Seed quality of transplanted Aman rice as impacted by rainfed in the ripening phase

Abstract

The aim of the study was to investigate the seed quality of different transplanted Aman rice cultivars that are influenced by rainfed during ripening phases. For this, several experiments have been performed during the transplanted Aman season of 2014, 2015, and 2016 at the Bangladesh Rice Research Institute, Gazipur. Two planting dates and three rice varieties were used in the treatment, and the treatments were organized in a randomized complete block design with three replications.In all the parameters of yield and yield components, the association between planting dates and variety was not significant. Also the relationship between planting dates and variety did not greatly affect the germination percentage, seedling vigor index, high density grain shoot dry weight, and root dry weight. Sixteen august planting produced a greater number of tillers m^{-2}, panicles m^{-2}, grain $panicle^{-1}$, 1000-grain weight, grain and straw yield in the case of yield and yield components. While, the 1000-grain weight of panicles m^{-2}, grain $panicle^{-1}$, was greatly influenced by the variety. The highest 1000 grain weight and grain yield was produced by BRRI dhan46. The SVI, HDG percent, SDW and RDW were greatly influenced by planting dates in terms of seed quality. All of these criteria were higher for planting on 16 August than for planting on 12 September. Varieties were greatly influenced by all the seed quality parameters. BRRI dhan46 received the highest GM percent, SVI, HDG percent, SDW and RDW.

Key words: Rice, seed quality, rainfed and ripening phase.

1.Introduction

About 48 percent of the world's 141 million hectares of rice are estimated to be grown in rainfed areas where insufficient water at one growth stage or another limits yield of rice (Sikuku et al 2010). Approximately 13 percent of the world's 156 million ha of rice is grown under upland conditions as rainfed rice, where moisture stress affects the growth of rice and decreases grain yield and quality (Crosson, 1995; Carlos et al., 2008). Bangladesh has a tropical climate with climatic conditions, such as temperature and rainfall, differing considerably. The country's total area is 14.86 million ha (147,570 square kilometers), and the area under cultivation is 8.52 million ha. While it is not uniformly spread across regions or seasons, the country receives plenty of rainfall. The estimated annual rainfall is about 2,320 mm, varying from 1,110 mm in the northwest to 5,690 mm in the northeast (FAO, 2010). During the monsoon season, most rainfall occurs between mid-June and September. There is very little rain between November and March, and there is pre-monsoon rain with thunderstorms during the time between April and May. In Bangladesh, transplanted aman rice varieties are normally grown in a rainfed environment that covers roughly 48.9% of the total rice area and contributes to 38.14% of the total production of rice (BRRI, 2012). In the Aman season, modern T. Aman varieties cover about 80.5 percent of the rice region (BRRI, 2019).

Drought could be described as the lack of sufficient moisture needed for a plant to grow properly and to finish its life cycle. In rainfed regions, the lack of sufficient moisture leading to drought is a typical phenomenon, induced by rainfall and inadequate irrigation. Drought impacts the growth and productivity of plants and, consequently, decreases rice grain production. The decline in yield can rely on the crop's developmental phase. The sensitivity of rice yield towards ground soil moisture varies with the most vulnerable stage of growth at flowering, followed by the stage of booting and grain filling (O' Toole, 1982).

Drought has been one of the main abiotic restraints in Bangladesh for rice cultivation under rainfed conditions and induces a large yield loss. It is possible to resolve the delay in crop growth caused by water stress at the seedling stage, but water stress at the reproductive stage can cause significant decreases in rice yield. At the reproductive stage or at early ripening stages, transplanted aman typically suffers from water deficit, reducing crop yield phases. With early transplantation on 1 June, a crop growth simulation model showed a yield potential of 7,218 t/ha under low water stress during flowering and maturity process, while high water stress during flowering, maturity and all flowering and maturity phases resulted in a yield reduction of 46 percent, 37 percent and 73 percent respectively (Mahmood et al., 2004).

