ha	53.68d	61.26	83.88d	88.05e	6.23g	8.13	9.76f	10.1f	0.82i	1.89i	3.19f	2.38f
2 seedlings hill^{-1}× 60 kg N ha^{-1}	56.07c	65.70	92.19c	97.25c	8.38e	11.28	11.14e	11.86e	0.85g	2.33f	3.48def	2.74cde
2 seedlings hill^{-1} × 120 kg N ha^{-1}	60.23b	69.90	93.03a	103.10ab	10.61c	13.33	13.88c	14.62c	0.91d	2.76c	3.81bcd	3.0lbc
4 seedlings hill^{-1}× 0 kg N ha	52.63de	62.04	84.54d	91.36d	7.98f	8.52	9.38f	9.75f	0.84h	1.94h	3.26f	2.45ef
4 seedlings hill^{-1}× 60 kg N ha^{-1}	57.16c	66.75	93.35c	98.43c	9.74d	11.29	12.82d	13.54d	0.89e	2.5e	3.64cde	2.80cd
4 seedlings hill^{-1} × 120 kg N ha^{-1}	61.15ab	70.63	99.43a	104.15a	11.20b	13.51	15.30b	15.38b	0.97b	2.89b	4.00ab	3.20ab
6 seedlings hill^{-1}× 0 kg N ha	51.65e	62.59	85.26d	96.57c	8.50e	9.67	11.00e	11.24e	0.87f	1.97g	3.32ef	2.52def
6 seedlings hill^{-1}× 60 kg N ha^{-1}	59.71b	66.53	96.42b	101.47b	10.33bc	11.78	13.68c	14.42c	0.94c	2.62d	3.85bc	3.05bc
6 seedlings hill^{-1} × 120 kg N ha^{-1}	62.55a	72.18	99.69a	104.99a	12.69a	14.59	17.34a	17.99a	1.03a	3.04a	4.19a	3.39a
Level of significance	**	NS	*	**	0.05	NS	0.01	0.01	0.01	0.01	0.05	0.01
Sx	0.631		0.555	0.651	0.442		0.235	0.222	0.003	0.003	0.074	0.111

Number of tillers hill^{-1}of transplant *aman* rice was significantly influenced by the time of nitrogen application at different growth stages which was especially noticeable at 40, 60 and 80 DAT (Table 2). The maximum number of tillers hill^{-1}11.72, 13.01 and 13.45 were found at 40, 60 and 80 DAT, respectively, when whole amount of nitrogen application in three equal splits at 15 DAT, early tillering and panicle initiation stages. At 20 DAT the number of tillers hill^{-1} was not significantly affected by the application of nitrogen at different growth stages of transplant *Aman* rice (cv. BR23).

Number of tillers hill^{-1} was significantly affected by the interaction between number of seedlings hill^{-1} and rate of nitrogen. At 20 DAT the maximum number of tillers hill^{-1} (12.69) was produced in 6 seedlings hill^{-1} combined with 120 kg N ha^{-1}. Minimum number of tillers hill^{-1} (6.23) was produced in 2 seedlings hill^{-1} when the crop was not fertilized with nitrogen (Table 3). This trend of plant height was found at 60 and 80 DAT. Number of tillers hill^{-1} was significantly affected by the interaction between seedlings hill^{-1}and time of nitrogen application. At 60 and 80 DAT the maximum number of tillers hill^{-1} (14.85 and 15.25) were produced when in 6 seedlings hill^{-1} in combination with nitrogen application in three equal splits at 15 DAT, early tillering and panicle initiation stages (Table 4).

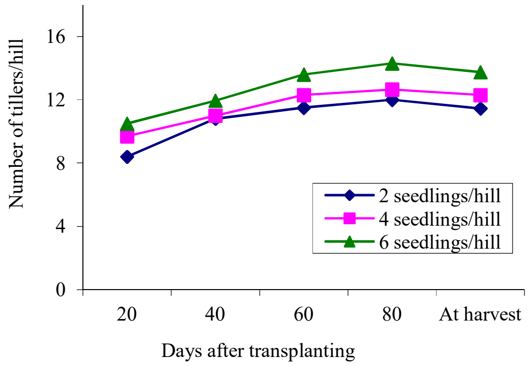

Figure 1. Effect of number of seedlings hill^{-1} on the total tillers hill^{-1}of late transplant *Aman* rice (cv. BR23)

