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Response pattern of local, inbred and hybrid monsoon rice varieties to elevated nitrogen levels

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ABSTRACT

The experiment was conducted at the Bangladesh Agricultural University during July to December 2017 to investigate the response of local, inbred and hybrid rice varieties to elevated nitrogen fertilizer application. The experiment comprised two factors such as factor A: nitrogen levels viz., control (without N fertilizer), 40, 80, 120, 160 and 180 kg N ha^{-1}; factor B: rice varieties viz., Latma (local), BRRI dhan49 (inbred) and Agrodhan-12 (hybrid). Experiment was laid out in a Split-plot design with three replications where nitrogen levels were assigned to main plots and varieties were to sub-plots. Nitrogen levels, varieties and their interactions significantly influenced the yield contributing characters and yield of rice. Agrodhan-12 fertilized with 120 kg N ha^{-1} produced the highest grain yield which was statistically similar to BRRI dhan49 interacted with 80 kg N ha^{-1}. The lowest yield was obtained from Latma without N fertilizer. The treatment 40 kg N ha^{-1} resulted the highest nitrogen use efficiency. In terms of yield and economic performances, 120 kg N ha^{-1} performed best. Based on these results it may conclude that 120 kg N ha^{-1} is the optimum dose for hybrid Agrodhan-12, whereas 80 kg N ha^{-1} for local Latma or inbred BRRI dhan49.

Keywords: Aman rice, Nitrogen levels, Yield performance, N use efficiency, Grain yield, Split-plot.

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Introduction

Rice is one of the most important food crops feeding more than 50% of the world's populations [1], and about 90% of the world rice is grown in Asia [2]. The top ten rice producing countries in the world today are India, China, Indonesia, Bangladesh, Thailand, Vietnam, Burma, the Philippines, Cambodia and Pakistan [3]. These countries also consume about 90% of the world's rice. According to the Food and Agricultural Policy Research Institute, the world's demand for milled rice can be expected to rise to 496 million tons in 2020, from 439 million tons in 2010. This demand for rice is expected to increase until 2035.

Nitrogenous fertilizer is one of the major inputs of rice production [4]. The doubling of crop production over the past four decades has been associated with a 7-fold increase in the use of nitrogenous fertilizers worldwide [5]. Besides, the excessive fertilization and unique conditions of paddy fields promote nitrogen losses to the environment, which results in low nitrogen utilization rate and unstable grain production. Farmers of the developing countries have the tendency to apply a higher amount of nitrogenous fertilizer than the optimum to get desirable yield of rice [6], but over application of nitrogenous fertilizer may actually decrease grain yield by increasing susceptibility to lodging, and disease and insect pest infestation [7, 8]. Hence, before making nitrogen fertilizer recommendations for a particular rice variety, one should identify the optimum dose, nitrogen use efficiency and economics to get maximum out returns from minimum input.

Now-a-days, different inbred and hybrid rice varieties are gaining popularities in the Asian countries due to their higher yield potentiality than local varieties (Islam et al., 2017). However, local culti-

vars have advantages of withstanding environmental stress, and pests and diseases [9]. Hybrid varieties, on the other hand possess a more vigorous and extensive root system and rapid growth rate during vegetative period. Uphoff et al. [10] stated that high yielding or hybrid rice varieties yielded more than 15 t ha^{-1}, while traditional/local varieties produced 6-12 t ha^{-1} under well managed condition. Iqbal et al. [4] revealed that inbred and hybrid rice varieties are highly responsive to different levels of nitrogen.

Variety-wise fertilizer recommendation is one of the important options to increase rice yield. So it is very essential to know nitrogen response behaviour of inbred and hybrids compared to the local rice varieties. However, the response of different local and inbred rice varieties in comparison with hybrid varieties to elevated levels of nitrogen especially under Bangladesh condition is not well flourished and widely known to the researchers. In this back drop, this study was undertaken to investigate into the differences in response to elevated doses of nitrogenous fertilizer among local, inbred and hybrid rice varieties and to identify the best economic dose(s) for local, inbred or hybrid rice varieties.

Materials and Methods

Experimental Site

The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University (latitude 24.75° N, longitude 90.50° E and elevation from sea level l8 m) during June-December, 2017. The experimental area was a fairly leveled well drained medium high land belonging to the Sonatola series of non–calcareous dark grey floodplain soil under the Old Brahmaputra Floodplain agro-ecological zone [11]. The experimental soil was silt loam having bulk density of 1.35 g cc^{-1} and pH 5.70. The soil contained 0.09% total nitrogen, 1.02% organic matter, 5.68 ppm available phosphorus, and 49.12 ppm exchangeable potassium and 8.28 ppm available sulphur. The experimental site was characterized by high temperature, high humidity and heavy rainfall with occasional gusty wind in April-September and scanty rainfall associated with moderately low temperature during October-March. During the growing season (July– December, 2017), monthly average maximum, minimum temperature, relative humidity and average of monthly total rainfall were 32.3°C, 24.4°C, 84.6% and 229.5 mm, respectively.