Water tension disrupts the filling of grains and the quality of rice grains (Sehgal et al 2017 and Britz et al 2007). Water stress decreases grain weight after the flowering stage (Bouman and Tuong, 2001). Boonjung and Fukai (1996) recorded that there was a small impact on subsequent growth and grain yield when drought occurred during vegetative stages. The reduction in yield by up to 30 percent was due to decreased panicle number per unit area and spikelet number per panicle. They also estimated that drought reduced the percentage of filled grains by up to 40 percent at the grain filling point, and decreased the individual grain mass by 20 percent. During grain filling, the impact of stress was also related to its magnitude. At that point, tension hastened maturity. The findings indicate that the variance in yield components due to the availability of water is correlated with the variation in the development of dry matter at specific growth stages. Rahman and Yoshida (1984) suggested that the rate of grain filling was impaired by water tension, decreased yield per panicle of rice by 29-40% in the small-seeded variety IR747(L) and 19-32% in the large-seeded variety PP, R13-12-3. The length of the grain filling had no bearing on it. O'' Toole (1982) stated that the response of rice yield to soil water status varies with growth stage being most vulnerable at flowering, followed by booting and grain filling stage. Due to water stress in the flowering stage, further reduction in grain yield is primarily due to the reduction in fertile panicle and filled grain percentage. The remobilization of accumulated carbon reserves and water deficit during grain-filling increased plant senescence and accelerated grain-filling was also stimulated by water tension. Senescence caused by water deficiency typically shortens the time of grain filling which may result in a decrease in grain weight. Water deficiency-related yield loss after anthesis is attributed to decreased panicle numbers and enhanced sterility (Zeigler et al., 1994). The early stage of grain ripening is the third vulnerable stage and the ripening period is inhibited by drought. In Bangladesh, T.Aman rice is mainly grown in a rainfed state. During November, this crop suffers from drought at the ripening stage.

No adequate information is available on the impact of rainfed in the ripening phase on rice yield and seed quality. This experiment was therefore carried out to investigate the impact of rainfed in the ripening stage on rice yield and seed quality.

2. Materials and Methods

The experiment was performed at the BRRI farm, Gazipur during T. Aman season to examine the seed quality of rice which are affected by rainfed during the ripening phase of 2014, 2015 and 2016. Two planting dates (D_1= 16 August and D_2= 12 September) and three varieties of rice (V_1= BRRI dhan40, V_2= BRRI dhan41 and V_3= BRRI dhan46) were used in the treatment. The treatments were arranged with three replications in a Randomized Complete Block (RCB) design. The plot scale was 4m × 4m. At 20cm × 20cm spacing, thirty days of old seedlings @ three seedlings per hill were transplanted. Fertilizers as N, P_2O_5, K_2O and S were applied @ 80-60-40-10 kg ha-1 from urea, triple super phosphate, muriate of potash and gypsum, respectively. One third of urea and other all fertilizers were applied at the basal. At 15 days after transplanting (DAT) and 7 days before panicle initiation (PI) stage, the rest of the urea was applied in approximately consecutive splits as top-dressed, followed by their integration with the soil. All other cultural operations were conducted for proper crop management as and when appropriate. The weather data was collected from the BRRI Plant Physiology Division. Data on yield and yield components were documented at maturity. The GM%, SVI, HDG%, SDW and RDW of harvested crop seeds were also taken for seed quality performance monitoring.

2.1 Seed Germination (GM%)

Using the standard protocol (ISTA 1985), seed germination experiments were performed with three replicates of 100 seeds in Petri dishes containing two filter papers moistened at 25xC with 7 ml of distilled water. On the seventh day, the first counts of natural germination were taken (abnormal seeds were not considered as germinated). Structures (hulls) covering any ungerminatedfirm seeds were extracted and germination experiments were continued for a further 7 days before final germination counts were taken.

2.2 Seedling vigor index (SVI)

As suggested by Abdul-Baki et al. (1973), it was determined using the following formula, expressed as.

Vigor Index (VI) = Germination (%) x Seedling length (cm)

In order to measure the seedling length, five standard seedlings were randomly chosen from the germination test to measure the seedling length on the tenth day. From the collar area to the tip of the primary leaf, the seedling length was determined. In centimetres, the mean seedling length was expressed.

2.3 High Density grains (HDG)

HDG was measured by soaking the grains in a 1.20 specific gravity salt solution using the gravity salt process (Padmaja Rao et al. 1985). The HD grain index (HDGI) was measured and expressed as a percentage by dividing the number of HD grains by the number of spikelets (Mallik et al. 1990) on main branches (PB), secondary branches (SB) and panicles (P).