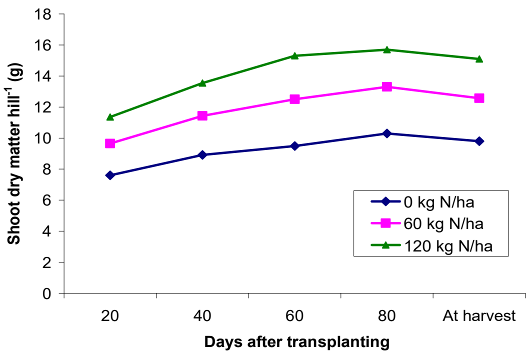

Figure 2. Effect of nitrogen rate on the total tillers hill^{-1}of late transplant *Aman* rice (cv. BR23)

At 20 DAT the number of tillers hill^{-1} was not significantly affected by the interaction between number of seedlings hill^{-1} and time of nitrogen application. Number of tillers hill^{-1}was significantly affected by the interaction between nitrogen rate and time of nitrogen application at 40 and 80DAT (Table 5). At 40 DAT the maximum number of tillers hill^{-1} (13.90) was produced when the crop was fertilized with 120 kg N ha^{-1} in combination with nitrogen application in three equal splits at 15 DAT, early tillering and panicle initiation stages, which was statistically similar to that of the interaction between 120 kg N ha $^{-1}$ and two times of nitrogen application at 15 DAT and early tillering stage (Table 5). The minimum tillers hill^{-1} (8.61) was produced by the crop under no nitrogen (control) treatment. Similar trend was found at 80 DAT. Number of tillers hill^{-1} was significantly affected by the interaction of number of seedlings hill^{-1}, rate of nitrogen and time of nitrogen application at 40 and 60 DAT (Table 6). At 40 DAT the maximum number of tillers hill^{-1} (15.30) was found when interaction among 6 seedlings hill^{-1}, 120 kg N ha^{-1} and three times of nitrogen application at 15 DAT, early tillering and panicle initiation stages which was statistically similar to that of the interaction among among 4 seedlings hill^{-1}, 120 kg N ha^{-1} and two times of nitrogen application at 15 DAT, early tillering (Table 6). At 60 DAT the maximum number of tillers hill^{-1} (19.45) was produced when interaction among 6 seedlings hill^{-1}, 120 kg N ha^{-1} and three times of nitrogen application at 15 DAT, early tillering and panicle initiation stages.

***Leaf area index (LAI)*:** Leaf area index (LAI) increased with time and reached maximum at 60 DAT and then tended to decrease. The plant communities of higher population density adjusted their leaves with greater LAI from early stage of growth. These results corroborate the findings of Kim (1990), who reported that LAI increased with increase in plant density. At 20 DAT, the highest value of LAI (0.95) was observed in the crop grown from 6 seedlings hill^{-1} and the lowest one (0.86) when 2 seedlings were transplanted hill^{-1} (Figure 3).

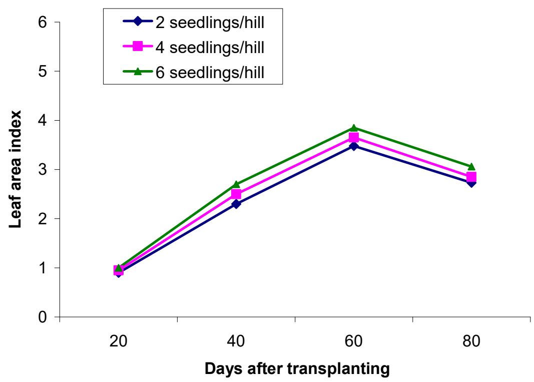

Figure 3. Effect of number of seedlings hill^{-1} on leaf area index (LAI)of late transplant *Aman* rice (cv. BR23)

The crop grown from 4 seedlings $hill^{-1}$ was intermediate in respect of LAI. Similar trend of LAI was found at 40, 60 and 80 DAT. This result agrees with the findings of Paul *et. al.* (2013). At 20 DAT, the highest value of leaf area index (0.97) was observed when 120 kg N ha^{-1} was applied.

