Original Research Article

YIELD PERFORMANCE OF TWO DROUGHT TOLERANT RICE MUTANTS IN BORO SEASON AT TWO SEMI DROUGHT PRONE AREAS OF BANGLADESH

Abstract

Climate change is the biggest challenge for sustainable crop production all over the world, where drought is one of the outrageous factors. Two experiments were conducted to examine the suitability and productivity of drought tolerant two rice mutants cultivating in Boro season. The experiments were consisted of two mutants, derived from NERICA rice variety namely, RM-16(N)-8-1, RM-16(N)-10-1 and one Boro variety BRRI dhan58 and it was conducted at the farmer's field of two semi drought prone areas as Mymensingh and Jamalpur districts of Bangladesh from December, 2021 to May, 2022. The experiments were laid out in Randomized Complete Block Design (RCBD) with three replications. Higher yield (7.01 tha^{-1}) was recorded in the mutant RM-16(N)-10-1 compared to the variety BRRI dhan58 (6.46 t ha^{-1}). Higher days to maturity was found in BRRI dhan58 (151.50 days) compared to the mutants RM-16(N)-10-1 (150.50 days) and RM-16(N)-8-1 (148 days). The highest effective tiller hill^{-1} (25.10) and number of filled grain panicle^{-1} (142.50) were recorded in the mutant RM-16(N)-10-1 where in RM-16(N)-8-1, effective tiller hill^{-1} and number of filled grain panicle^{-1} were 22.88 and 138.92 respectively, and in BRRI dhan58 effective tiller hill^{-1} was 21.56 and number of filled grain panicle^{-1} was 142.46. Higher 1000 seed wt. (23.53 g) was found for RM-16(N)-10-1 compared to other two genotypes. And the maximum yield potential (7.01 tha^{-1}) was recorded in the mutant RM-16(N)-10-1. Furthermore, it will be useful for Bangladesh to choose drought tolerant genotypes with high yield potential and future breeding stock.

Keywords: Genotypes, Mutant, Effective tiller, Fertilizers, Panicle length, Rice yield

Introduction:

"Rice (*Oryza sativa* L.) is one of the most hunger meeting foods for the people of Bangladesh. Around 85% of the cultivable area of Bangladesh is used for rice cultivation with an annual production of 37.61 million tons from 11.71 million ha of land. The average yield of rice in Bangladesh is 2.92 tha^{-1}, which is very low" (BBS 2015). "The agro-climatic conditions of Bangladesh are very much suitable for rice cultivation. But now a day's climatic issue specially drought is one of the majors constrains of rice production. Yield reduction occur due to drought in rice almost 20 percent of total yield loss in our country. The two mutants RM-16(N)-10-1 and RM-16(N)-8-1 were derived from NERICA through Nitrogen Ion Beam radiation technique. However, paddy soil fertility will be enhanced in the coming years due to the pressure of population increment and food demand. Demand of rice would increase around 25% to accord with population growth" (Maclean *et al.* 2002). "Bangladesh is a small country with a large population, current population of Bangladesh is about 169.4 million and at present, population growth is 1.16%" (BBS 2021). "The arc on Bangladesh's land resources to produce more rice will augment in near future due to the increasing population and food demand. High yielding varieties demand a greater amount of fertilizers where nitrogen is where nitrogen is the vital one" (Chang *et al.* 1964). "Future technologies depend on adopting high-yielding cultivars with efficient use of different manures and fertilizers. Bangladesh has three rice-growing seasons, namely Aus, Aman, and Boro. Boro rice is commonly known as winter rice" [Hossain et al. 2021]. According to Lal (2013) Boro rice varieties are cultivated from the month November to May under irrigated conditions. These are mainly photo-insensitive, transplanted in waterlogged, low-lying or medium land with sequel water. "According to the Department of Agriculture Extension, during 2017-2018 total of 48.59 lac hectare lands were used for Boro rice production, which was 8.55% more than 2016-2017 and production was 195.78 lac ton 8.66 percent higher than 2016-2017" (Rakib 2019). Mainuddin (2021) reported that "in Bangladesh, farmers use 48.59 lakh hectare lands for Boro rice cultivation. If RM-16(N)-8-1 and RM-16(N)-10-1 were cultivated in Boro season, it would easy to determine the more productive Boro rice mutant". Information is not available on the cultivation of RM-16(N)-8-1 and RM-16(N)-10-1 in the Boro season. Based on this, our experiment has been undertaken to determine the suitability of RM-16(N)-8-1 and RM-16(N)-10-1 cultivating in Boro season, to know the yield potential and select the suitable one for further evaluation to release as a promising variety.

