EVALUATION OF FOUR *AMAN* RICE VARIETIES BASED ON MORPHO-PHYSIOLOGICAL CHARACTERS AND YIELD ATTRIBUTES

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Abstract

An experiment was conducted to study the morpho-physiological parameters and yield indices at three locations (Mymensingh HQs, Rangpur and Magura substations) of Bangladesh Institute of Nuclear Agriculture (BINA) with four varieties during *Aman* season (July-December). The aim of this study was to evaluate the performance based on morpho-physiological characteristics and yield attributes of some BINA released modern *Aman* rice varieties. The rice varieties were *viz.*, Binasail, Binadhan-7, Binadhan-11 and Binadhan-12. The experiments were set following RCBD design with three replications. The physiological parameters like chlorophyll content, photosynthesis rate and nitrate reductase activity showed initially higher values and decreased gradually with age. The yield-contributing characters were the highest in Binadhan-7, thereby grain yield, followed by Binadhan-11. The lowest grain yield was recorded in Binasail for its lower yield attributing traits. Although location did not effect on yield but in terms of interaction with location Binadhan-7 performed better in Mymensingh followed by Rangpur and Magura.

Keywords: Chlorophyll, photosynthesis, nitrate reductase activity, Rice

Introduction

Including Bangladesh, about half of the world's population consumes rice (*Oryza sativa* L.) as their primary diet. The demand for rice will only increase due to the growing world population, making it more difficult to create high-yielding rice cultivars (Zhang *et al*., 2013). Due to the ongoing development of numerous potential varieties for various rice ecosystems, Bangladesh's farmer-level rice output is growing daily. As a result, this link between farmers and technology has enabled Bangladesh to become self-sufficient in the production of food grains. Around 75% of the total cultivated land and more than 80% of the total irrigated area are planted rice, according to the Bangladesh Rice Research Institute (BRRI). Rice is so essential to the Bangladeshi people's way of life. With only 70.88 million people living in the country in 1971, Bangladesh produced roughly 10.59 million tons of rice overall. Nonetheless, the nation is currently producing roughly 39.1 million tons to feed its about 18.0 million inhabitants. This suggests that rice production increased far more quickly than the population did. In Bangladesh, rice is grown almost all year round in three seasons from April to July, August to December, and January to May.

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These three seasons are known as Aus, Aman, and Boro. In Bangladesh, total cultivating area for *Aman* rice is larger than *Boro* rice but in term of production *Boro* contribute more than *Aman* (BBS, 2024). Bangladesh Institute of Nuclear Agriculture (BINA) has developed some short duration high yielding *Aman* rice varieties which has tremendous effect in agriculture not only aids in removal of poverty but also makes it possible to cultivate the winter/rabi crops after harvest like potato, pulses, oilseeds, winter vegetables and wheat. Among them, Binasail is a late potential rice variety which is perfect to cultivate post flood situation. Binadhan-7 has mitigated Monga from the northern part of Bangladesh, Binadhan-11 and Binadhan-12 both are known as submergence tolerant. Although the studied varieties are developed several years back and the average yield is medium but still are cultivated due to their potentiality. Several investigations have been done regarding yield, fertilizer recommendation and spacing of these varieties. However, there is little information available in Bangladesh about the morpho-physiological traits in terms of yield and yield contribution. Therefore, it is imperative that more study should be done in order to determine and create sustainable technology for growing *Aman* rice in the current local conditions during the *Aman* season. The relationship between chlorophyll content, photosynthesis, and nitrate reductase (NR) activity are complex but all parameters positively correlated with rice growth and yield. Photosynthetic nitrogen use efficiency is higher in rice with reduced chlorophyll content than in normally pigmented plants which increase PSII efficiency, and resulted in higher electron transport rate and improve light distribution in the canopy (Gu *et al.,* 2017). Likewise, nitrate reductase activity can be used as a method of crop yields estimation due to its positive correlation with crop productivity (Putra *et al.,* 2020). Photosynthesis is recognized as one of the most efficient ways to increase nitrogen use efficiency and crop yield have proposed that further increases in crop yield potential will rely in large part on improved photosynthesis (Zhong *et at.,* 2017) Investigating the physiological and anatomical determinants of rice photosynthesis, along with the plant's response to environmental stimuli, is crucial for enhancing rice yield. The photosynthesis process in rice is constrained by their capacity for CO_2 diffusion and the efficiency of their biochemical functions (Evan and Clarke, 2019). Nitrate reductase (NR) is the first enzyme of the nitrogen reduction pathway in plants, leading to the production of ammonia (Berger *et.al.,* 2020). More attention should be paid on the potentiality of variety rather yield alone. For this physiological parameter analysis is crucial to figure out the varietal potential to be sustained with higher yield. The current study was undertaken to compare the performance of morpho-physiological characteristics in relation to yield of these important rice varieties in *Aman* season which can enrich breeder to select parent materials for hybridization process.