2.4 Shoot and Root dry weight

Shoot and root were gathered to establish Shoot dry weight (SDW) and Root dry weight (RDW), put on an oven (65˚C, 72 h) and measured.

2.5 Statistical Analysis

Using the Crop Stat Analysis package, the collected data was analyzed.

3. Results and Discussion

3.1 Yield and Yield Components

The relationship between planting dates and variety was negligible in all the yield and yield variable parameters over the years. Only the key effect has therefore been defined and discussed below:

3.1.1 Effect of planting dates on yield and yield components

The planting dates have had a major impact on yield and yield materials, regardless of the year (Table 1 and 2). Irrespective of year, planting on 16 August resulted in higher numbers of m^{-2} tillers, m^{-2} panicles, panicle^{-1} grain, 1000-grain weight, grain and straw yield. In 12 September planting, the grain yield substantially decreased may be attributed to a decline in rainfall, temperature and solar radiation during the ripening process (Fig. 1 & 2 and Table 3), while rainfall during the vegetative and reproductive phase was higher in 2014 than in 2015 and 2016, but there was no rainfall in all three years during the ripening phase and plants were suffered due to lack of water. This finding agrees with the results of Boonjung and Fukai (1996); Moonmoon and Islam (2017). Effective tillers hill^{-1}, complete spikelets panicle^{-1}, filled grains panicle^{-1}, 1000-grain weight and grain yield hill^{-1} were recorded to be more destructive by drought stress at grain filling (anthesis to maturity), followed by panicle initiation point. This may be attributed to a substantial decrease in the photosynthetic rate resulting in decreased production of panicle and grain filling; consequently, the yield of rice was significantly reduced.

3.1.2 Effect of variety on yield and yield components

Irrespective of year, varieties were severely impacted by panicles m^{-2}, grain panicle^{-1} and 1000 grain weight, but the number of tillers m^{-2} grain and straw yield was not greatly affected (Table 1 and 2). Due to the highest number of m^{-2} panicles, grain panicle^{-1} and 1000 grain weight, BRRI dhan46 gave the highest grain yield.

Table 1. Effect of planting date and variety on tiller number and yield components in T. Aman season of 2014, 2015, and 2016.

Treatments	Tiller m^{-2} (no.)			Panicle m^{-2} (no.)			Grain $panicle^{-1}$ (no.)			1000- grain wt. (g)		
	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015	2016
Planting dates												
16 August	223	229	230	201	198	199	100	96	97	23.77	24.16	23.15
12 Sept	210	205	206	187	183	184	94	89	90	22.58	22.56	22.60
LSD at 5%	2.0	12.95	10.85	3.0	2.27	2.25	5.09	2.51	2.49	1.10	1.06	1.04
Varieties												
BRRI dhan40	218	219	218	194	189	190	93	91	92	22.23	22.30	22.32
BRRI dhan41	216	213	215	195	189	189	96	90	91	23.53	23.68	23.65
BRRI dhan46	217	220	221	196	194	194	97	95	96	23.76	24.13	24.15
LSD at 5%	ns	ns	ns	ns	2.78	2.76	3.02	3.07	3.04	1.35	1.30	1.28

ns=Not significant.

Table 2. Effects of date and variety planting, on rice grain and straw yield during 2014, 2015, and 2016 of T. Aman season.

Treatments	Grain yield (t ha^{-1})			Straw yield (t ha^{-1})		
	2014	2015	2016	2014	2015	2016
Planting dates						
16 August	4.48	4.50	4.49	6.02	6.00	6.02
12 Sept	3.56	3.50	3.49	5.47	5.41	5.43
LSD at 5%	0.48	0.49	0.47	0.63	0.58	0.58
Varieties						
BRRI dhan40	3.96	3.95	3.94	5.67	5.70	5.73
BRRI dhan41	3.97	3.92	3.91	5.65	5.57	5.59
BRRI dhan46	4.13	4.12	4.12	5.90	5.86	5.88
LSD at 5%	ns	ns	ns	ns	ns	ns

ns=Not significant

Table 3. Effects of planting date and variety on the flowering and maturity date in T. Aman season during 2014, 2015, and 2016.