Experimental Treatments and Design

The experiment comprised six levels of nitrogen application *viz.* 0, 40, 80, 120, 160 and 180 kg N ha^{-1} and three rice varieties *viz.* Latma (local), BRRI dhan49 (high yielding inbred) and Agrodhan-12 (hybrid). The experiment was laid out in a Split-plot design with three replications where nitrogen levels were assigned to main plots and varieties were in sub-plots. The size of unit plot was 4.0 × 2.5 m (10 m^2) where block to block and plot to plot distances were 1m and 0.5 m, respectively.

Crop Husbandry and Data Recording

Twenty-five days old seedlings were transplanted at 25 cm× 15 cm spacing with three seedlings $hill^{-1}$. The fertilizers TSP, MoP, Gypsum, and Zinc sulphate were applied @ 130-120-70-10 kg ha^{-1}, respectively. All the fertilizers were applied as basal dose except urea which was applied as top dressing in 3 equal installments at 15 days after transplanting (DAT), tillering and panicle initiation stages as per the treatment specification. Weeding was done manually twice at 30 and 45 DAT. Intercultural operations *e.g.* gap filling, irrigation and drainage were done as per requirement. As there were no remarkable infestation of disease and insect, hence no plant protection measure was taken. At maturity (when 90% of the seeds became golden yellow in color), three square meter area from each plot was marked from the central portion and cut manually from the ground level to take grain and straw yields. Agrodhan-12, Latma and BRRI dhan49 variety were harvested at 13, 18 and 20 November, 2017, respectively. The grains were cleaned and dried to a moisture content of 14%. Straws were sun dried properly. Final grain and straw yields $plot^{-1}$ were recorded and converted to t ha^{-1}. Prior to harvesting, five hills were randomly selected from each plot for recording data on different yield contributing characters. Nitrogen use efficiency, grain yield merit and monetary advantage were calculated as follows:

$$\text{Nitrogen use efficiency} = \frac{\text{Total grain yield}}{\text{Amount of applied nitrogen}} \quad \text{.....(i)}$$

$$\text{Grain yield merit (\%)} = \frac{\text{Grain yield of N applied plot} - \text{grain yield of control plot}}{\text{Grain yield of coltrol plot}} \times 100 \ldots\ldots\ldots\ldots\ldots \text{(ii)}$$

$$\text{Monetary advantage} = \text{Total grain yield (t ha}^{-1}) \times \text{Unit price of the grain} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(iii)}$$

Statistical Analysis

The recorded data related to yield contributing characters and yield were compiled and tabulated in proper form for statistical analyses. Analysis of variance was done at 5% probability level with the help of MSTAT–C computer package program. The mean differences among the treatments were evaluated with DMRT test. The relationship between grain yield and fertilizer dose were fitted by the following quadratic model using 'R' statistical programme:

$$Y = a + bX + cX^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (iv)$$

Where, Y = seed yield (t ha^{-1}), X = the dose of the nitrogen applied (kg ha^{-1}), a, b and c are the parameters of the model.

Results and Discussion

Yield Contributing Characters

All the yield contributing characters differed significantly due to nitrogen levels, but only number of effective tillers hill^{-1} and 1000-grain weight differed significantly among the varieties (Table 1). Whereas, their interactions had significant effect on all the yield contributing characters (Table 1). The highest number of effective tillers hill^{-1} (18.15), grains panicle^{-1} (213.80), 1000-grain weight (26.27 g) and longest panicle (19.72 cm) were observed in 120 kg N ha^{-1}, which was statistically identical to 80 kg N ha^{-1} (Table 1). The lowest number of effective tillers hill^{-1} (12.14), grains panicle^{-1} (170.87), 1000-grain weight (22.59 g) and shortest panicle (15.58 cm) were found from the control (Table 1). The hybrid variety Agrodhan-12 produced the highest number of effective tillers hill^{-1} (16.98) and 1000-grain weight (24.98 g), and both the values were statistically similar with BRRI dhan49 (Table 1). Local variety Latma produced the lowest number of effective tillers hill^{-1} (15.36) and 1000-grain weight (22.84 g).