Materials and Methods

Four *Aman* rice varieties with medium yield potential (<6 tha^{-1}) *viz*., Binasail, Binadhan-7, Binadhan-11 and Binadhan-12 were selected to evaluate their morpho-physiological characters and yield attributes at three locations, e.g. BINA head quarter, Mymensingh, and BINA sub-stations, Rangpur and Magura. Experiments were set following RCBD design with three replications. Unit plot size was 4m x 3m. Distance between line to line and plant to plant was 20 cm and 15 cm. The experimental area was fertilized with 120, 80, 80, 20 and 5 kg ha-1 of N, P2O5, K2O, S and Zn applied in the form of urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum and zinc sulphate, respectively. The entire amounts of triple super phosphate, muriate of potash, gypsum and zinc sulphate were applied as basal dose at final land preparation. Urea was top dressed in three equal installments i.e., after seedling recovery, during the vegetation stage and at 7 days before panicle initiation. Transplanting was done with 30-days-old seedling. Normal weeding and other cultural practices were done as and when necessary. Chlorophyll content was measured by Chlorophyll Meter SPAD-502Plus KONICA MINOLTA. Photosynthesis ($\mu molCO_2m^{-2}S^{-1}$) rate was measured by LI-6800 Portable Photosynthesis System. Nitrate reductase enzyme (NR) ($\mu g/g$ fresh weight) was estimated according to the method suggested by (Smarrelli and Campbell, 1983). At harvest, 10 hills plot^{-1} were randomly selected for collecting data of plant morphology and yield contributing characters. The plants were separated into leaf, stem and root and the corresponding dry weight were recorded after oven drying at 80 ± 2^0C for 72 hours. Grain yield was finally converted into tha^{-1}. The collected data were subjected to analysis of variance (ANOVA) technique (Gomez and Gomez, 1984) and the mean differences were adjusted with Duncan's Multiple Range Test (DMRT) using the statistical computer package, MSTAT-C (Russell, 1968).

Results and Discussion

Chlorophyll content (SPAD value) showed significant variation in terms of variety and location at different growth stages. Chlorophyll content was higher at initial stage (tillering) and gradually decreased at later stage (grain filling) (Fig. 1). Initial increase was observed and decreased thereafter by Patra *et al.* (2021). All the varieties showed similar trend in case of initial chlorophyll content except Binadhan-7. Binadhan-7 showed higher initial chlorophyll content (42.74). At later growth stages that is flowering and grain filling, Binadhan-11 (39.04) and Binadhan-12 (33.53) showed higher chlorophyll content respectively. All the locations showed similar trend of chlorophyll content at different growth stages due to depending on the age of the plant, the species and the growing season, chlorophyll content in leaf tissues varies (Ramesh *et al.*, 2002). Chlorophyll is positively correlated with photosynthetic rate. In rice, the leaf is metabolically active and critically important in determining yield. It has been assigned an important role in terms of supply of photosynthates to the grains (Suárez *et al.,* 2021). Increased grain yield was observed by Rahman *et al.* (2013) in BRRI dhan34 when chlorophyll was higher. Abou-khalifa *et al.* (2008) also found the similar results. At panicle initiation and flowering stage this value was static for Binadhan-7 and Binadhan-11 and finally decreased significantly.
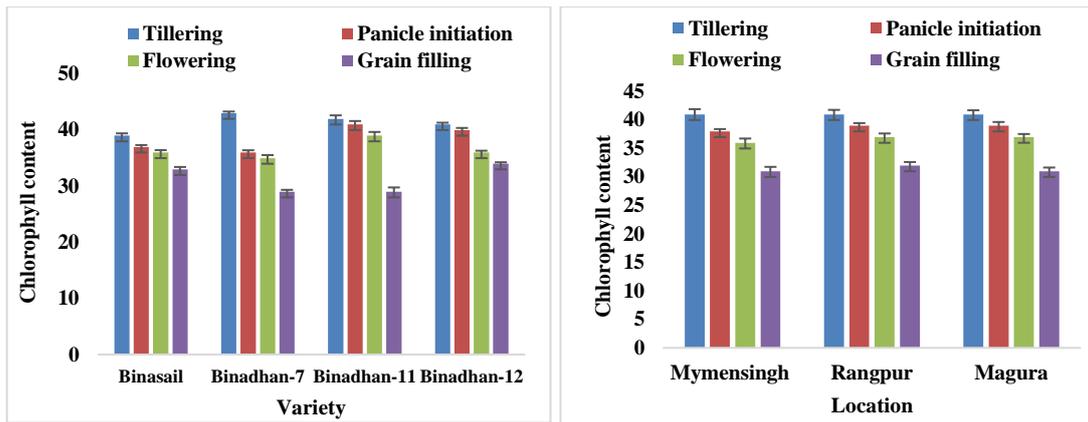
Fig. 1. Chlorophyll content of *Aman* rice varieties with locations at different growth stages

