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Effect of age of seedlings at staggered planting and nitrogen rate on the growth and yield of transplant *Aman* rice

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Abstract

An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during July to December 2015 to find out the effect of age of seedlings at staggered planting and nitrogen rate on the growth and yield of transplant *Aman* rice (cv. BRRI dhan46). The experiment comprised three ages of seedlings viz. 30, 45 and 60-day old and six nitrogen rate viz. 0, 40, 60, 80, 100 and 120k kg N ha^{-1}. The experiment was laid out in a Randomized Complete Block Design with three replications. The effect of age of seedlings and nitrogen rates and their interaction were significant on yield and yield contributing characters of transplant *Aman* rice. The highest plant height, total dry matter production hill^{-1} and leaf area index were recorded in 30-day old seedlings with 80 kg N ha^{-1}. Grain yield gradually increased with the use of relatively younger seedlings and 30-day old seedlings produced the highest number of effective tillers hill^{-1} (5.34), grains panicle^{-1} (110.9), 1000-grain weight (24.60 g), grain yield (4.06 t ha^{-1}) and straw yield (5.17 t ha^{-1}). In case of nitrogen rate, 80 kg N ha^{-1} produce the highest grains panicle^{-1} (113.1), 1000-grain weight (25.39 g), grain yield (4.37 t ha^{-1}) and straw yield (5.59 t ha^{-1}). In interaction, 30-day old seedlings with 80 kg N ha^{-1} produced the highest effective tillers hill^{-1} (6.22), grains panicle^{-1} (124.1), 1000-grain weight (26.91g), grain yield (4.71 t ha^{-1}) and straw yield (6.16 t ha^{-1}). Therefore, 30-day old seedlings with 80 kg N ha^{-1} appeared as the promising technique to obtain the highest grain yield. It was also observed that under adverse situation delaying in transplanting may be continued up to 15 September with aged seedlings (60-day old) from the same source and application of nitrogen ranging from 100–120 kg ha^{-1} to obtain grain yield ranging from 3.8–4.0 t ha^{-1}.

Keywords: Age of seedlings**,** Staggered planting, Nitrogen rate

Introduction

Rice (*Oryza sativa* L.) is the leading cereal of the world and more than half of the human race depends on rice for their daily sustenance. Bangladesh is an agricultural country and its agriculture is predominantly rice based. In Bangladesh, there are three distinct growing seasons of rice according to changes in seasonal conditions such as *Aus, Aman* and *Boro.* Among them total *Aman* rice covers 55, 90, 340 hectares land with a production of 1, 34, 83, 437 metric tons (BBS, 2015). Horizontal expansion of rice area is not possible due to limited land resources and high population density. So, the only avenue left is to increase production of rice by vertical means through introduction of high yielding varieties and subsequent management practices. The yield of transplant *Aman* rice can be increased with the improved cultivation practices like proper age of seedlings and proper nitrogen rate. The use of seedlings from the same source having the same sowing date first transplanted at optimum date and thereafter at different dates is termed as staggered planting of rice seedlings having different ages. Transplanting of healthy seedlings of optimum age ensures better rice yield. When seedlings are transplanted at right time, tillering and growth proceed normally. Seedling age is an important factor due to its tremendous influence on plant height, tiller production, panicle length, grains panicle^{-1} and other yield contributing characters (Islam and Ahmed, 1981). In Bangladesh, sometimes transplanting of *Aman* rice is delayed due to late recession of flood water, an unavailability of seedlings and as a result farmers cannot transplant *Aman* rice. In such cases more seedlings can be raised in the nursery bed which can be transplanted in the main field at a later date than the optimum one so that the damage caused by the flood is minimized. So, in case of staggered planting yield loss can be minimized by applying N fertilizer at higher rate in aged seedlings to get better yield. Nitrogen is an essential plant nutrient that plays a vital role in increasing protein in the grains, increases tillering, vegetative growth, grain and straw yields. The farmers usually do not apply nitrogen in their fields properly and timely. Efficient fertilizer management gave higher yield of crop and reduced fertilizer cost (Hossain and Islam, 2006). On the other hand excess amount of nitrogenous fertilizer results in lodging of plants, prolonging growing period, delaying in maturity, susceptibility to insect pests and diseases and ultimately reduces yield (Uddin, 2003). It is essential to apply proper amount of nitrogenous fertilizer that will be technically effective, economically viable and socially acceptable to obtain higher yield. Therefore, the present investigation was conducted to find out the effect of age of seedlings at staggered planting and nitrogen rate on the growth, yield and yield contributing characters of transplant *Aman* rice (cv. BRRI dhan46).