Materials and Methods

The two mutants RM-16(N)-10-1 and RM-16(N)-8-1 were derived from NERICA-10 through Nitrogen Ion Beam radiation technique at Chiang Mai University in Thailand.

Study location

The experiments were conducted at the farmer's field of Mymensingh (24.75° N, 90.42° E) and Jamalpur (24.93° N, 89.95° E) districts during the period from from December, 2021 to May, 2022 to study the suitability and productivity of RM-16(N)-8-1 and RM-16(N)-10-1 rice mutants cultivating in Boro season.

Table 1. Physio-chemical features of the initial soil (0-15 cm depth)

		Mymensingh	Jamalpur
% sand (0.2-.02 mm)	:	23	40
% silt (0.02-.002 mm)	:	65.5	35
% clay (<0.002 mm)	:	12.5	25
Textural class	:	Silt loam	Loam
PH	:	6.21	5.75
OM (%)	:	1.65	1.45
Total Nitrogen (%)	:	0.11	0.09
Available Phosphorus (ppm)	:	26.05	16.27
Exchangeable Potassium (me %)	:	0.15	0.21
Available Sulphur (ppm)	:	14.00	13.45

Experimental design and data collection

Two advanced lines: RM-16(N)-8-1 and RM-16(N)-10-1, along with BRRI Dhan58 as checks were tested at farmers' field in two locations namely, Mymensingh (Sadar) and Jamalpur (Sadar). The field experiments were laid out in Randomized Complete Block Design (RCBD) with three replications (Gomez, 1984). The size of each unit plot was 5m × 6m (30 m^2). Forty days aged single seedling transplanted in each hill maintaining 20 cm distance between row to row and 20 cm distance between hill to hill. Nitrogen, Phosphorus, Potassium, Zinc, and Sulphur were used as Urea, TSP, MoP, Zinc Sulphate, and Gypsum maintaining the doses as 200 kg ha^{-1}, 100 kg ha^{-1}, 130 kg ha^{-1}, 4 kg ha^{-1} and 75 kg ha^{-1} respectively. The total TPS, MoP, Zinc Sulphate, Gypsum were applied as basal doses. One-third of Urea was applied after seven days of transplanting. The urea was applied at top-dress at two equal slips at 30 days and 45 days after transplanting. To control soil pests and pre-emergence weeds, pesticides and herbicides were applied. Virtako 40WG was applied to control yellow stem borer infestation and Nativo 75WG was used to control blast and sheath blight infection, following recommended doses. Irrigations were done several times when necessary. Data were recorded on the plant height (cm), panicle length (cm), no. of effective tillers $hill^{-1}$, no. of grains $panicle^{-1}$, no filled grains $panicle^{-1}$, no. of unfilled grains $panicle^{-1}$, yield (tha^{-1}) and days to maturity. "MSTAT computer package was used to analyze the mean value of the collected data statistically, using the analysis of variance technique and Duncan's Multiple Range Test (DMRT) was done to adjust the mean differences" (Gomez and Gomez 1984).

Climatic Condition

During the growing period temperature had distinct fluctuations at two locations (Fig. 1). Highest temperature was recorded in Jamalpur 29°C in the month of May 2022 and the lowest temperature was also found at Mymensingh 19.5°C in the month of January 2022. The temperature graph showed the comparative temperature pattern of two locations during growing period. Maximum rain fall was found in Mymensingh (350 mm) in the month of May 2022 and minimum was found at Jamalpur (2 mm) in the month of December 2021 which is a moderately drought prone area.