Table 4. Effect of interaction between number of seedlings $hill^{-1}$ and time of nitrogen application on the number of total tillers $hill^{-1}$, leaf area index and shoot dry matter $hill^{-1}$ of late transplant *Aman* rice (cv. BR23)

Number of seedlingshill^{-1} × Time of Napplication	Number of tillers hill^{-1}				Leaf area index				Shoot dry matter hill^{-1}(g)			
	20 DAT	40 DAT	60 DAT	80 DAT	20 DAT	40 DAT	60 DAT	80 DAT	20 DAT	40 DAT	60 DAT	80 DAT
2 seedlings hill^{-1} x(15DAT + ET)	8.37	11.05bc	11.59d	12.07e	0.85e	2.30i	3.40	2.59e	2.75	9.97f	19.05e	25.55
2 seedlings hill^{-1}x(15 DAT+ET+PI)	8.52	11.03bc	11.72d	12.19de	0.87e	2.32h	3.56	2.75d	2.67	9.47g	19.25e	25.63
2 seedlings hill^{-1}x (15 DAT+ET+PI+F)	8.33	10.66c	11.46d	12.24de	0.86e	2.35g	3.53	2.79cd	2.64	9.18g	19.44e	26.36
4 seedlings hill^{-1} x15 DAT+ET)	9.61	11.89a	12.40c	12.98c	0.90d	2.41f	3.60	2.80cd	3.01	10.45cd	20.67cd	26.80
4 seedlings hill^{-1}x(15 DAT+ ET+PI)	9.73	10.61c	12.46	12.92c	0.89d	2.43e	3.64	2.79cd	2.93	10.39de	20.37d	27.40
4 seedlings hill^{-1}x(15 DAT+ET+PI+F)	9.58	10.81c	12.65c	12.77cd	0.91c	2.50d	3.67	2.87bc	2.82	10.19ef	20.94bc	27.11
6 seedlings hill^{-1} x(15 DAT+ET)	10.57	12.22a	13.54b	13.99b	0.92c	2.52c	3.76	2.96ab	3.39	11.09a	21.03bc	27.00
6 seedlings hill^{-1} x(15 DAT+ET+PI)	10.74	12.18a	14.85a	15.25a	0.98a	2.56a	3.81	3.00a	3.35	10.89b	21.39b	28.16
6 seedlings hill^{-1}x(15 DAT+ET+PI+F)	10.81	11.63ab	13.63 b	14.40b	0.95b	2.54b	3.79	2.93a	3.26	10.69bc	23.09a	28.57
Level of significance	NS	0.01	0.05	0.05	0.01	0.01	NS	0.05	NS	0.05	0.01	NS
S$\underline{x}$		0.235	0.235	0.222	0.003	0.003		0.034		0.086	0.169	

Table 5. Effect of interaction between nitrogen rate and time of nitrogen application on production of tillers $hill^{-1}$, leaf area index and shoot dry matter $hill^{-1}$ of late transplant *Aman* rice (cv. BR23)

Nitrogen rate x Time of N application	Number of tillers hill^{-1}				Leaf area index				Shoot dry matter hill-1 (g)			
	20 DAT	40 DAT	60 DAT	80 DAT	20 DAT	40 DAT	60 DAT	80 DAT	20 DAT	40 DAT	60 DAT	80 DAT
0 kg N ha-^{1} x (15 DAT + ET)	7.72	8.61 e	10.11	10.46e	0.84d	1.93g	3.26	2.45	2.38f	7.84f	16.27e	22.32
0 kg N ha^{-1} x (15 DAT+ET+PI)	7.60	8.81 e	10.04	10.29e	0.85e	1.93g	3.26	2.45	2.41f	7.84f	16.40e	22.98
0 kg N ha^{-1} x (15 DAT+ET+PI+F)	8.39	8.89e	9.98	10.25e	0.84e	1.94g	3.26	2.45	2.41f	7.84f	16.32e	23.35
60 kgN ha^{-1}x (15 DAT+ET)	9.46	12.27c	12.29	12.87d	0.89d	2.44f	3.57	2.77	3.02d	10.85d	21.03d	26.86
60 kg N ha^{-1} x (15 DAT+ET+PI)	9.61	11.12d	12.83	13.39cd	0.90d	2.47e	3.71	2.87	2.91e	10.35e	20.68d	27.21
60 kg N ha^{-1} x (15 DAT+ET+PI+F)	9.98	10.96d	12.52	13.56c	0.90d	2.54d	3.69	2.95	2.85e	10.16e	21.83c	27.67
120 kg N ha^{-1}x (15 DAT+ET)	11.38	14.28a	15.13	15.71b	0.94c	2.86c	3.93	3.13	3.75a	12.82a	23.46b	30.18
120 kg N ha^{-1}x (15 DAT+ET+P))	11.78	13.90a	16.15	16.67a	100a	2.91b	4.03	3.23	3.64b	12.50b	23.93b	31.00
120 kg N ha^{-1}x (15 DAT+ET+PI+F)	11.34	13.25b	15.32	15.60b	0.99b	2.91a	4.04	3.24	3.46c	12.07c	25.33a	31.02
Level of significance	NS	0.01	NS	0.01	0.01	0.01	NS	NS	0.01	0.01	0.01	NS
S$\underline{x}$		0.235		0.222	0.003	0.003	0.074		0.027	0.086		

