



## Morphological Characterization of Deepwater Rice Genotypes

**M.M. Emam Ahmed**<sup>1</sup> 

**Md. Maksudul Haque**<sup>2</sup> 

**A.B.M Arif Hasan Khan Robin**<sup>3</sup> 

**Mohammad Anwar Hossain**<sup>4</sup> 

<sup>1</sup>Scientific officer, Plant Breeding Division, Bangladesh Rice Research Institute, Gazipur 1701, Bangladesh

<sup>2</sup>Scientific officer (Golden Rice), Plant Breeding Division, Bangladesh Rice Research Institute, Gazipur 1701, Bangladesh

<sup>3,4</sup>Department of Genetics and Plant Breeding, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh

( Corresponding Author)

### Abstract

The experiments was conducted to study the early establishment morphological characters of advanced deep water rice. The parameters such as plant height, number of leaves, and number of effective & non-effective tillers were studied with different DAS as treatment in field condition. The genotype BR224-2B-2-5, BR5915-B-7, Bazzail-65 & Gabura showed more plant height at 30 DAS & 60 DAS. But HBJ.A.IV & Bazail-65 showed more plant height at 90 DAS & 120 DAS. BR224-2B-2-5 & BR5915-B-7 showed more leaves and tillers at early stage (60 DAS). But HBJ.A.IV & Birpala showed better performance for same characters at later stage (90 DAS, 120 DAS & 150 DAS). The advanced genotype BR224-2B-2-5 is able to establish significantly at early stage as it showed vigorous growth against stress condition present at early stage. HBJ.A.IV and Birpala have potential of producing more leaves and tillers throughout the growth stages and HBJ.A.IV and Birpala is the tall type DWR cultivar as it produced more seedling height and plant height than others. The yield of the genotype BR224-2B-2-5 and BR5915-B-7 are 3.07 t ha<sup>-1</sup> and 2.71 t ha<sup>-1</sup> respectively. Finally, the advanced genotype BR224-2B-2-5 may be a good source to meet the future challenge.

**Keywords:** Morphological, Characterization, Deepwater, Rice (*Oryza Sativa* L.).

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## 1. Introduction

Rice (*Oryza sativa L.*) is the most important and extensively cultivated cereal crops in Bangladesh. Rice has been considered as staple food and about 80% of the total cultivated lands in Bangladesh are used for rice cultivation [1]. Bangladesh is the world's fourth largest rice producer. In the last three to four decades, great efforts in rice research and farming innovations were made to boost rice production. The country's total production has also increased to about 33.3 million tons (milled rice) in 2011 whereas Indonesia, India, and China produced 44.31, 103.8 and 135.1 million tons respectively [2]. Furthermore, rice alone contributes about 9.5 % of the total agricultural GDP in the country. Among all crops, rice is the driving force of Bangladesh agriculture. In fact, food production in Bangladesh is dominated by a single crop (rice) and a single season (Boro, which accounts for over 60% of total rice production) [3].

Rice is considered as major crop in Bangladesh. It is not only the main source of carbohydrate but also provides 69.61% of calories and 56.15% of the proteins in the average daily diet of the people [4]. The rice production also increased steadily along with net food demands (rice & wheat) and reached 32.1 and 33.3 million tons in 2009 and 2010 [2].

Complete submergence annually affects about 16 million ha of rice in South and Southeast Asia, and about one third of the total rice growing area in Africa. The effect of damage caused by transient submergence is dependent on the characteristics of flood waters, including temperature, turbidity, concentration of dissolved gases, and extent of light penetration [5].

Deepwater rice (DWR) is grown in flooded conditions with water more than 50 cm (20 inch) deep. More than 100 million people in South and Southeast Asia rely on deepwater rice for their sustenance. Many districts of Bangladesh are flooded during the rice cultivation season every year and thus, curtail the national rice yield by causing severe damage to the rice cultivated field. Therefore, it is high time to select potential rice cultivars for breeding program to develop submergence tolerant as well as flash flood resistant rice variety [6]. The topographical situation along with availability of water and sub tropical climate constitutes an excellent habitat for rice cultivation in Bangladesh. In fact, there are different rice ecosystems, namely upland (direct seeded pre-monsoon Aus), irrigated (mainly, dry season Boro), rainfed lowland (mainly monsoon season transplanted Aman, medium-deep stagnant water up to 50-100cm) [7].