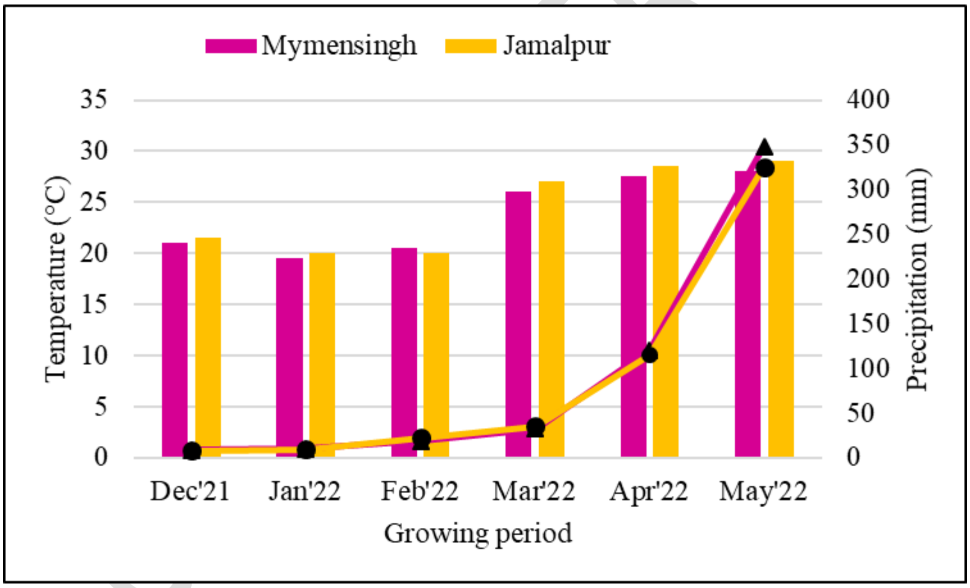

Fig. 1. Comparative temperature and rainfall pattern of two locations during growing period

Results and Discussion

Days to maturity

Significant results were found in days to maturity among the germplasm. Lesser days to maturity was found in 16(N)-8-1 (148 days) compared to the mutants RM-16(N)-10-1 (150.50 days) and BRRI dhan58 (151.50 days) (Table. 1). Lowest maturity period was recorded in Mymensingh (147 days) and Highest at Jamalpur (152 days). Maturity might differ due to genotypic differences which is supported by Ghosh *et al.* (2015), who has recorded variation of days to maturity due to different varieties and Haque *et al.* (2016) reported wide genotypic variation in phenological events among 14 Aus cultivars. The duration also may depend on cultural management, soil and climatic conditions (edaphic factors) which agrees with Ahmed *et al.* (2015).

Plant height (cm)

There was a significant difference among these genotypes for plant height. The highest plant height was observed in BRRI dhan58 (92.55 cm) and the lowest was observed in RM-16(N)-8-1 (85.75 cm) followed by RM-16(N)-10-1 rice mutant (87.80 cm) (Table. 1). Highest plant height was observed at Mymensingh for BRRI dhan58 (97.70 cm) and lowest was recorded also in Mymensigh for RM-16(N)-8-1 (85.30 cm). The difference in the plant height may occur due to different genetic potentials among the genotypes, it is similar to Sarkar (2014) that, variable plant height occurs due to varietal differences.

Panicle length (cm)

Significant results were found in panicle length among the germplasm. RM-16(N)-8-1 had a higher panicle length (16.88 cm) than BRRI dhan58 (12.38 cm) and RM-16(N)-8-1 (13.65 cm) rice mutant. (Table 1). Highest panicle length was observed at Mymensingh for RM-16(N)-8-1 (17.32 cm) and lowest was recorded in Jamalpur for BRRI dhan58 (11.51 cm). The difference in the plant may occur due to genetic character which is similar to Sarkar (2014).