The lowest LAI value (0.84) was found when nitrogen was not applied. Application of 60 kg N ha^{-1} was intermediate regarding LAI. This trend of LAI was found at 40, 60 and 80 DAT (Figure 4). Similar finding was also reported by Paul *et al.,* 2014. Ray *et al.* (2015) also stated that high nitrogen levels (80 kg N ha^{-1}) resulted to higher LAI in rice. It was observed that LAI gradually increased with time and reached at the maximum at 60 DAT and then declined. Leaf area index (LAI) was significantly affected by the time of nitrogen application (Table 2). The highest value of LAI (0.92 3.67 and 2.85) was observed at 20, 60 and 80 DAT, respectively, when nitrogen was applied in three splits at 15 DAT, early tillering and panicle initiation stages.

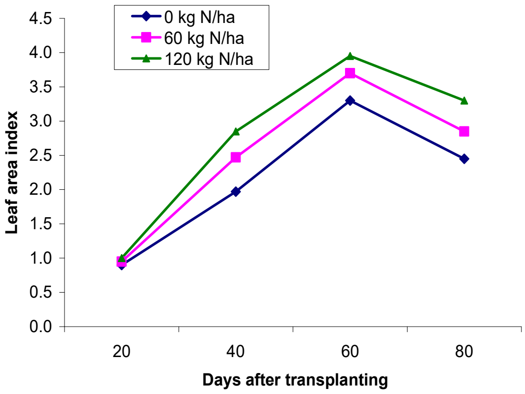

Figure 4. Effect of nitrogen rate on leaf area index (LAI)of late transplant *Aman* rice (cv. BR23)

At 40 DAT highest value of LAI (2.46) was observed when nitrogen was applied in four equal installments at 15 DAT, early tillering, panicle initiation and flowering stages. Leaf area index was significantly affected by the interaction between numbers of seedlings hill^{-1}and rate of nitrogen application. LAI was found the highest at all DATs when 6 seedlings were transplanted hill^{-1} in combination with 120 kg N ha^{-1} (Table 3). The lowest values of LAT at all DATs were found in 2 seedlings hill^{-1}in control. Leaf area index (LAI) was significantly affected by the interaction between number of seedlings hill^{-1}and time of nitrogen application at all DATs except 60DAT (Table 4). The highest LAI was found at all DATs when 6 seedlings hill^{-1}was combined with three times nitrogen application at 15 DAT, early tillering and panicle initiation stages. Leaf area index was significantly affected by the interaction between nitrogen rate and time of nitrogen application at 20 and 40 DAT (Table 5). The highest LAI was found at 60 DAT and lowest at 20 DAT. Leaf area index (LAI) was significantly affected by the interaction of number of seedlings hill^{-1}, rate of nitrogen and application time of nitrogen at 20 and 40 DAT. At 20 DAT highest value of LAI (1.10) was observed when combination of 6 seedlings hill^{-1}, 120 kg N ha^{-1} and three times nitrogen application at 15 DAT, early tillering and panicle initiation stages (Table 6). The lowest value was found (0.81) when combination of two seedlings hill^{-1} and no fertilization of nitrogen. Similar trend of LAI was found at 40 DAT.

***Shoot dry matter*:** Shoot dry matter hill^{-1} was significantly influenced by the number of seedlings hill^{-1} at all growth stages. At 20 DAT the highest shoot dry weight hill^{-1} was found with 6 seedling hill^{-1}at 80 DAT (Figure 5). The lowest shoot dry matter was observed hill^{-1} was found with 2 seedlings hill^{-1}. This trend of LAI was found at 40, 60 and 80 DAT.