Planting dates	Variety	Date of flowering	Date of maturity
16-Aug	BRRI dhan40	Oct 24±3	Nov 25± 2
	BRRI dhan41	Oct 26± 3	Nov 27± 2
	BRRI dhan46	Oct 29±2	Nov 29± 2
12-Sep	BRRI dhan40	Nov 14± 3	Dec 17± 2
	BRRI dhan41	Nov 12±2	Dec 15±2
	BRRI dhan46	Nov 09±1	Dec 10± 2

3.2 Seed Quality

The relationship between planting dates and variety was not significant for seed quality in every years, such as GM %, SVI, HDG %, SDW and RDW (Table 4 and 5).

3.2.1 Effect of planting dates on seed quality

Planting dates significantly affected the SVI, HDG percent, SDW and RDW, but planting dates did not significantly affect the GM percent. Above these criteria performed well for planting on 16 August than for planting on 12 September. Significantly reduced seed quality (SVI, HDG percent, SDW and RDW) in later planting could be due to decreased rainfall in the ripening period (Fig 1 and Table 3), while GM percent did not decrease significantly.Britz et al (2007) and Sehgal et al (2017) found that water stress interferes with grain filling and rice grain quality.

3.2.2 Effect of variety on seed quality

Variety has a substantial influence on all the parameters. In BRRI dhan46, the highest GM percentage was reported (95.00), followed by BRRI dhan41 and the lowest in BRRI dhan40 (88.83). In BRRI dhan46, the SVI was also the highest and in BRRI dhan40, the lowest. The HDG percent also followed the same pattern as the GM percent and SVI percentage. In BRRI dhan46 (45.0 mg), the SDW was the highest, followed by BRRI dhan40 and the lowest in BRRI dhan41 (39.67 mg).The variety of rice also had a major influence on RDW, but BRRI dhan46 (45.0 mg) was the highest and BRRI dhan41 was the lowest (36.66 mg) (Table 4 and Table 5).

Table 4. Impact of date and variety planting, on seed quality of rice in T. Aman season during 2014, 2015, and 2016.

Treatments	GM%			SVI			HDG%		
	2014	2015	2016	2014	2015	2016	2014	2015	2016
Planting dates									
16 August	93.00	93.00	93.11	1371.97	1306.56	1284.33	86.26	89.94	84.70
12 Sept	91.00	92.00	92.11	1196.68	1152.33	1214.33	82.97	85.43	85.65
LSD at 5%	1.7	ns	ns	145.31	142.46	189.80	2.56	0.61	ns
Varieties									

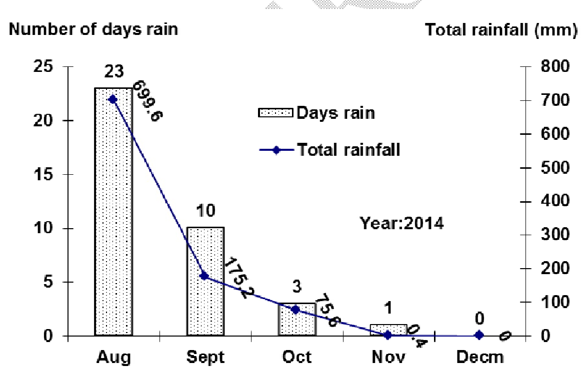
Treatments	GM%			SVI			HDG%		
	2014	2015	2016	2014	2015	2016	2014	2015	2016
BRRI dhan40	88.83	90.66	90.68	1242.97	1208.17	1165.00	82.23	86.99	83.59
BRRI dhan41	92.17	92.50	92.48	1270.68	1214.50	1309.67	84.48	87.34	85.06
BRRI dhan46	95.00	94.66	94.65	1333.73	1265.67	1273.33	87.13	88.72	86.89
LSD at 5%	2.11	2.42	2.40	ns	ns	ns	3.15	0.74	1.46

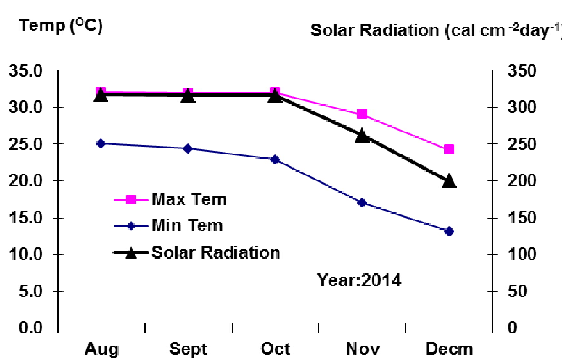
ns=Not significant.