In case of interaction, the highest number of effective tillers hill^{-1} (21.02), grains panicle^{-1} (244.15), 1000-grain weight (30.12 g) and longest panicle (25.25 cm) were found in Agrodhan-12 applied with 120 kg N ha^{-1}, which was statistically similar to BRRI dhan49 interacted with 80 kg N ha^{-1} application (Table 2). The lowest number of effective tillers hill^{-1} (8.02), grains panicle^{-1} (156.25), 1000-grain weight (22.22 g) and shortest panicle (15.05 cm) were found in the local variety Latma without N application. The variations among the varieties regarding these yield contributing characters are mainly related to their genetic makeup [12].

The number of effective tillers hill^{-1} at higher rates of nitrogen could be attributed to increased photosynthate production and its translocation for panicle formation at the reproductive stage [12, 13] also found that number of effective tillers hill^{-1} was significantly influenced by the higher dose of nitrogen. There was a significant increase in number of grains panicle^{-1} with increase in each successive level of N up to 80 kg N ha^{-1} for inbred and local variety, and 120 kg N ha^{-1} for hybrid variety. Further increase in the rate of nitrogen fertilizer from the above-mentioned levels reduced the number of grains (Table 2). Similar type of results were also reported by [14, 9, 12].

The results also showed that hybrid variety Agrodhan-12 needs higher dose of nitrogen (120 kg N ha^{-1}) to produce highest 1000-grain weight compared to inbred BRRI dhan49 (80 kg N ha^{-1}). Due to application of higher nitrogen, plant may get the higher sink in its grain. More nitrogen may increase the dry matter partitioning in grain and then converted into seed protein content and higher seed protein increased the 1000-grain weight. This result contradicts with the findings of [15] who found no significant differences in 1000-grain weight due to application of different levels of nitrogen. Mingotte et al. [16] and Boldieri et al. [17] also reported that 1000-grain mass differences was due to cultivars, and had no influence of the nitrogen application. However, 1000-grain weight differences among different varieties were also reported by [18, 19].

Table 1. *Effect of N-levels and variety on yield contributing characters and harvest index of monsoon rice*

	No. of effective tillers hill^{-1}	Panicle length (cm)	No. of grains panicle^{-1}	Weight of 1000-grain (g)	Harvest index (%)
Nitrogen Levels (kg ha^{-1})					
0	12.14e	15.58c	170.87d	22.59d	45.14
40	16.80c	16.91b	186.91a	23.47cd	44.79
80	17.66ab	19.52a	209.95ab	25.71ab	45.62
120	18.15a	19.72a	213.80a	26.27a	46.75
160	17.10bc	16.41bc	201.73b	24.72bc	46.96
180	15.67d	15.99bc	182.83c	24.51bc	43.88
CV (%)	3.62	5.53	5.25	5.14	6.10
Level of sig.	**	**	**	**	NS
Varieties					
Latma	15.36b	16.50	187.94	22.84b	45.13
BRRI dhan49	16.42a	17.67	196.88	24.82ab	45.74
Agrodhan-12	16.98a	17.90	198.23	24.98a	45.70
CV (%)	6.73	10.36	9.83	9.13	2.31
Level of sig.	**	NS	NS	*	NS

Values with common letter (s) within a column do not differ significantly at 5% level of probability analysed by LSD.
*, ** indicate significant at 5% and 1% level of probability, respectively, NS= Non-significant

Table 2. *Interaction effect of N-levels and variety on yield contributing characters and harvest index of monsoon rice*

Interaction [N-levels (kg ha^{-1}) × Variety]		No. of effective tillers hill^{-1}	Panicle length (cm)	Grains panicle^{-1}	Weight of 1000-grain (g)	Harvest index (%)
0	Latma	8.02e	15.05b	156.25d	22.22b	42.77d
	BRRI dhan49	13.22de	15.85b	175.12cd	22.56b	45.04bc
	Agrodhan-12	15.19cd	16.02b	181.24b-d	23.01b	46.14bc
40	Latma	16.55bc	16.85b	178.52b-d	23.56b	44.57cd
	BRRI dhan49	15.98cd	17.01b	184.02b-d	22.98b	44.47b-d
	Agrodhan-12	17.88b	16.88b	190.12bc	23.88b	45.33b-d
80	Latma	16.52bc	16.81b	201.23bc	24.45b	44.26cd
	BRRI dhan49	20.92ab	24.75a	238.52a	29.02a	47.29ab
	Agrodhan-12	15.56cd	17.02b	198.21bc	23.67	45.44bc
120	Latma	16.65bc	17.12b	200.01bc	24.18b	44.91cd
	BRRI dhan49	16.78bc	16.80b	201.12bc	24.52b	47.68ab
	Agrodhan-12	21.02a	25.25a	244.15a	30.12a	48.27a
160	Latma	17.58b	15.55b	205.52b	24.08b	47.65ab
	BRRI dhan49	16.52bc	16.56b	197.25bc	24.89b	45.78bc
	Agrodhan-12	17.20b	17.13b	198.55bc	25.21b	46.84b
180	Latma	16.88bc	16.59b	186.15bc	24.56b	44.67cd
	BRRI dhan49	15.12c	16.12b	185.25bc	24.98b	44.19cd
	Agrodhan-12	15.02c	15.11b	177.11cd	24.01b	44.12cd
CV (%)		6.73	10.36	9.83	9.13	2.31
Level of sig.		**	**	*	*	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability analysed by LSD.
*, ** indicate significant at 5% and 1% level of probability, respectively, NS= Non-significant.