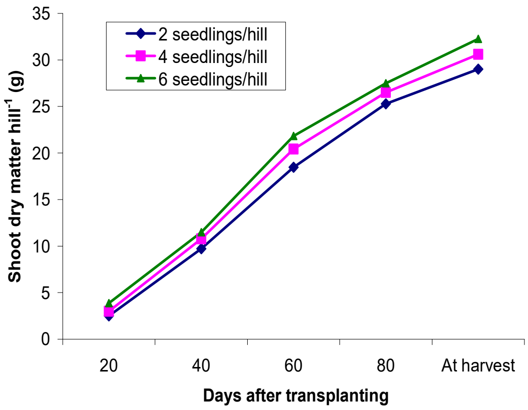

Figure 5. Effect of number of seedlings hill^{-1} on shoot dry matter hill^{-1} of late transplant *Aman* rice (cv. BR23)

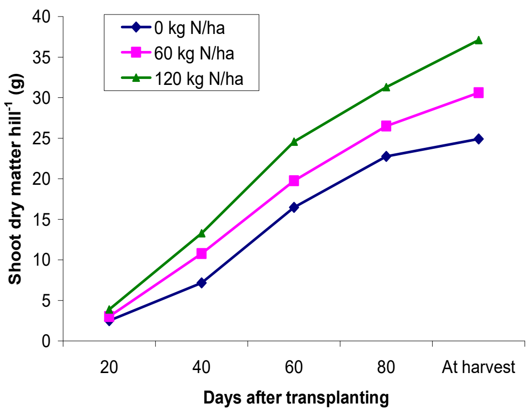

Figure 6. Effect of nitrogen rate on shoot dry matter hill^{-1} of late transplant *Aman*rice (cv. BR23)

It was observed that at each sampling date, shoot dry matter hill^{-1} increased with increasing seedlings number hill^{-1}. It was mainly contributed by the higher number of total tillers hill^{-1}. The highest production of shoot dry matter in the modern varieties may be achieved due to higher leaf area throughout the growth period.

Table 6. Effect of interaction of number seedlings hill^{-1}, rate of nitrogen and time of nitrogen application production of tillers hill^{-1}, leaf area index , shoot dry matter hill^{-1} and yield of late transplant *Ama*n rice (cv. BR23)