Table 5. Shoot and root dry weight (mg) of 10 days of seedling as impacted by the planting and variety date in the 2014, 2015 and 2016 T. Aman season.

Treatments	Shoot dwt of 10 Seedling (mg) at 10 days old			Root dwt of 10 Seedling (mg) at 10 days old		
	2014	2015	2016	2014	2015	2016
			Planting dates			
16 August	42.46	42.44	35.55	41.78	41.17	35.55
12 Sept	40.47	40.88	50.00	40.04	39.66	48.88
LSD at 5%	1.56	0.83	26.75	1.35	0.81	28.80
			Varieties			
BRRI dhan40	42.58a	41.33	39.87	40.92	40.09	45.00
BRRI dhan41	39.93b	39.67	40.00	41.89	38.47	36.66
BRRI dhan46	42.25a	44.00	45.00	41.42	42.68	45.00
LSD at 5%	1.91	1.02	ns	ns	0.99	ns

ns=Not significant.





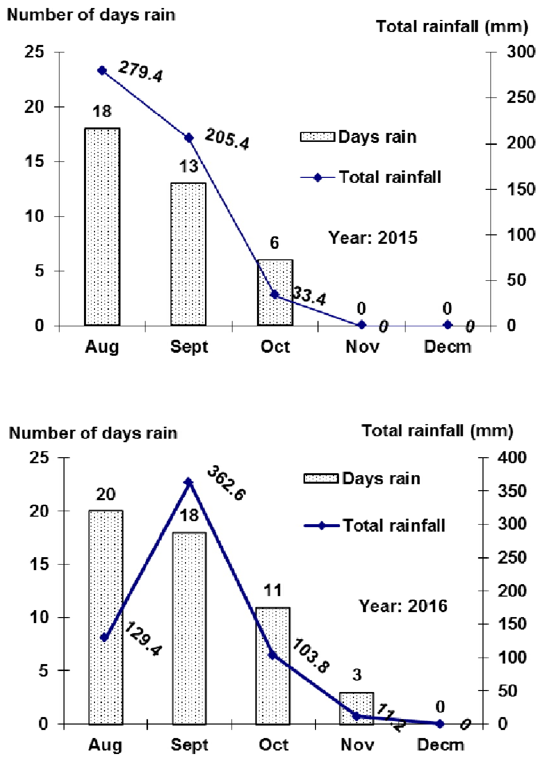


Fig. 1. Monthly number of rainy days and total rainfall during T.Aman 2014,2015 and 2016

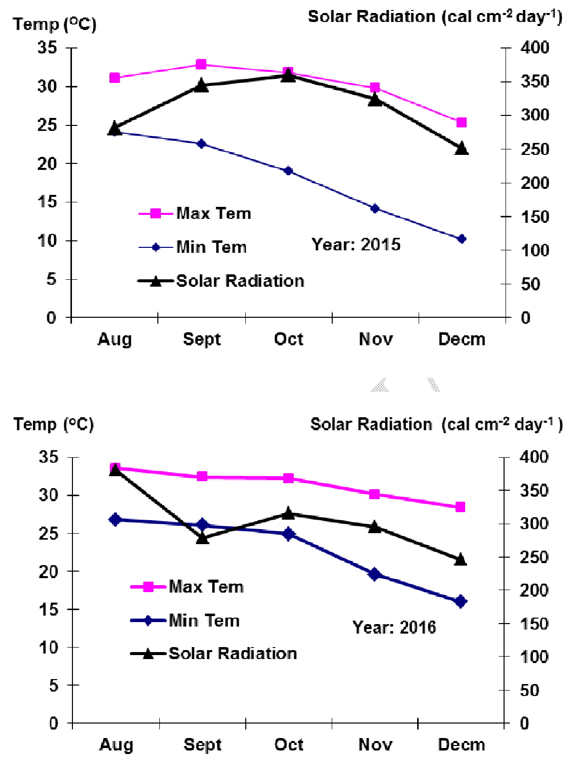


Fig. 2. Monthly temperature and solar radiation during T.Aman 2014,2015 and 2016

4. Conclusion

Planting on August 16 yielded higher grain yields than planting on September 12. BRRI dhan46 was the top yielder among the varieties, compared to BRRI dhan40 and BRRI dhan41. In view of seed quality, 16 August performed better than planting on 12 September. In the case of varieties, the highest in terms of GM %, SVI, HDG %, SDW and RDW was BRRI dhan46.