Grain and Straw Yield

Nitrogen level, variety and their interactions significantly influenced the grain and straw yields of rice (Figure 1). The figure showed that there was an increasing trend found with the increased N levels up to 120 kg N ha^{-1} and thereafter decreased (Fig. 1). The highest grain (8.26 t ha^{-1}) and straw (9.40 t ha^{-1}) yield were found from the application of 120 kg N ha^{-1}, whereas the lowest grain (4.27 t ha^{-1}) and straw (5.19 t ha^{-1}) yield were found from control *i.e.* 0 kg N ha^{-1}. Hybrid variety Agrodhan-12 produced the highest grain (6.83 t ha^{-1}) and straw (8.07 t ha^{-1}) yield followed by inbred BRRI dhan49, whereas the lowest grain (5.96 t ha^{-1}) and straw (7.25 t ha^{-1}) yield were obtained from the local variety Latma (Fig. 2).

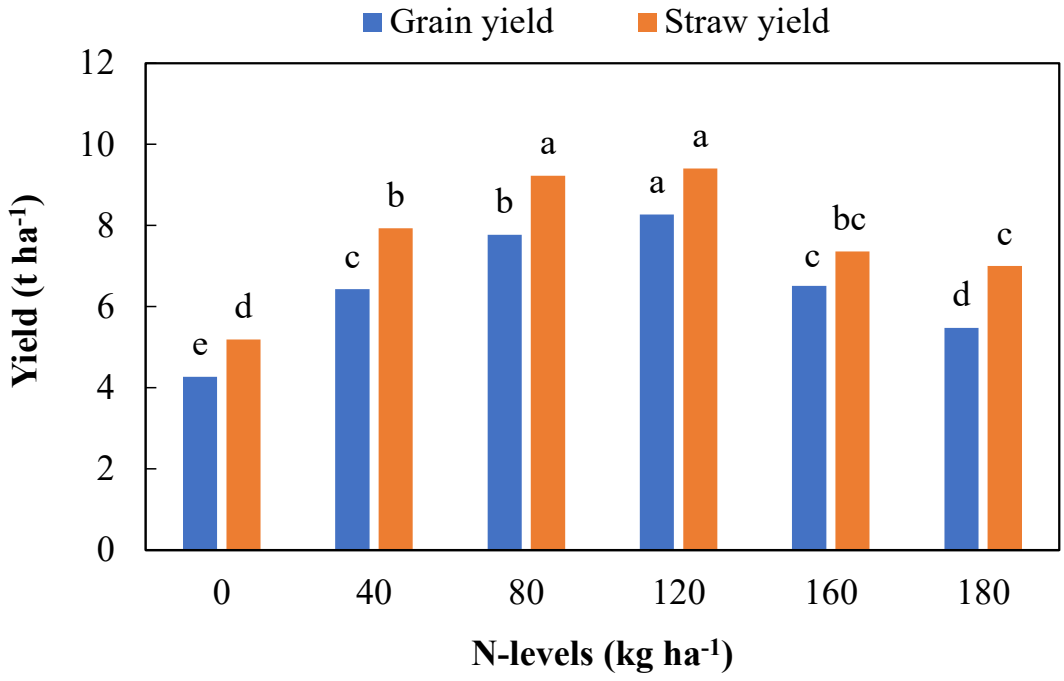

Fig 1. *Effect of N-level on grain and straw yield of monsoon rice*

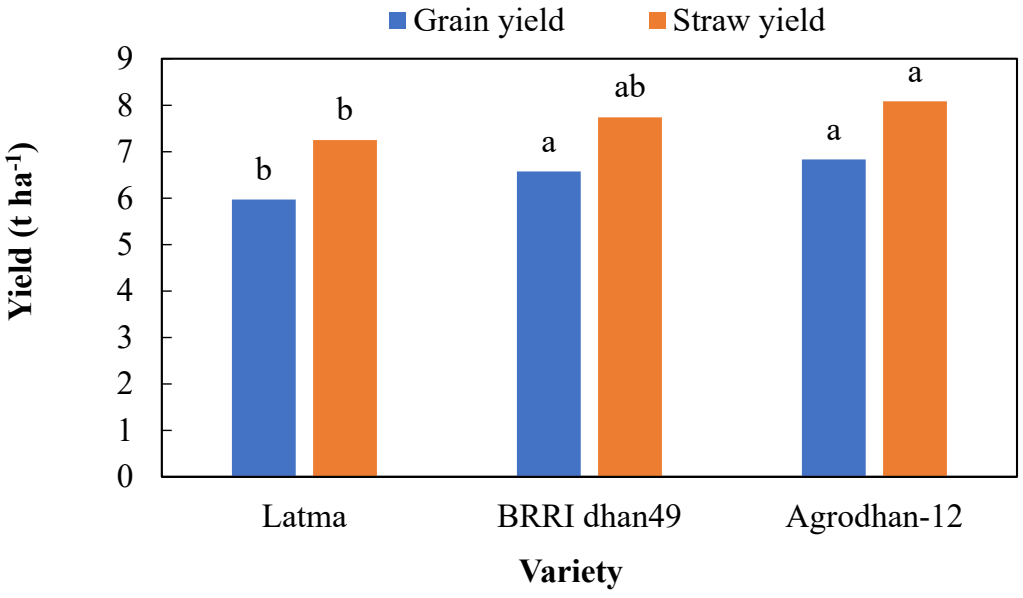

Fig 2. *Effect of variety on grain and straw yield of monsoon rice*

For interaction, the highest grain (8.70 t ha^{-1}) and straw (9.58 t ha^{-1}) yield were found in Agrodhan-12 applied with 120 kg N ha^{-1} which was statistically identical with BRRI dhan49 coupled with 80 kg N ha^{-1} (Fig. 3). The lowest grain (3.24 t ha^{-1}) and straw (4.12 t ha^{-1}) yield were found from Latma applied with no N. Similar results were also reported by Iqbal et al. [4], who reported that BRRI dhan49 and BRRI hybrid dhan4 produced highest grain yield of 5.4 and 4.9 t ha^{-1} at 80 kg N ha^{-1}, respectively. However, in the same study BRRI hybrid dhan2 gave the highest grain yield of 8.3 t ha^{-1} at 160 kg N ha^{-1}. Fertilizer rate more than 160 kg N ha^{-1} reduced the grain yield. Jisan et al. [20] estimated that the highest grain yield of some transplant monsoon rice varieties (BRRI dhan49, BRRI