Number of seedlings hill^{-1} x rate (kg ha^{-1}) x Time of N application	Number of tillers hill^{-1}				Leaf area index				Shoot dry matter hill^{-1} (g)				Grain yield (t ha^{-1})
	20 DAT	40 DAT	60 DAT	80 DAT	20 DAT	40 DAT	60 DAT	80 DAT	20 DAT	40 DAT	60 DAT	80 DAT	
$S_1xN_oxT_1$	6.44	8.11k	9.67jk	9.94	0.810	1.88s	3.20	2.38	1.17	7.27	15.24n	21.50	2.98
$S_1xN_oxT_2$	6.26	7.98k	9.85h-j	10.08	0.840	1.90s	3.20	2.39	2.22	7.26	15.41n	21.80	2.98
$S_1xN_0xT_3$	5.79	8.30k	9.76i-k	10.02	0.81o	1.90s	3.17	2.37	2.21	7.28	15.34n	22.56	2.98
$S_1xN_1xT_1$	7.76	11.61e-h	10.83g-j	11.42	0.84mn	2.31o	3.34	2.54	2.86	10.51	19.42j	25.90	3.45
$S_1xN_1xT_2$	8.41	11.27gh	11.59g	11.96	0.86k-m	2.32o	3.60	2.80	2.66	9.57	19.53j	25.60	3.71
$S_1xN_1xT_3$	8.99	10.98h	11.19g	12.22	0.86k-m	2.36n	3.51	2.88	2.62	9.41	20.0ij	26.02	3.52
$S_1xN_2xT_1$	10.72	13.44b-d	14.28de	14.86	0.91gh	2.72l	3.65	2.85	3.23	12.15	22.51ef	29.26	3.84
$S_1xN_2xT_2$	10.90	13.85bc	13.92d-f	14.53	0.92fg	2.76h	3.87	3.07	3.14	11.57	22.81de	29.50	4.00
$S_1xN_2xT_3$	10.22	12.70de	13.44ef	14.48	0.92fg	2.80g	3.91	3.11	3.09	10.85	23.00de	30.50	3.90
$S_2xN_oxT_1$	8.28	8.03k	9.60jk	10.19	0.84mn	1.94r	3.27	2.46	2.31	7.93	16.34m	22.26	3.06
$S_2xN_oxT_2$	8.00	8.73jk	9.31k	9.57	0.83n	1.95qr	3.25	2.45	2.34	7.92	16.451m	23.20	3.06
$S_2xN_oxT_3$	7.68	8.80jk	9.24k	9.51	0.851mn	1.94r	3.26	2.46	2.33	7.93	16.34m	23.60	3.05
$S_2x\ N_1xT_1$	9.59	12.34d-g	12.71f	13.30	0.92fg	2.42m	3.55	2.75	2.80	10.811	22.16efg	27.90	3.58
$S_2xN_1xT_2$	9.94	10.54hi	12 97ef	13.50	0.87jk	2.451	3.66	2.73	2.73	10.68	20.80hi	28.00	3.71
$S_2xN_1xT_3$	9.71	10.98h	12.78f	13.83	0.89hi	2.65j	3.72	2.92	2.70	10.55	21.50gh	28.50	3.63
$S_2xN_2x\ T_1$	10.97	15.30a	14.89cd	15.47	0.94e	2.87f	3.99	3.19	3.92	12.62	13.53cd	30.26	3.95
$S_2xN_2xT_2$	11.27	12.56d-f	15.10b-d	15.70	0.98d	2.89e	4.00	3.20	3.73	12.57	23.88c	31.02	4.12
$S_2xN_2xT_3$	11.35	12.66de	15.93bc	14.97	1.01c	2.91d	4.02	3.22	3.42	12.10	25.00b	29.25	4.06
$S_3xN_OxT_1$	8.24	9.70ij	11.07gh	11.27	0.86kl	1.97pq	3.31	2.51	2.67	8.33	17.25kl	23.20	3.14
$S_3xN_0xT_2$	8.55	9.71ij	9.98g-i	11.24	0.89ij	1.96qr	3.33	2.52	2.69	8.33	17.36k	23.95	3.13
$S_3xN_oxT_3$	8.71	9.59ij	9.96g-i	11.23	0.87jk	1.98p	3.34	2.53	2.70	8.33	17.28kl	23.90	3.13
$S_3xN_1x\ T_1$	11.04	12.86cd	13.33ef	13.91	0.93f	2.61k	3.82	3.02	3.39	11.25	21.51gh	26.80	3.68
$S_3xN_1xT_2$	10.48	11.54f-h	13.13de	14.73	0.96d	2.64j	3.87	3.07	3.34	10.80	21.72fg	28.04	3.84
$S_3xN_1xT_3$	11.26	10.93h	13.59ef	14.63	0.95e	2.61k	3.85	3.05	3.22	10.51	24.0 1c	28.50	3.83
$S3xN_2xT_1$	12.45	14.09b	16.24b	14.81	0.97d	3.00c	4.14	3.34	4.10	13.68	24.34bc	31.02	4.11
$S_3xN_2xT_2$	13.18	15.30a	19.45a	19.80	1.10a	3.08a	4.23	3.43	4.03	13.36	25.10b	32.50	4.48
$S_3xN_2xT_3$	12.45	14.38ab	16.34b	17.36	1.04b	3.03b	4.20	3.40	3.87	13.25	28.00a	33.32	4.21
Level of significance	NS	0.01	0.01	NS	0.01	0.01	NS	NS	NS	NS	0.01	NS	NS
$S\underline{x}$		0.408	0.407		0.005	0.005					0.293		

Means of column having the same letter(s) do not differ significantly as per DMRT, DAT= Days after transplanting, ET= early tillering stage, PI = panicle initiation stages, F = flowering stages, NS = Not significant, S_1 = 2 seedlings hill^{-1}, S_2 = 4 seedlings hill^{-1}, S_3 = 6 seedlings hill^{-1}, N1 = 0 kg N ha^{-1}, N2= 60 kg N ha^{-1}, N3= 120 kg N ha^{-1}, T_1 = 15 DAT + ET, T_2 = I S DAT + ET + PI, T_3 = 15 DAT + ET + PI + F.