Rice is a semi-aquatic plant and one of the most important crops cultivated in both tropical and temperate regions. DWR is grown in more than 50 cm water for one month or longer during the cropping season. Based on stature and depth of water, these are of two types: (i) traditional tall, and (ii) floating. Traditional tall cultivars are tall with long leaves, and grown at water depths between 50 and 100 cm; floating rice is grown in 100 cm or deeper situations. In Bangladesh most of the rice grown in the low lying areas during monsoon are floating rice, generally called as deepwater rice, locally known as broadcast aman, jolidhan, poushdhan etc. [8].

In Bangladesh deepwater rice covers an area of 0.48 million ha [7] where there is no other option to cultivate modern T. aman varieties. In haor & beel areas like Sunamganj, Sylhet, Habiganj, B. Baria, Faridpur, Gopalganj and Pabna, local deepwater rice varieties are cultivated which have low yield potential [8].

The depth of water in some areas can exceed 4 m as in floating rice areas. Apparently each of these types of floods requires specific adaptive traits, which necessitates the development of unique varieties [9]. Though DWR is cultivated in small areas with low yield, attention should be given to achieve breakthrough in yield potential. Many advanced lines of DWR having better yield potential have been developed by Bangladesh Rice Research Institute (BRRI).

Screening genotypes at seedling stages have several benefits, such as low cost, ease of handling, less laborious and getting rid of susceptible genotypes at earliest [10]. *In vitro* selection techniques involving the use of Polyethylene glycol (PEG), is one of the reliable methods for screening desirable genotypes and to study further the effects of water scarcity on plant germination indices [11, 12]. PEG is a non-penetrating and non-toxic osmotic substance which can be used to lower the water potential of culture medium [13]. The selected abiotic stress tolerance rice cultivars have a potential of direct introduction in to farmer fields [14] or utilize them in breeding programs to develop abiotic stress tolerance rice cultivars [14, 15].

Early establishment of crop is necessary for DWR to face the flood water throughout the growing season (typically one or two months). The crop established before monsoon begins or floodwater enters can withstand better in raising water level situation. Thus, effective crop growth can boost up total grain production at the end of the season. Crop improvement against moisture stress has been difficult mainly for 1) lack of suitable screening technique that allows large population and 2) complexity in its arrival times and extents, since it occurs with different intensity and extent in different years. Growth study along with different plant structures is of utmost necessity for crop improvement under stress condition. Though DWR area is comparatively low compared to total rice area, there is necessity of working on it because there exist low lying rice areas where it is one and only option during Aman season.

If high yield potential DWR varieties are introduced, there will be significant increase in national rice production. Hence there is need of advanced breeding lines to select for a rice variety suitable for DWR areas. Considering the above facts, the present research studies was undertaken to fulfill the following objectives: To study the osmotic stress tolerance of newly developed advanced DWR genotypes through PEG treatment and to study the extent of variation of growth status of advanced rice genotypes under osmotic stress and actual field conditions.

## 2. Materials and Methods

The experiment was conducted at the Deepwater Rice Field of BRRI, Regional Station, Habiganj during the period of May, 2014 to November, 2014 to characterize seven advanced DWR genotypes morphologically. The experiment was carried at the field of BRRI, Regional Station, Habiganj from April to November in 2014. The site is at 24°5' N latitude and 91°3' E longitude having an elevation of 14 m from the sea level. The soil of the area is acidic

(pH 4.5) and clay type. Texture of the soil is heavy with high organic matter content (3.9%). On average yearly rainfall of that place is 2330 mm. In 2014, the highest temperature recorded in May is 33° C and the lowest in January is 12° C. The range of the on average flooding height is 250-300 cm that occurs in between July to August. The experiment was laid out in a randomized complete block design (RCBD) with three replications. The unit plot size was 5 x 5 m. Flash flood occurs from the last week of April to May and it is one of the highest risks of the haor (depressed) areas.

## 2.1. Experimental Treatments

The experimental treatments were as follows:

### A. Genotypes: 7

- i. BR224-2B-2-5B
- ii. BR5915-B-7B
- iii. Bazail-65
- iv. Gabura
- v. Lal-khama
- vi. Hbj.A.IV
- vii. Birpala

### B. Morphological data on different days after sowing (DAS): 5

- i. 30 DAS
- ii. 60 DAS
- iii. 90 DAS
- iv. 120 DAS
- v. 150 DAS

## 2.2. Design of the Experiment

### 2.2.1. Collection of Experimental Data

Before harvesting according to treatments (30 DAS, 60 DAS, 90 DAS, 120 DAS and 150 DAS) following data was taken:

- i. Plant height (cm)
- ii. Number of leaves plant<sup>-1</sup>
- iii. Number of effective tillers plant<sup>-1</sup>
- iv. Number of non-effective tillers plant<sup>-1</sup>

#### i. Plant height (cm)

The height of five rice plants were measured from the ground level to the tip of flag leaf and mean plant height was recorded in cm.