Materials and Methods

The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from July to December 2015. The experiment consisted of the following treatments. i) Age of seedlings at staggered planting viz. 30-day old seedlings (A_1), 45-day old seedlings (A_2) and 60-day old seedlings (A_3) ii) Nitrogen rate viz. 0 kg N ha^{-1} (N_0), 40 kg N ha^{-1} (N_1), 60 kg N ha^{-1} (N_2), 80 kg N ha^{-1} (N_3), 100 kg N ha^{-1} (N_4) and 120 kg N ha^{-1}(N_5). The experimental field was medium high land belonging to the Sonatola Soil Series of Grey Floodplain soil under the agro-ecological zone of Old Brahmaputra Floodplain (AEZ-9). The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 4.0 m x 2.5 m. The land was fertilized as per treatment specification. The experimental plots were fertilized with nitrogen in the form of urea at the rate of 0, 40, 60, 80,100 and 120 kg ha^{-1} in the special plots, respectively. Urea was applied as top dressing in three equal splits at 15, 30 and 45 days after transplanting (DAT). In addition, Triple super phosphate, Muriate of potash, Gypsum and Zinc sulphate were applied in all plots @ 100, 70, 60 and 10 kg ha^{-1}, respectively during final land preparation. Seedlings were transplanted on the well puddled experimental plots on 10 August, 25 August and 10 September 2015 as per specified ages of seedlings. Three seedlings were transplanted in each hill with a spacing of 25 cm $\times$ 15 cm. All management practices were done as and when necessary. Five hills were selected randomly from each unit plot and uprooted before harvesting for recording data on yield components. Maturity of crops was determined when 90% of the grains became golden yellow in color and then the crops were harvested. Crops which were transplanted as 60-day old seedlings matured earlier and harvested on 2 December 2015. Transplanted seedlings of 30-day old and 45-day old matured later and harvested on 10 December 2015. The crop of individual plot was threshed and grains were cleaned and sun dried to moisture content of 14%. Straws were sun dried properly. Finally grain and straw yields plot^{-1} were recorded and converted to t ha^{-1}. The recorded data were compiled and tabulated for statistical analysis. Analysis of variance was done with the help of computer package, MSTAT-C. Collected data were analyzed using “Analysis of variance” technique and the significance of the mean differences was adjudged by the Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Results and Discussion

Effect of age of seedlings at staggered planting on yield and yield contributing characters of transplant *Aman* rice cv. BRRI dhan46

Results showed that age of seedlings at staggered planting had significant effect on plant height, effective tillers, grains panicle^{-1}, grain yield and biological yield (Table 1). Highest plant height (109.4 cm), maximum number of effective tillers hill^{-1} (5.34), grains panicle^{-1} (110.9), grain yield (4.07 t ha^{-1}), straw yield (5.17 t ha^{-1}) and biological yield (9.23 t ha^{-1}) were recorded in 30-day old seedlings. Similar result was found by Razzaque *et al.* (2000), who reported that seedling age showed significant effect in respect of grains panicle^{-1}. The higher number of effective tillers hill^{-1} and the higher number of grains panicle^{-1} were mainly responsible for the highest grain yield. Effect of seedling age resulted higher grain and straw yield because the 30-day old seedlings got less time in the nursery bed and thus they quickly recovered the transplanting shock in the main field. Panicle initiation started earlier within the plant and more spikelets formed which ultimately resulted in more number of spikelets panicle^{-1}. Thus the yield components were improved and sterility percentage was decreased which were mainly responsible for the improvement of grain yield. Lower grain, straw and biological yield are obtained from 60-day old seedlings because they remained more days in the nursery bed and as a result basal node was formed in the seedlings. Again it took more time to establish in the main field.