The increase of TDM depends on the leaf area production as reported by Tanaka (1983). Shoot dry matter production hill^{-1} was significantly affected by the rate of nitrogen application. Results revealed that at 20, 40, 60 and 80 DAT the highest shoot dry matter was obtained when the crop was fertilized with 120 kg N ha^{-1} and the control treatments gave the lowest shoot dry matter (Figure 6). Shoot dry matter production $hill^{-1}$ progressively increased with the increase of nitrogen rate. Shoot dry matter production $hill^{-1}$increased gradually from earlier stage to later stages of growth. The difference between treatments for shoot dry matter production were lower both in the early and later stages of growth but a remarkable difference was observed between 40 and 60 DAT. Shoot dry matter production of rice increased with increasing rate of nitrogen was also observed by Reddy *et al.* (1984). At 20 DAT, the highest shoot dry matter $hill^{-1}$ (3.66g) was achieved from two equal splits of nitrogen application at 15 DAT and early tillering stage (Table 2). The lowest shoot dry matter $hill^{-1}$ (2.91g) was obtained when nitrogen was applied in four equal splits at 15 DAT, early tillering, panicle initiation and flowering stages. This trend of shoot dry matter was found at 40 and 60 DAT. At 80 DAT, the highest shoot dry matter (27.35g) was accumulated in four equal splits of nitrogen application at 15 DAT, early tillering, panicle initiation and flowering stages which was statistically identical to nitrogen application in three equal splits at 15 DAT, early tillering and panicle initiation stages (27.06g). The lowest (26.45g) one was found at nitrogen application in two equal splits at 15 DAT and early tillering stage (Table 2). At 20 DAT, interaction between a number of 6 seedlings $hill^{-1}$ and 120 kg N ha^{-1} application produced the highest shoot dry matter $hill^{-1}$ (4.00g). The lowest (2.20g) one was recorded from planting 2 seedlings $hill^{-1}$ and no fertilization of nitrogen (Table 1). This trend of shoot dry matter was found at 40, 60 and 80 DAT. The interaction between number of seedlings $hill^{-1}$ and time of nitrogen application was significant at 40 and 60 DAT. At 40 DAT the highest shoot dry matter (11.09g) was produced when transplanted 6 seedlings $hill^{-1}$ and two times of nitrogen application at 15 DAT and early tillering stage (Table 4). The lowest shoot dry matter (9.18g) produced when transplanted 2 seedlings $hill^{-1}$ and nitrogen application at four times at 15 DAT, early tillering, panicle initiation and flowering stages. At 60 DAT the highest shoot dry matter (23.09g) was produced when transplanted 6 seedlings $hill^{-1}$ and four times of nitrogen application at 15 DAT, early tillering, panicle initiation and flowering stages. Results revealed that interaction between rate of nitrogen 120 kg N ha^{-1} and two times application at 15 DAT and early tillering stage produced the highest shoot dry matter at 20 and 40 DAT (Table 5). The interaction effect of number of seedlings $hill^{-1}$, rate of nitrogen and time of nitrogen application at 60 DAT was significant on shoot dry matter production. The highest shoot dry matter (28.00g) production when combination of 6 seedlings $hill^{-1}$, 120 kg N ha^{-1} and four times of nitrogen application at 15 DAT, early tillering, panicle initiation and flowering stages (Table 6). The lowest shoot dry matter (15.24g) production when combination of 2 seedlings $hill^{-1}$ and no nitrogen (Table 6). The interaction effects at 20, 40 and 80 DAT were non-significant (Table 6). The higher production of shoot dry matter in the modem varieties may be achieved due to the higher leaf area throughout the growth period. The grain yield was found statistically non-significant but numerically the highest in 6 seedlings $hill^{-1}$, 120 kg N ha^{-1} and nitrogen application in three equal splits at 15 DAT, early tillering and panicle initiation stages. From the above results it can be concluded that growth parameters and yield of late transplanted *Aman* rice (cv. BR23) were found better in 6 seedlings $hill^{-1}$ and 120 kg N ha^{-1} when applied in 3 or 4 splits.

References

Akanda MRU, Eunus M, Islam MA. Ali MI (1986). Nitrogen application timing and performance of BR4 transplant aman rice. Bangladesh J. Agri. 11(1):39-43.

BBS (Bangladesh Bureau of Statistics) (2015). Year book agricultural statistics, Ministry of planning, Govt. People's Republic of Bangladesh, Dhaka.pp : 37- 49.