#### i. Number of leaves plant<sup>-1</sup>

All the leaves present on same sample plants were counted and average data kept on data sheet.

#### ii. Number of effective tillers plant<sup>-1</sup>

All the effective tillers of five randomly selected plants were counted and were averaged.

#### iii. Number of non-effective tillers plant<sup>-1</sup>

All the non-effective tillers of same selected plants were counted and were averaged.

#### iv. Yield (t ha<sup>-1</sup>)

The grain was harvested when the plant reached 80% maturity and yield of each individual plot was estimated at 14% moisture.

## 2.3. Statistical Analysis of Data

The recorded data were compiled and tabulated in proper form for statistical analysis. Analysis for variance was done following the RCBD with the help computer package MSTAT software. The mean differences were compared with DMRT [16].

## 3. Result and Discussion

### 3.1. Response among the Genotypes/Varieties for Different Plant Characters

The mean squares of genotype for plant height, number of leaves, number of effective tillers and number of non-effective tillers are significant indicating the presence of adequate variability among the genotypes for these parameters (Table 1). The results of genotypic responses to different DAS are presented in Table 2 and Figure 1, 2, 3 and 4. The yield data is also presented here to make a justified conclusion to present study (Table 2 and Figure 5).

Table-1. Summary of analysis of variance on some plant characters in field condition

Sources of variance	Degree of freedom	Mean Square				
		Plant height	Number of leaves	Number of effective tillers	Number of non-effective tillers	Yield
Factor A (Genotype)	6	161.39**	438.35**	26.95**	1.02**	0.035**
Factor B (Treatment)	4	80786.10**	9685.06**	669.68**	15.82**	31.851**
AB	24	255.02**	224.77**	12.73**	0.60**	0.035**
Error	68	33.22	26.02	3.52	0.31	0.002

Note: \*\*significant at 1% level of probability

**Table-2.** Mean performance of different genotypes/varieties for different plant characters

Name of the genotype/variety	Plant height (cm)	Number of leaves	No. of effective tillers	No. of non-effective tillers	Yield (t ha <sup>-1</sup> )
BR224-2B-2-5	127.67a	30.07bc	7.0b	0.87 bc	3.07 a
BR5915-B-7	124.53 ab	26.53 c	7.13 b	0.87 bc	2.71 c
Bazail-65	124.73 ab	26.53 c	6.60 b	0.67 c	2.97 b
Gabura	120.53 bc	31.53 b	6.93 b	1.00 abc	2.74 c
Lal-khama	118.73 c	36.33 a	8.07 b	1.2 ab	2.73 c
Hbj.A.IV	119.87 c	39.13 a	9.80 a	1.4 a	2.75 c
Birpala	120.53 bc	38.73 a	9.67 a	1.27 ab	2.30 c
LSD (0.05)	3.95	3.69	1.39	0.39	0.07
S.E(±)	1.40	1.30	0.49	0.13	0.01

Note: \* The values bearing different letters in the same column are significantly different at 5% level of probability

The plant height varied from 118.73 to 127.67 cm and maximum plant height (127.67 cm) was found in the genotype BR224-2B-2-5 whereas minimum plant height (118.73 cm) for Lal-khama (Table 2). In case of number of leaves, the data showed a variation from 26.53 to 39.13 and maximum number of leaves was found in Hbj.A.IV whereas minimum number of leaves in BR5915-B-7 & Bazail-65. The number of effective tillers varied from 9.80 to 6.93 and maximum number of effective tillers was recorded for the genotype Hbj.A.IV whereas minimum number effective tillers for Bazail-65. BR224-2B-2-5, BR5915-B-7, Bazail-65, Gabura, Lal-khama showed no significant difference. The number of non effective tillers, varied from 0.67 to 1.4 and the highest value 1.4 was found in Hbj.A.IV and the lowest value was found for the genotype Bazail-65. In case of yield, the data varied from 2.30 to 3.07 t ha<sup>-1</sup> and the highest yield was obtained from BR224-2B-5-2 (3.07 t ha<sup>-1</sup>) and lowest yield from Birpala (2.30 t ha<sup>-1</sup>) (Table 2).