Table 2. Variation in yield and yield contributing characters of the selected rice genotypes

Locations	Genotypes	Days to maturity	Plant height (cm)	Panicle length (cm)	No. of effective tiller hill^{-1}	No. of filled grains panicle^{-1}	No. of unfilled grains panicle^{-1}	1000 seed weight (g)	Grain yield (tha^{-1})
Mymensingh	**RM-16(N)-8-1**	147b	85.3b	17.32a	24.32ab	130.5c	28.43c	24.23a	6.53b
	RM-16(N)-10-1	149ab	87.1b	14.63b	25.75a	141.25a	33.25b	23.24a	7.23a
	BRRI dhan58	152a	93.7a	13.25b	23.28b	133.67b	40.75a	21.83b	6.58 b
Jamalpur	**RM-16(N)-8-1**	149b	86.2	16.43a	21.43b	147.33b	31.67b	22.29ab	6.13
	RM-16(N)-10-1	152a	88.5	12.67b	24.45a	143.75c	28.83b	23.82a	6.79
	BRRI dhan58	151ab	91.4	11.51b	19.83c	151.25a	37.25a	21.73b	6.33
Combined	**RM-16(N)-8-1**	148.00b	85.75c	16.88a	22.88b	138.92b	30.05b	23.26a	6.33b
	RM-16(N)-10-1	150.50a	87.80b	13.65b	25.10a	142.50a	31.04b	23.53a	7.01a
	BRRI dhan58	151.50a	92.55a	12.38b	21.56b	142.46a	39.00a	21.78b	6.46b
	F test	**	**	**	**	**	**	*	**
	CV (%)	3.86	2.89	5.12	4.55	8.47	7.23	2.86	5.52

Same letter (s) in a column indicates do not differ significantly at P≤ 0.05

No. of effective tillers per hill

Maximum number of tillers per hill was recorded in RM-16(N)-10-1 (25.10) and minimum number of tillers per hill was recorded in BRRI dhan58 (21.56) followed by RM-16(N)-8-1 (22.88) (Table 2) which was statistically significant. Maximum no. of effective tillers hill^{-1}

was observed at Mymensingh for RM-16(N)-10-1 (25.75) and the minimum was recorded in Jamalpur for BRRI dhan58 (19.83). In earlier, Jisan *et al.* (2014) reported that variations in the number of tillers per hill occurs due to varietal characters.

No. of filled grains per panicle

A higher number of filled grains was found in RM-16(N)-10-1 (142.50) compared to BRRI dhan58 (142.46) which was statistically insignificant to check variety. Maximum no. of filled grain was found in Jamalpur for BRRI dhan58 (151.25) and minimum in Mymensingh for RM-16(N)-8-1 (130.50). Chowhan (2017) exposed that variation in grain filling may have occurred due to genetic, environmental or cultural management practices.

No. of unfilled grains per panicle

There was a significant difference among these genotypes in the number of unfilled grains per panicle. A higher number of unfilled grains was found in BRRI dhan58 (39.00) compared to RM-16(N)-10-1 (31.04). Maximum no. of unfilled grain was found in Mymensingh for BRRI dhan58 (40.75) and minimum also in Mymensingh for RM-16(N)-8-1 (28.43). Chowhan (2017) exposed that "variation in grain filling may have occurred due to genetic, environmental or cultural management practices". Haque *et al.* (2016) also observed "a wide genotypic variation in phenological traits among 14 Aus cultivars".

1000 seed weight (g)

Both the mutants and variety had significant difference for thousand seed weight where maximum weight was obtained in 16(N)-10-1 (23.53 g), 16(N)-8-1 (23.26 g) and minimum in BRRI dhan58 (21.78). Highest thousand seed were recorded in Mymensingh for 16(N)-10-1 (24.23 g) and lowest in Jamalpur for BRRI dhan58 (21.73). However, it is also an essential factor to differentiate among the genotypes of a large population. Pawar *et al.* (2014) reported that 1000 seed weight of 43 different rice genotypes differed significantly due to their different genetic pattern.