Gomez KA, Gomez AA (1984). Statistical Procedure for Agricultural Research.International Rice Research Institute, Philippines, John Wiley and Sons. New York, Chichester, Brisbane, Toronto, Singapore.pp: 680.

IRRI, (1972). Techniques for field experiments with rice. Los Banos, Laguna, Philippines, pp. 5-56

Jahan S, Sarkar MAR, Paul SK. (2017). Variations of growth parameters in transplanted *Aman*rice (cv. BRRI dhan39) in response to plant spacing and fertilizer management. *Archives of Agriculture and Environmental Science,* 2(1): 1-5.

Jisan MT, Paul SK, Salim M (2014). Yield performance of some transplant *aman* rice varieties as influenced by different levels of nitrogen. *J. Bangladesh Agril. Univ*., 12 (2):321-324.

Khatab KA, Osman EAM, EL-Masry AA (2013). Rice productivity and its inner quality as affected by anhydrous ammonia rates with foliar application of organic acids. *Adv. Appl.Sci. Res*., 4:165-173.

Kim CK., Kee SY, Lim MS, Cho CI (1987). Effect of nitrogen split application on the rice growth and yield production under machine transplanting in rice (*Oryza sativa* L.). *Korean J. Crop Sci.* 32(1):48-54. [Cited from Rice Abst. 1989. 12(4):192].

Kirttania, B, Sarkar MAR, Paul SK, Islam MS (2013). Morpho-physiological attributes of transplant *Aman* rice as influenced by variety, age of tiller seedlings and nitrogen management. *J. Agrofor. Environ.*, 7 (2):149-154.

Paul SK., Roy B, Hasan AK, Sarkar MAR (2017). Yield and yield components of short duration transplant *Aus* rice (cv. Parija) as influenced by plant spacing and nitrogen level. *Fundamental and Applied Agriculture,* 2(2): 233-236.

Paul SK, Islam MS, Sarkar MAR, Das KR and Islam SMM (2016). Impact of variety and levels of nitrogen on the growth performance of HYV transplant *Aman* rice. *Progress. Agric.* 27: 32-38.

Paul S K, Rahman K S and Sarkar M A R (2013). Physiological attributes of transplant *aman*rice (cv. BRRI dhan52) as affected by tiller seedlings and urea super granules. *Progress. Agric.* 24(1 & 2): 17 – 27.

Paul SK, Islam SMM, Sarkar MAR, Alam A, Zaman F (2014). Physiological parameters of transplant *Aman* rice (cv. BRRI dhan49) as influenced by weeding regime and integrated nutrient management. *J. Agrofor. Environ.,*8(2): 121-125.

Portech S, Islam MS (1984). Nutrient status of some of the more important agricultural soil of Bangladesh. In: Proc. Int. Symp. Soil Test Crop Response Correlation Studies.Dhaka. pp. 97-106.

Qurashi T. A., Salam M. A., Jannat M. and Rabbani M. G. (2013). Evaluation of urea super granule as a source of nitrogen in transplant *aman* rice. *Progress. Agric.* 24(1 & 2): 29-37.

Ray S, Sarkar MAR, Paul SK, Islam AKMM. Yeasmin S (2015). Variation of growth, yield and protein content of transplant *Aman* rice by three agronomic practices. *Agricultural and Biological Sciences Journal,* 1 (4):167-176.

Reddy MD. Mitra BN (1984). Effect of time of planting, age and number of seedlings per hill on yield and yield components of rice varieties in flood prone situations. *Thai. J Agric. Sci.* 17(1):41-49. [Cited From Rice Abst. 7(12):252].

Tanaka A (1983). Physiological aspects of productivity. In: Potential productivity of field crops under different environments. Intl. Rice Res. Inst. Los Banos, Philippines. pp. 61-99.

Uddin MH (2003). Effect of plant spacing and nitrogen levels on yield of transplanted *Aman* rice cv. BR39.*MS Thesis*, Dept. Agron. Bangladesh Agril. Univ., Mymensingh. p.16-44.

Zannat ST, Paul SK, Salam MA (2014).Effect of weeding regime and nitrogen management on the performance of transplant aromatic *Aman* rice (cv. Binadhan-9).*Bangladesh J. SeedSci. & Tech.*, 18 (1 & 2):29-34.