dhan56, BRRI dhan57 and BRRI dhan52) at 75 kg N ha^{-1} where the highest nitrogen rate used was 75 kg N ha^{-1}. In another study, Rahman et al. [12] obtained the highest grain yield of two transplant monsoon rice varieties (Binadhan-7 and BRRI dhan49) at 90-120 kg N ha^{-1} where the highest nitrogen rate used was 150 kg N ha^{-1}. Ferdous et al. [21] found highest grain yield of Binadhan-16 at 70 kg N ha^{-1} where the highest nitrogen rate used was 90 kg N ha^{-1}.

Harvest Index

Except of their interaction, nitrogen level and variety had no significant effect on harvest index (Table 1 and 2). Agrodhan-12 applied with 120 kg N ha^{-1} provided the highest harvest index (48.27%), and Latma without N application provided the lowest value (Table 2)

Nitrogen Use Efficiency

The results showed that the nitrogen use efficiency (NUE) was highest at 40 kg N ha^{-1}. Further increase in nitrogen levels decreased the NUE (Fig. 4). This is because at higher concentration of nitrogen, the absorption exceeds the utilization [22]. According to Yaduvanshi [23], an increase in doses of N fertilizer rates from 60 to 120 and 180 kg N ha^{-1} decreased NUE. It was also observed that the excessive use of nitrogen fertilizers resulted in decrease of physiological NUE and caused serious environmental pollution [22].

Grain Yield Merit and Monetary Advantage

An increasing trend of grain yield merit was found among the treatments up to 120 kg N ha^{-1} and thereafter decreased (Fig. 4). Apparently, 120 kg N ha^{-1} exhibited the maximum grain yield merit (93.62%) and which was very near (81.94%) to 80 kg N ha^{-1} over control treatment. Similar trend was also found in monetary advantage. Application of 120 kg N ha^{-1} gave the highest economic return (1, 65,356 Tk.) and which was very near (1, 55,378 Tk.) to 80 kg N ha^{-1} over control.