Grain yield (tonnes per hectare)

There was a significant difference between the two varieties in yield performance. According to (Table 1), higher grain yield was observed in the mutant RM-16(N)-10-1 (7.01 tha^{-1}) compared to BRRI dhan58 (6.46 tha^{-1}) and the other mutant 16(N)-8-1 (6.33 tha^{-1}). Highest yield was found in Mymensingh for RM-16(N)-10-1 (7.23 tha^{-1}) and minimum in Jamalpur for RM-16(N)-8-1 (6.13 tha^{-1}) also for BRRI dhan58 (6.33 tha^{-1}). This result was similar to Dutta *et al.* (2002), who observed that yield was affected by the filled grains $panicle^{-1}$. Kiani and Nematzadeh (2012) reported that "filled grains $panicle^{-1}$ was significantly correlated with grain yield".

Correlation among the yield and yield contributing traits

Correlation study indicated that there was a significant positive correlation between number of filled grains per panicle and grain yield. A positive correlation was also found between number of effective tillers per hill and grain yield. A good negative correlation was found in between number of unfilled grains per panicle and thousand seed weight (Fig. 2). Thousand seed weight and grain yield also showed positive correlation. According to Zhao *et al.* (2020) "grain yield was significantly and positively correlated with the plant height, grain number m^{-2}, filled grain number per panicle, filled grain percentage and grain weight".

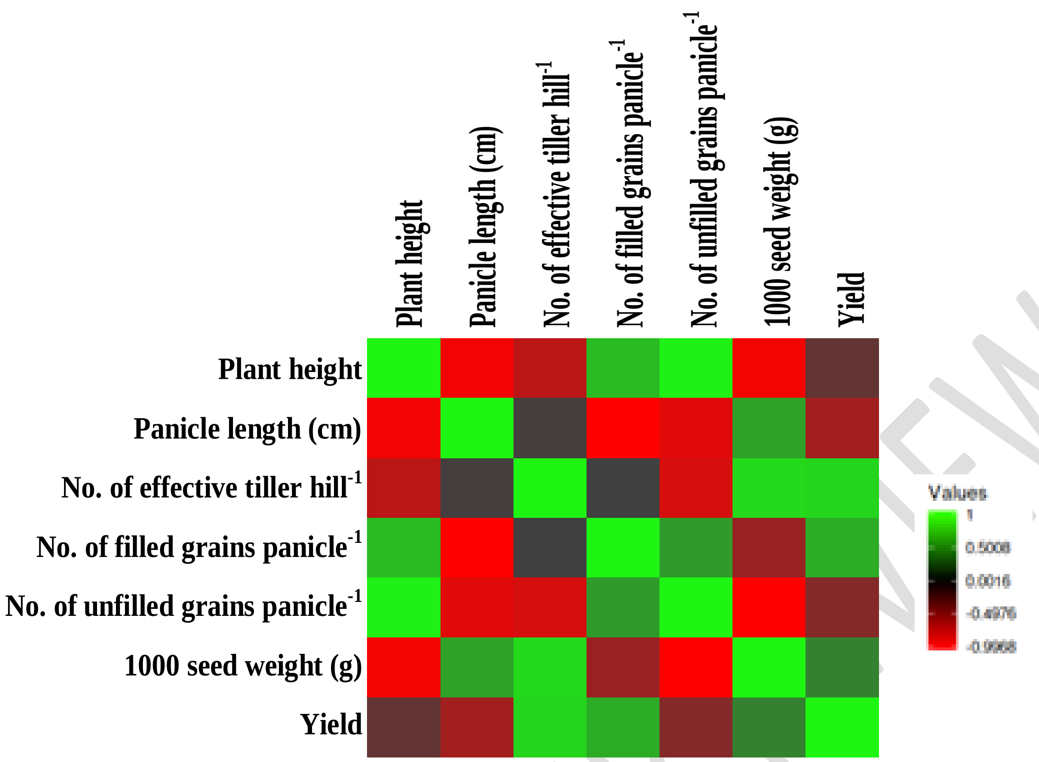

Fig. 2. Correlation among the yield and yield contributing traits of the selected rice genotypes using heatmap

Conclusion

This study revealed that the mutant RM-16(N)-10-1 had a high yield potential compared to 16(N)-8-1 and BRRI dhan58 over two semi-drought prone areas in Bangladesh. Based on the yield performance, RM-16(N)-10-1 could be selected for further evaluation to release it as a promising variety.

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