References

Abdul-Baki A, Anderson JD. Vigor determination in Soybean seed by multiple criteria. Crop Sci. 1973;13(6):630-633.

BBS (Bangaldesh Bureau of Statices). 2018. Yearbook of Agricultural Statistices of Bangladesh. Government of Bangladesh.

BRRI (Bangladesh Rice Research Institute). 2012-13. BRRI Annual Report. BRRI, Gazipur-1701.

BRRI (Bangladesh Rice Research Institute). 2018-19. BRRI Annual Report. BRRI, Gazipur-1701.

Boonjung H and S Fukai. 1996. Effects of soil water deficit at different growth stages on rice growth and yield under upland conditions. 2. Phenology, biomass production and yield. Field Crop Research. Vol 48 Issue 1 pages: 47-55.

Britz, S J, P V V Prasad, R A Moreau, L H jr Allen, D F Kremer and K J Boote. 2007. Influence of growth temperature on amounts of tocopherols, tocotrienols and γ-oryzanol in brown rice. *J. Agric. Food Chem.* 55:7559–7565.

Carlos, A C C, A Orivaldo, P S Rogério and P M Gustavo. 2008. Grain quality of upland rice cultivars in response to cropping systems in the Brazilian tropical savanna. Sci. Agric., (Piracicaba, Braz.), 65(5): 468-473.

Crosson P. 1995. Natural resource and environmental consequences of rice production. In: Fragile Lives in Fragile Ecosystems. Proceedings of the International Rice Research Conference, 13-17 February 1995, Los Banos. International Rice Research Institute, PO Box 933, Manila, Philippines, 83-100.

FAO (Food and Agriculture Organization). 2010. FAOs Information System on Water and Agriculture. http// www.fao.org/nr/water/aquastat/countries_regions/ Bangladesh.

Mahmood R, D R Legates and M Meo. 2004. The Role of Soil Water Availability in Potential Rainfed Rice Productivity in Bangladesh: Applications of the CERES-Rice Model. Applied Geography 24: 139–159.

Mallik, S., A. M. Aguilar, B. S. Vergara, 1990: Inheritance of highdensity grain and its relationship with other panicle characters. Oryza **27**, 437 444.

Moonmoon, S and T Islam. 2017. Effect of drought stress at different growth stages on yield and yield components of six rice (*Oryza sativa* L.) genotype. Fundamental and applied agriculture. 2(3):285-289.

O"Toole, J.C. 1982. Adaptation of rice to drought-prone environments. In: Drought Resistance in Crops with Emphasis on Rice. IRRI, Manila, Phillippines, PP:195-216.

Padmaja Rao, S., B. Venkateswarlu, T. L. Acharyulu, 1985: Screening techniqes for differentiating the degree of spikelet filling in rice. Plant Soil **88**, 289 293.

Rahman, MS and S Yoshida. 1985. Effect of water stress on grain filling in rice. Soil Sci. Plant Nutr., 31(4):497-511.

Sehgal, A, K Sita, J Kumar, S Kumar, S Singh and K H M Siddique. 2017. Effects of drought, heat and their interaction on the growth, yield and photosynthetic function of lentil (*Lens culinaris* Medikus) genotypes varying in heat and drought sensitivity. *Front. Plant Sci.* 8:1776. doi: 10.3389/fpls.2017.01776.

Sikuku P. A., G W Netondo, D M Musyimi and J C Onyango. 2010. Effect of water deficit on days to maturity and yield of three nerica raifed rice varieties. ARPN Journal of Agricultural and Biological Science. 5(3):1-9

Zeigler R.S., S A Leong and P S Teng. 1994. Rice blast disease. IRRI, Manila Philippines. pp. 7-10.