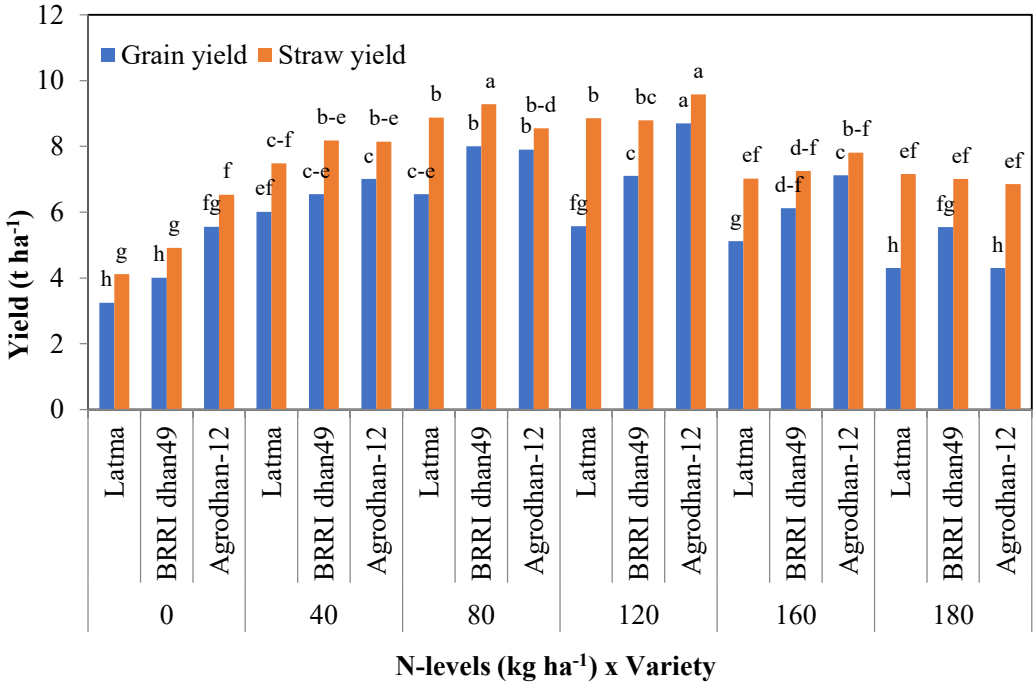

Fig 3. *Effect of variety on grain and straw yield of monsoon rice*

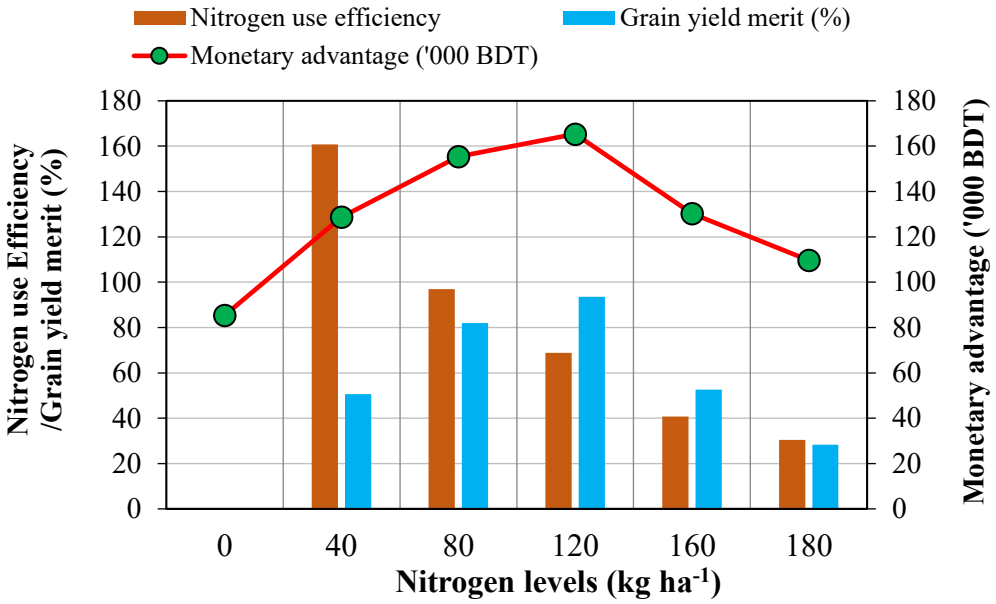

Fig 4. *Effect of N-levels on the nitrogen use efficiency, grain yield merit and monetary advantage of rice (The unit price of the grain was considered as 20 tk. kg^{-1})*

Optimum Nitrogen Dose

The yield response of three monsoon rice varieties in relation to nitrogen levels could be best explained by the quadratic equation (Fig. 5). The test analysis indicated that more than 88%, 95% and 93% of the variation in crop performance (grain yield) occurred due to nitrogen rates in local Latma, inbred BRRI dhan49 and hybrid Agrodhan-12, respectively. The estimated coefficients of the polynomial regression models showed significant variation. The estimated optimum dose of nitrogen for these three monsoon rice varieties lies in between 80 to 120 kg ha^{-1} because all these three varieties showed the highest yield when 80 to 120 kg ha^{-1} of nitrogen were applied (Fig. 5).