Table 1. Effect of age of seedlings at staggered planting on yield contributing characters and yield of transplant *Aman* rice cv. BRRI dhan46

Age of seedlings	Plant height (cm)	No. of effective tillers hill^{-1}	No. of non-effective tillers hill^{-1}	Panicle length (cm)	No. of grains panicle^{-1}	No. of sterile spikelets panicle^{-1}	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
A_1	109.4a	5.34a	2.48a	21.72a	110.9a	17.63b	24.60a	4.07a	5.17a	9.23a	43.78
A_2	108.3a	5.14b	2.23c	20.29b	107.3b	19.28a	24.19a	3.79b	4.74b	8.52b	44.15
A_3	95.18b	4.85c	2.33b	19.64c	89.32c	20.07a	22.76b	3.5c	4.53c	8.03c	43.46
$S\bar{x}$	0.786	0.057	0.025	0.171	0.643	0.525	0.377	0.028	0.037	0.055	0.363
Level of significance	**	**	**	**	**	**	**	**	**	**	NS
CV (%)	3.20	4.69	4.44	3.53	2.67	11.73	6.72	3.13	3.24	2.70	3.53

In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT). ** =Significant at 1% level of probability, NS = Not significant
A_1 = 30-day old seedlings, A_2 = 45-day old seedlings, A_3 = 60-day old seedlings.

Effect of nitrogen rate on yield and yield contributing characters of transplant *Aman* rice cv. BRRI dhan46

The effect of nitrogen rate on yield and yield contributing characters was significant (Table 2). The tallest plant (111.6 cm), highest number of total tillers hill^{-1} (8.78), effective tillers hill^{-1} (5.92), longest panicle (21.40 cm), highest grains panicle^{-1} (113.1), grain yield (4.37 t ha^{-1}), straw yield (5.59 t ha^{-1}) and biological yield (9.96 t ha^{-1}) were obtained from 80 kg N ha^{-1} (N_3). Application of 80 kg N ha^{-1} encouraged the vegetative growth of rice in terms of plant height, number of effective tillers hill^{-1}, which ultimately resulted in the increase of grain yield. This is may be due to the absorption of more nutrient, moisture and also for availability of more sunlight. Similar result was observed by Uddin *et al*. (2013). Lowest grain yield was obtained in control treatment (N_0). Younger seedlings produced more tillers than the older ones due to quick regeneration of seedlings, uptake of nutrients and plant vigor. On the other hand application of nitrogen increase the number of effective tillers which ultimately increase the grain yield.

Table 2. Effect of nitrogen rate on yield and yield contributing characters of transplant *Aman* rice cv. BRRI dhan46

Nitrogen rate	Plant height (cm)	No. of effective tillers hill^{-1}	No. of non-effective tillers hill^{-1}	Panicle length (cm)	No. of grains panicle^{-1}	No. of sterile spikelets panicle^{-1}	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
N_0	96.78d	2.92e	1.44d	19.72d	94.19d	21.78a	22.24c	2.38e	3.55e	5.93e	40.27b
N_1	101.5c	5.11d	2.33c	20.13cd	95.63d	20.19ab	23.33bc	3.69d	4.56d	8.24d	44.71a
N_2	104.2bc	5.39c	2.51a	20.43bcd	100.6c	19.63ab	23.85abc	3.96c	4.94c	8.90c	44.50a
N_3	111.6a	5.92a	2.85a	21.40a	113.1a	15.89d	25.39a	4.37a	5.59a	9.96a	43.91a
N_4	106.4b	5.74ab	2.55b	20.96ab	106.9b	17.37cd	24.34ab	4.23b	5.21b	9.43b	44.81a
N_5	105.1b	5.59bc	2.40c	20.65bc	104.5b	19.11bc	23.95ab	4.07c	5.05c	9.12c	44.60a
Sx	1.11	0.080	0.035	0.241	0.910	0.742	0.533	0.039	0.052	0.077	0.514
Level of significance	**	**	**	**	**	**	**	**	**	**	**
CV (%)	3.20	4.69	4.44	3.53	2.67	11.73	6.72	3.13	3.24	2.70	3.53

In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT). ** =Significant at 1% level of probability, NS = Not significant.
N_0 = Control, N_1 = 40 kg N ha^{-1}, N_2 = 60 kg N ha^{-1}, N_3 = 80 kg N ha^{-1}, N_4 = 100 kg N ha^{-1} and N_5 = 120 kg N ha^{-1}.