For Binadhan-12 this value was decreased from flowering stage to maturity. The SPAD value was maximum in each growth stage almost appeared for the application of nitrogen @ 150 kg/ha (Wu *et al.,* 2023). Among the locations Magura showed initial increase to decrease the chlorophyll content. Photosynthesis rate showed significant variation among the varieties and locations (Fig. 2). Photosynthesis rate showed higher in tillering and decreased gradually up to grain filling stage. Both varieties and locations showed the similar trends. Among the varieties Binadhan-11 showed the highest photosynthesis rate among the varieties at different growth stages and among the locations Mymensingh showed the highest. Yasmeen *et al*. (2016) also reported the similar results. Photosynthesis rate was initially increased at tillering stage remained the same at panicle initiation to flowering stage (Fig. 2) then decreased at maturity. Photosynthesis in these stages provides the majority of the carbohydrates for grain filling. In these stages flag leaf development is occurred which is important for yield potential by having higher photosynthetic rate (Kalaignan, 2024).
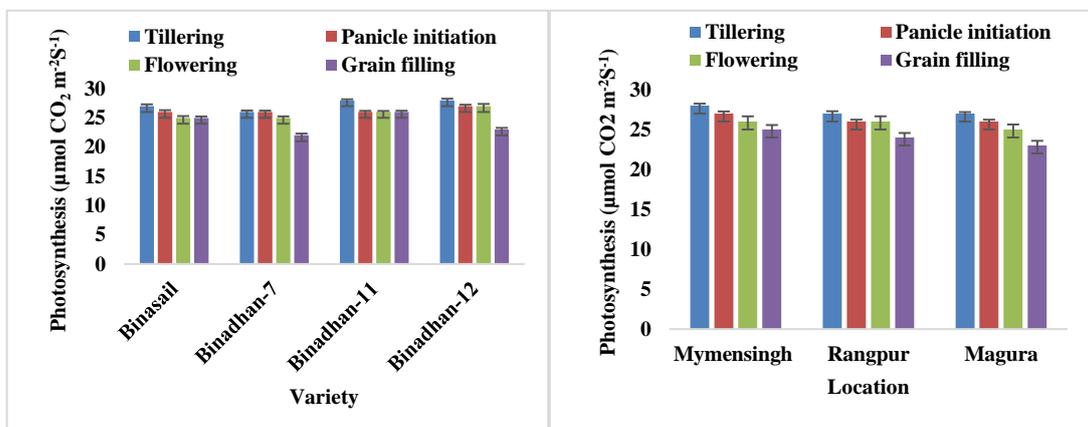

Fig. 2. Photosynthesis rate of *Aman* rice varieties with locations at different growth stages

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In rice, nitrate reductase (NR) plays a crucial role in nitrogen assimilation by catalyzing the reduction of nitrate to nitrite, a vital step in converting inorganic nitrogen into usable forms for plant growth (Gao *et al*., 2019). Nitrate reductase activity among the varieties and locations also showed the similar trends as photosynthesis rate (Fig. 3). The results are in conformity with many authors (Islam, 2022; Islam and Arefin, 2022).