Conclusion

It is well known that hybrid variety needs more nutrient than inbred or local to exibit maximum yield potential. This statement also reflects in the current research where hybrid variety Agrodhan-12 produced highest grain yield when applied with 120 kg N ha^{-1}, and the local Latma and inbred BRRI

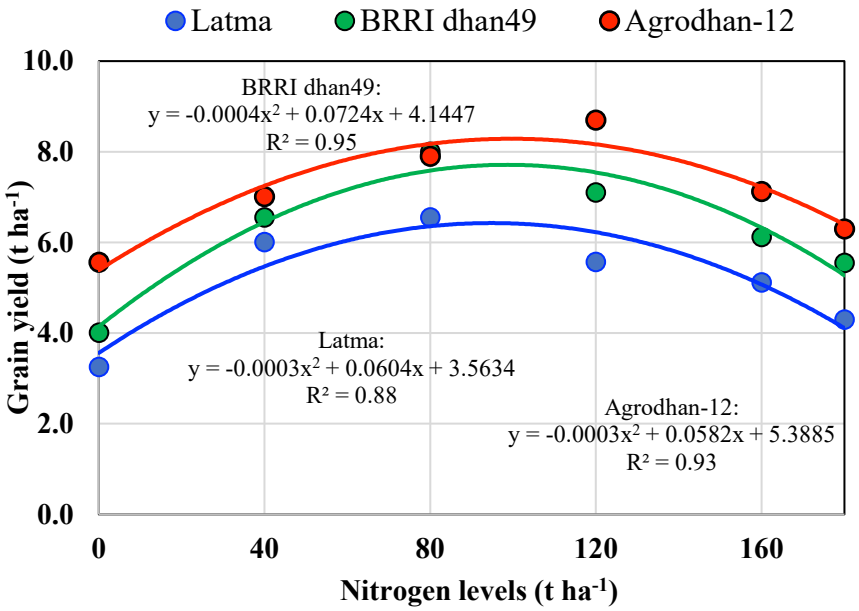

Fig 5. *Yield response of Latma (local), BRRI dhan49 (inbred) and Agrodhan-12 (Hybrid) to different nitrogen levels*

dhan49 produced highest grain yield at 80 kg N ha^{-1}. Based on the results it may concluded that Agrodhan-12 can be cultivated with the application of 120 kg N ha^{-1}. Whereas, local Latma and inbred BRRI dhan49 can be cultivated with the application of 80 kg N ha^{-1}. Their optimum dose of nitrogen lies in between 80 to 120 kg N ha^{-1}. However, further multi-location trials should be conducted with a wide range of varieties before drawing a concrete decision.

References

[1] Thakur, A. K., Rath, S., Patil, D. U. & Kumar, A., Effects on rice plant morphology and physiology of water and associated management practices of the system of rice intensification and their implications for crop performance, Paddy water Environment, 9(1) (2011) 13-24. https://doi.org/10.1007/s10333-010-0236-0

[2] Rahman, M. M., Potential benefits of dry direct seeded rice culture: A review. Fundamental and Applied Agriculture, 4(2) (2019) 744-758. doi: https://doi.org/10.5455/faa.16534.

[3] GRiSP (Global Rice Science Partnership), Rice almanac, 4th edition, Los Baños (Philippines): International Rice Research Institute, 2013.

[4] Iqbal, M., Ahmed, M.N., Sarkar, M. I. U., Alom, F. & Rana, M. M., Response of modern and hybrid rice varieties to different levels of nitrogen under rice–rice cropping pattern. Eco-friendly Agriculture, J., 7(10) (2014) 105-109.

[5] Hirel, B., Le Gouis, J., Ney, B. & Gallais, A., The challenge of improving nitrogen use efficiency in crop plants: towards a more central role for genetic variability and quantitative genetics within integrated approaches, J. of Experimental Botany, 58(9) (2007) 2369-2387. https://doi.org/10.1093/jxb/erm097.

[6] Saleque, M. A., Naher, U. A., Choudhury, N. N. & Hossain, A. T. M. S., Variety-specific nitrogen fertilizer recommendation for lowland rice. Communications in Soil Science and Plant Analysis, 35(13-14) (2004)1891-1903. https://doi.org/10.1081/LCSS-200026811.

[7] Duy, P. Q., Abe, A., Hirano, M., Sagawa S. & Kuroda, E. (2004) Analysis of lodging-resistant characteristics of different rice genotypes grown under the standard and nitrogen-free basal dressing accompanied with sparse planting density practices, Plant Production Science, *7*(3), 243–251. https://doi.org/10.1626/pps.7.243.