Interaction effects of age of seedlings at staggered planting and nitrogen rate on yield and yield contributing characters of transplant *Aman* rice cv. BRRI dhan46

The interaction of age of seedlings at staggered planting and nitrogen rate had significant effects on all plant characters except number of total tillers hill^{-1}, panicle length, number of sterile spikelets panicle^{-1}, 1000-grain weight and harvest index (Table 3). Apparently the tallest plant (115.8 cm) was obtained from 30-day old seedlings with 80 kg N ha^{-1}($A_1 \times N_3$) and the shortest plant (89.11 cm) was obtained from 60-day old seedlings with 40 kg N ha^{-1} ($A_3 \times N_1$). The highest number of total tillers hill^{-1} (8.89) was obtained from 30-day old seedlings with 80 kg N ha^{-1}($A_1 \times N_3$) and the lowest number of total tillers hill^{-1} (4.00) was obtained from 60-day old seedlings with control treatment 0 kg N ha^{-1}($A_3 \times N_0$). It was observed that the highest number of effective tillers hill^{-1} (6.22) was found from 30-day old seedlings with 80 kg N ha^{-1} ($A_1 \times N_3$). The lowest number of effective tillers hill^{-1} (2.33) was found from 60-day old seedlings with control treatment 0 kg N ha^{-1}($A_3 \times N_1$). The highest non-effective tillers hill^{-1} (3.00) was obtained from 60-day old seedlings with 80 kg N ha^{-1} ($A_3 \times N_3$) and the lowest number of non effective tillers hill^{-1} (1.33) was obtained from 30-day old seedlings with control treatment ($A_1 \times N_0$) which was statistically similar with combination ($A_2 \times N_0$). The highest number of grains panicle^{-1} (124.1) was obtained from 30-day old seedlings with 80 kg N ha^{-1}($A_1 \times N_3$) and the lowest number of grains panicle^{-1} (83.00) was obtained from 60-day old seedlings with control treatment 0 kg N ha^{-1} ($A_3 \times N_0$). It was observed that the highest number of sterile spikelets panicle^{-1} (22.00) was obtained from 60-day old seedlings with control treatment 0 kg N ha^{-1} ($A_3 \times N_0$) and the lowest number of sterile spikelets panicle^{-1} (14.22) was obtained from 30-day old seedlings with 80 kg N ha^{-1} ($A_1 \times N_3$). The maximum weight of 1000-grain was observed (26.91 g) in 30-day old seedlings with 80 kg N ha^{-1}($A_1 \times N_3$) and the minimum weight of 1000-grain was observed (21.57) 60-day old seedlings with control treatment 0 kg N ha^{-1} ($A_3 \times N_0$). The highest grain yield (4.71 t ha^{-1}) was obtained from 30-day old seedlings with 80 kg N ha^{-1} ($A_1 \times N_3$) and the lowest grain yield (2.29 t ha^{-1}) was obtained from 60-day old seedlings with control treatment 0 kg N ha^{-1} ($A_3 \times N_0$). Again the highest straw yield (6.17 t ha^{-1}) was obtained from 30-day old seedlings with 80 kg N ha^{-1} ($A_1 \times N_3$) and the lowest straw yield (3.25 t ha^{-1}) was obtained from 60-day old seedlings with control treatment 0 kg N ha^{-1} ($A_3 \times N_0$). The highest biological yield (10.8 t ha^{-1}) was obtained from 30-day old seedlings with 80 kg N ha^{-1}($A_1 \times N_3$) and the lowest biological yield (5.54 t ha^{-1}) was obtained from 60-day old seedlings with control treatment 0 kg N ha^{-1} ($A_3 \times N_0$). The highest harvest index (45.63%) was obtained from 45-day old seedlings with 100 kg N ha^{-1} ($A_1 \times N_4$) and the lowest harvest index (39.17%) was obtained from 30-day old seedlings with control treatment 0 kg N ha^{-1} ($A_3 \times N_0$).