Low level of association was observed between physiological, morphological and yield parameters in case of Binasail while Binadhan-7, Binadhan-11 and Binadhan- 12 showed the highest relationship. Similar trend was reported in cluster analysis of some rice genotypes (Khamraev *et al.,* 2025) in Uzbekistan. Although there is the variation between SPAD, NR, morphology and yield the values between the parameters were more stable might be regiatant to abiotic stress (Patra *et al.,* 2021; Timung and Bharali, 2020).
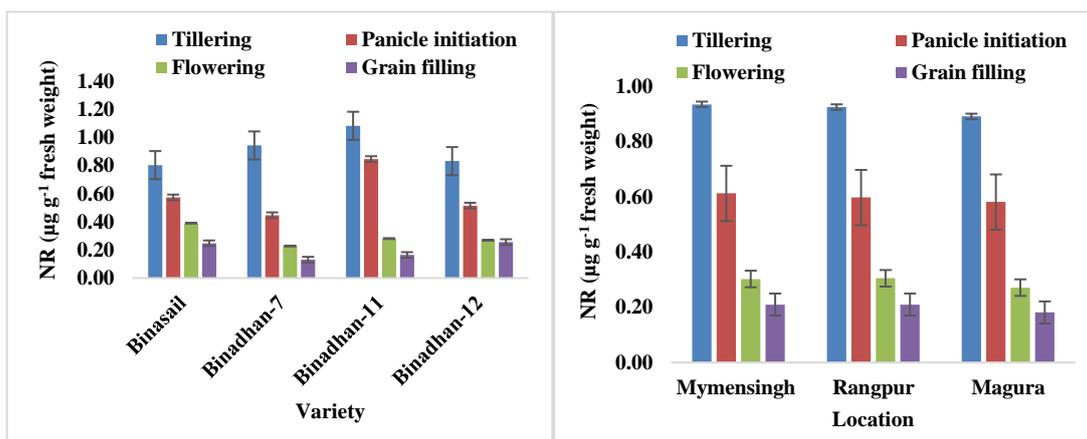

Fig. 3. Nitrate reductase activity (NRA) of varieties and locations at different growth stages

Significant variation was observed in yield and yield attributes among the varieties and locations (Table 1). The highest plant height, total tillers hill^{-1}, effective tillers hill^{-1}, panicle length, filled grain plant^{-1}, 1000-seed weight and straw weight plant^{-1} were observed Binasail (160.1 cm), Binadhan-7 (21.1), Binadhan-7 (20.0), Binasail (24.0 cm), Binadhan-12 (173.0), Binadhan-11 (26.9 g) and Binasail (7.6) respectively. The lowest unfilled grain was observed in Binadhan-12 (10.2). The highest grain yield was observed in Binadhan-7 (5.8 tha^{-1}) followed by Binadhan-12 (5.3 tha^{-1}) and the lowest was observed in Binasail (3.5 ha^{-1}). Awal *et al.* (2007) also observed variation in plant height due to varietal differences. Kabir *et al.* (2004) also observed significant variation among the cultivars. Diaz *et al*. (2000) also found variation in panicle length among the varieties. Among the locations there was no significant difference in terms of plant height, straw yield and grain yield.

Table 1. Effect of variety and location on yield and yield attributes of different rice varieties

Variety	Plant height (cm)	Total tillers hill[-1] (no)	Effective tillers hill[-1] (no)	Panicle length (cm)	Filled grain plant[-1] (no)	Unfilled grain plant[-1] (no)	1000-seed weight (g)	Straw yield (t ha^{-1})	Grain yield (t ha^{-1})
Binasail	160.1 a	17.3 d	14.4 d	24.0 a	110.6 d	24.3 a	21.5 c	7.6 a	3.5 d
Binadhan-7	83.8 b	22.1 a	20.0 a	21.9 b	136.5 b	22.4 b	25.1 b	6.6 c	5.8 a
Binadhan-11	107.1 b	19.4 c	17.7 c	17.8 c	118.0 c	18.7 c	26.9 a	6.7 c	4.7 c
Binadhan-12	100.7 b	20.5 b	18.8 b	17.4 c	173.0 a	10.2 d	16.7 d	7.2 b	5.3 b
F-test	**	***	***	***	***	***	***	***	***
Location									
Mymensingh	112.6	35.9 a	30.8 a	23.5 b	134.4 b	18.1 b	21.3 b	7.0	4.8
Rangpur	110.4	10.3 c	9.9 c	12.8 c	127.0 c	21.4 a	25.0 a	7.1	4.8
Magura	115.7	13.3 b	12.4 b	24.4 a	142.2 a	17.2 c	21.4 b	7.0	4.7
F-test	NS	***	***	***	***	***	***	NS	NS
CV%	16.4	1.7	2.5	1.7	0.6	2.3	2.0	3.0	3.2