[8] Jahan, N. A., Yeasmin, S., Anwar, M. P., Islam, M. A., Rahman, H. & Islam, A. K. M. M., Efficacy and economics of different need based nitrogen management approaches in winter rice, American J. of Plant Sciences, 9 (2018) 2601-2611. https://doi.org/10.4236/ajps.2018.913189.

[9] Rusdiansyah & Saleh, M., Response of two local rice cultivars to different doses of nitrogen fertilizer in two paddy fields. Agrivita J. of Agricultural Science, 39(2) (2017) 137-144. https://doi.org/10.17503/agrivita.v39i0.572.

[10] Uphoff, N., Kassam, A. & Harwood, R., SRI as a methodology for raising crop and water productivity: productive adaptations in rice agronomy and irrigation water management, Paddy water Environment, 1, (2011) 3-11. https://doi.org/10.1007/s10333-010-0224-4.

[11] FAO-UNDP (Food and Agriculture Organization-United Nations Development Programme), Land Resources Appraisal of Bangladesh for Agricultural Development. Agro-Ecological Regions of Bangladesh, BGD/81/035. Technical Report No. 2 (1988) FAO, Rome.

[12] Rahman, M. M., Islam, M. M., Hasan, M. M. & Hossain, M. D. (2019). Response of shord duration mon- soon rice varieties to nitrogen fertilization. Fundamental and Applied Agriculture, 4(4) (2019) 1060–1067. doi: https://doi.org/10.5455/faa.71090.

[13] Qurashi, T. A., Salam, M. A., Jannat, M. & Rabbani, M. G., Evaluation of urea super granule as a source of nitrogen in transplant Aman rice. Progressive Agriculture, 24(1-2) (2014) 29 37. https://doi.org/10.3329/pa.v24i1-2.19095

[14] Hach, C. V. & Nam, N. T. H., Responses of some promising high-yielding rice varieties to nitrogen fertilizer. Omonrice, 14 (2006) 78-91.

[15] Maqsood, M., Irshad, M., Hussain, M. I. & Rafiq, K., Effect of nitrogen on the growth, yield and quality of fine rice. Pakistan J. of Biological Science, *3*(11) (2000) 1831-1832. https://doi.org/10.3923/pjbs.2000.1831.1832.

[16] Mingotte, F. L. C., Hanashiro, R. K. & Filho D. F. (2013). Response of rice cultivars to nitro-

gen in Upland conditions. Revista Ceres, 60(1) (2013) 86-95. https://doi.org/10.1590/S0034-737X2013000100013

[17] Boldieri, F. M., Cazetta, D. A. & Filho, D. F., Adubaçao nitrogenada em cultivares de arroz de terras altas. Revista Ceres *57*(3) (2010) 421-428.https://doi.org/10.1590/S0034-737X2010000300020.

[18] Chowdhury, M. J. U., Sarkar, A. U., Sarkar, M. A. R. & Kashem, M. A. (2005). Effect of variety and number of seedlings hill's on the yield and its components on late transplanted Aman rice, Bangladesh J. of Agricultural *Sci*ence, *20*(2) (2005) 311-316.

[19] Rahman, M. A., Hossain, S. M. A., Sarkar, M. A. R., Hossain, M. S. & Islam, M. S., Effect of variety and structural arrangement of rows on the yield and yield components of transplant Aman rice. Bangladesh J. of Agricultural Science, 29(2) (2002) 303-307.

[21] Ferdous, J., Hossain, M. D., Anwar, M. P. & Tazri, Z., Growth and yield of transplanted aman rice cv. Binadhan-16 as influenced by seedling age and nitrogen fertilization at staggered planting. Fundamental and Applied Agriculture, 4(2) (2019) 785–791. https://doi.org/10.5455/faa.26627.

[22] Singh, H., Verma, A., Ansari, M. W. & Shukla, A., Physiological response of rice (*Oryza sativa* L.) genotypes to elevated nitrogen applied under field conditions. *Pl*ant Signaling Behavior, 9(7) (2014) e29015. https://doi.org/10.4161/psb.29015

[22] Singh, H., Verma, A., Ansari, M. W. & Shukla, A., Physiological response of rice (*Oryza sativa* L.) genotypes to elevated nitrogen applied under field conditions. *Pl*ant Signaling Behavior, 9(7) (2014) e29015. https://doi.org/10.4161/psb.29015

[23] Yaduvanshi, N. P. S., Substitution of inorganic fertilizers by organic manures and the effect on soil fertility in a rice–wheat rotation on reclaimed sodic soil in India. J. of Agricultural Science, 140(2) (2003) 161-168. https://doi.org/10.1017/S0021859603002934