Table 3. Effect of interaction between age of seedlings at staggered planting and nitrogen rate on yield and yield contributing characters of transplant *Aman* rice cv. BRRI dhan46

Interaction (Age of seedlings x nitrogen rate)	Plant height (cm)	No. of effective tillers hill^{-1}	No. of non-effective tillers hill^{-1}	Panicle length (cm)	No. of grains panicle^{-1}	No. of sterile spikelets panicle^{-1}	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
$A_1 \times N_0$	98.00d	3.44f	1.33i	20.86	101.9ef	21.67	22.78	2.50g	3.88i	6.38k	39.17
$A_1 \times N_1$	108.0bc	4.99e	2.78bc	21.24	103.6e	18.00	23.91	3.93d	4.73fg	8.66gh	45.40
$A_1 \times N_2$	110.3ab	5.74bc	2.78bc	21.57	109.0cd	17.89	24.47	4.25c	5.18cd	9.43de	45.07
$A_1 \times N_3$	115.8a	6.22a	2.67cd	22.60	124.1a	14.22	26.91	4.71a	6.17a	10.8a	43.34
$A_1 \times N_4$	112.6ab	5.89ab	2.78bc	22.43	113.9c	16.11	24.83	4.58ab	5.70b	10.2b	44.59
$A_1 \times N_5$	111.6ab	5.78bc	2.56de	21.60	112.9c	17.89	24.69	4.41bc	5.37c	9.78cd	45.14
$A_2 \times N_0$	97.00d	3.00g	1.33i	19.32	97.67fg	21.67	22.38	2.36g	3.51j	5.86l	40.23
$A_2 \times N_1$	107.4bc	5.33cde	2.11g	19.86	97.78fg	20.67	23.61	3.69e	4.53gh	8.22i	44.89
$A_2 \times N_2$	109.6abc	5.33cde	2.33f	20.12	105.7de	20.22	24.36	3.96d	4.87ef	8.83fgh	44.91
$A_2 \times N_3$	115.1a	5.89ab	2.89ab	21.11	119.2b	15.78	25.64	4.43bc	5.41c	9.84c	45.05
$A_2 \times N_4$	110.7ab	5.78abc	2.44ef	20.70	113.1c	17.67	24.76	4.26c	5.08de	9.35e	45.63
$A_2 \times N_5$	109.9abc	5.56bcd	2.33f	20.62	110.2cd	19.67	24.39	4.00d	5.05de	9.05efg	44.20
$A_3 \times N_0$	95.33d	2.33h	1.67h	18.98	83.00j	22.00	21.57	2.29g	3.25j	5.54l	41.41
$A_3 \times N_1$	89.11e	5.00e	2.11g	19.29	85.56j	21.89	22.47	3.43f	4.40h	7.83j	43.83
$A_3 \times N_2$	92.78de	5.11de	2.44ef	19.60	87.22ij	20.78	22.71	3.67e	4.77fg	8.44hi	43.53
$A_3 \times N_3$	103.9c	5.66bc	3.00a	20.50	96.11g	17.67	23.61	3.96d	5.20cd	9.16ef	43.33
$A_3 \times N_4$	96.11d	5.56bcd	2.44ef	19.75	93.56gh	18.33	23.43	3.83de	4.84ef	8.67gh	44.20
$A_3 \times N_5$	93.89de	5.44bcde	2.33f	19.74	90.44hi	19.78	22.77	3.79de	4.74fg	8.53hi	44.45
Sx	1.92	0.139	0.061	0.418	1.58	1.28	0.923	0.068	0.089	0.134	0.890
Level of significance	**	*	**	NS	*	NS	NS	*	*	*	NS
CV (%)	3.20	4.69	4.44	3.53	2.67	11.73	6.72	3.13	3.24	2.70	3.53

In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT).

** =Significant at 1% level of probability, * =Significant at 5% level of probability, NS = Not significant.

A_1 = 30-day old seedlings, A_2 = 45-day old seedlings, A_3 = 60-day old seedlings. N_0 = Control, N_1 = 40 kg N ha^{-1}, N_2 = 60 kg N ha^{-1}, N_3 = 80 kg N ha^{-1}, N_4 = 100 kg N ha^{-1} and N_5 = 120 kg N ha^{-1}.

Conclusion

From this study it can be concluded that 30-day old seedling with 80 kg N ha^{-1} may be used for better performance compared to other combinations in respect of growth and grain yield of transplant *Aman* rice (cv. BRRI dhan46). Again results revealed that in case of staggered transplanting, 60-day old seedlings with 100-120 kg N ha^{-1} can be used to obtain higher grain yield. BRRI dhan46 is a late variety and in case of adverse situation delaying in transplanting with aged seedlings (60-day old) from the same source it can be transplanted up to 15 September with application of nitrogen ranging from 100-120 kg ha^{-1} to obtain grain yield ranging from 3.8–4.0 t ha^{-1}.

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