The interaction between variety and location had significant effect on yield contributing characters and yield. Plant height was significantly affected by interaction effect between variety and location (Table 2). The tallest plant (165.6 cm) was obtained in Binasail with the location Rangpur and the shortest plant height (55.5 cm) was obtained in Binadhan-7 with the location Rangpur. The highest number of total tillers hill[-1] (41.5), number of effective tillers hill[-1] (36.5) was obtained in Binadhan-7 with the location Mymensingh, respectively. The lowest number of total tillers hill[-1] (9.1), number of effective tillers hill[-1] (8.8) was obtained in Binadhan-11 at the location Rangpur. The longest panicle lengths (26.0 cm) were recorded in Binasail and Binadhan-7 with the location of Mymensingh and Magura,.The shortest panicle length (8.1cm) was obtained in Binadhan-11 and Binadhan-12 with the location of Rangpur. The highest number of filled grain panicle[-1] (197.1) was obtained in Binadhan-12 at Magura and the lowest filled grain panicle[-1] (102.8) was obtained in Binasail at Rangpur location. Minimum number of unfilled grain panicle[-1] (7.0) was obtained in Binadhan-12 and maximum number of unfilled grain panicle[-1] (27.3) was obtained in Binasail with the location of Mymensingh. The 1000-seed weight (27.8 g) was highest in Binadhan-11 and the lowest (14.7g) was found in Binadhan-12 with the location of Mymensingh. The highest straw yield (7.8 tha[-1]) was recorded in Binasail at Rangpur location and the lowest straw yield (6.5 t ha^{-1}) was recorded in Binadhan-7 with the location Magura and Mymensingh. The highest grain yield (7.48 tha[-1]) was recorded in Binadhan-7 with the location Mymensingh on the other hand the lowest grain yield (3.39 tha[-1]) was obtained in Binasail with the location Mymensingh and Binasail with the location Magura respectively. Yield and its contributing traits in rice are influenced by several factors, including genotype, environment, and their interactions (Akter *et al*., 2015; Lee *et al*., 2023; Wang *et al*., 2017).

Table 2. Interaction effect of variety and location on yield and yield attributes of different rice varieties

Interaction	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Panicle length (cm)	Filled grain plant^{-1} (no.)	Unfilled grain plant^{-1} (no.)	1000-seed weight (g)	Straw yield (t ha^{-1})	Grain yield (t ha^{-1})
Binasail x Mymensingh	153.8 ab	29.3d	22.0c	26.1 a	109.8 i	27.3 a	18.7 f	7.7 ab	3.4 e
Binasail x Rangpur	165.6 a	9.9 h	9.3 g	20.0 d	102.8 j	19.6 f	26.7 ab	7.7 a	3.7 e
Binasail x Magura	160.8 ab	12.8 f	12.1 de	26.0 a	119.3 fg	26.0 b	19.0 f	7.4 abc	3.4 e
Binadhan-7 x Mymensingh	94.5 cd	41.5 a	36.5 a	25.4 a	134.7 e	20.8 e	24.9 cd	6.6 ef	5.8 a
Binadhan-7 x Rangpur	55.5 d	11.2 g	10.9 f	14.2 e	137.9 d	24.5 c	26.2 b	6.7 def	5.7 ab
Binadhan-7 x Magura	101.6 cd	13.5 ef	12.6 de	26.0 a	136.8 d	22.0 d	24.3 d	6.4 f	5.7 ab
Binadhan-11 x Mymensingh	103.8 c	36.0 c	32.2 b	20.7 d	120.9 f	17.2 g	27.2 a	6.5 f	4.6 d
Binadhan-11 x Rangpur	116.7 c	9.1 i	8.8 g	8.9 f	117.6 g	27.4 a	25.8 bc	6.6 ef	4.6 d
Binadhan-11 x Magura	100.9 cd	13.1 ef	12.0 e	23.8 b	115.5 h	11.6 i	27.7 a	7.0 cde	4.7 d
Binadhan-12 x Mymensingh	98.5 cd	36.7 b	32.6 b	21.8 c	172.4 b	7.0 k	14.3 g	7.2 bc	5.3 c
Binadhan-12 x Rangpur	104.0 c	11.0 g	10.9 f	8.3 f	149.6 c	14.1 h	21.2 e	7.3 abc	5.4 bc
Binadhan-12 x Magura	99.8 cd	13.8 e	13.0 d	22.0 c	197.1 a	9.4 j	14.7 g	7.1 cd	5.2 c
F-test	**	***	***	***	***	***	***	***	***
CV%	16.4	1.7	2.5	1.7	0.6	2.3	2.0	3.0	3.2

Conclusion

Physiological parameters like chlorophyll content (SPAD value), photosynthesis rate and nitrate reductase activity showed initial higher value and decreased gradually at later growth stage. Binadhan-7 showed higher initial chlorophyll content. Among the varieties Binadhan-11 showed the highest photosynthesis rate at different growth stages. Binadhan-7 showed the highest grain yield for its superior yield contributing characters followed by Binadhan-12. Among the locations Mymensingh showed better performance in terms of yield and yield attributes. Our results indicate that maintaining efficient photosynthetic functioning, chlorophyll content at the tillering from booting and flowering stages is the key to maintain growth and yield for rice.

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