### 3.2. Response of Genotypes/Varieties at Different DAS

Mean squares due to different treatments (T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub>, and T<sub>5</sub>) were significant (Table 2). The effect of different DAS is shown in Table 3. Among the five treatments T<sub>5</sub> (150 DAS) showed best result as the day increase plant responses significantly with DAS. Plant height and number of leaves were highly significant. In case of number of leaves, number of effective and non-effective tillers there were no significant difference between T<sub>4</sub> and T<sub>5</sub> (Table 3).

**Table-3.** Mean effect of different DAS on plant characters

Different DAS	Plant height (cm)	Number of leaves	Number of effective tillers	Number of non-effective tillers
T <sub>1</sub> = 30 DAS	35.52 e	4 d	0.0 d	0.0 c
T <sub>2</sub> = 60 DAS	100.62 d	16.72 c	4.52 c	0.28 c
T <sub>3</sub> = 90 DAS	119.91 c	39.28 b	8.85 b	1.19 b
T <sub>4</sub> = 120 DAS	153.43 b	50.76 a	12.62 a	1.81 a
T <sub>5</sub> = 150 DAS	202.38 a	52.67 a	13.42 a	1.91 a
LSD (0.05)	3.34	3.12	1.17	0.33
S.E. (±)	1.12	1.12	0.41	0.12

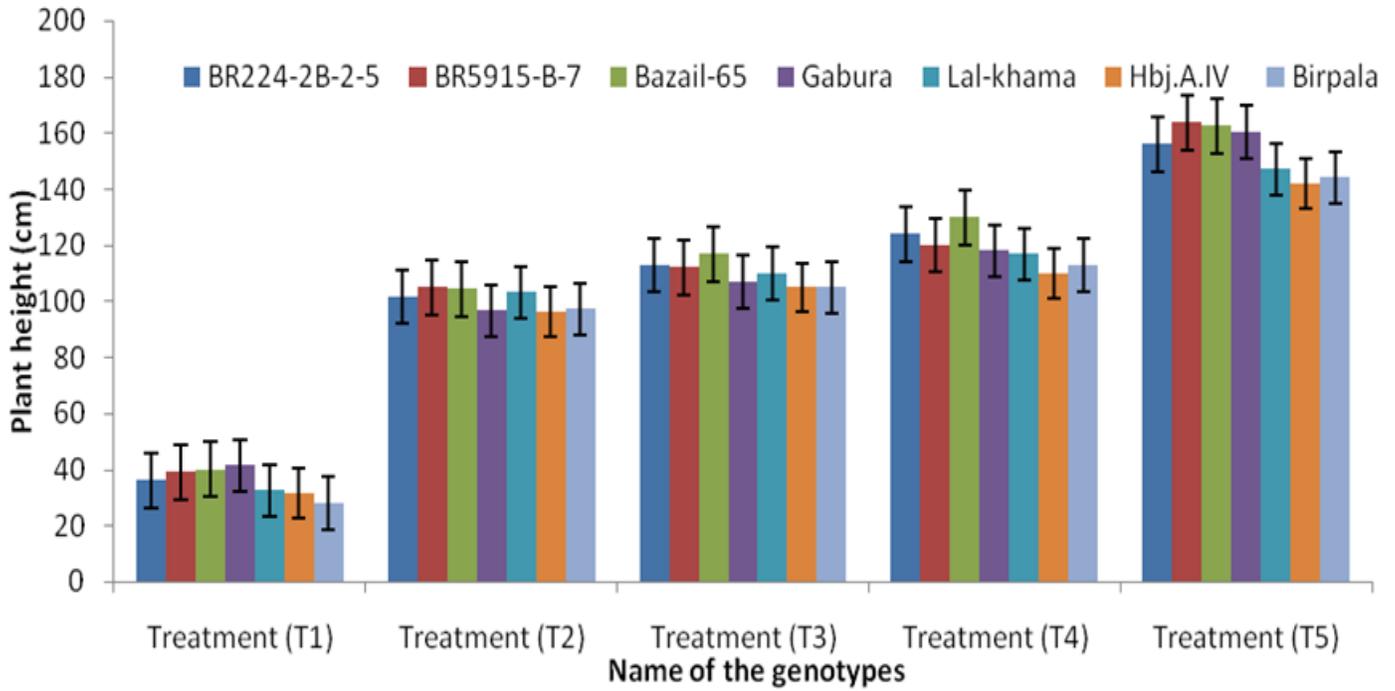
Note: \* The values bearing different letters in the same column are significantly different at 5% level of probability

### 3.3. Effects of Genotype X DAS Treatment on Plant Characters

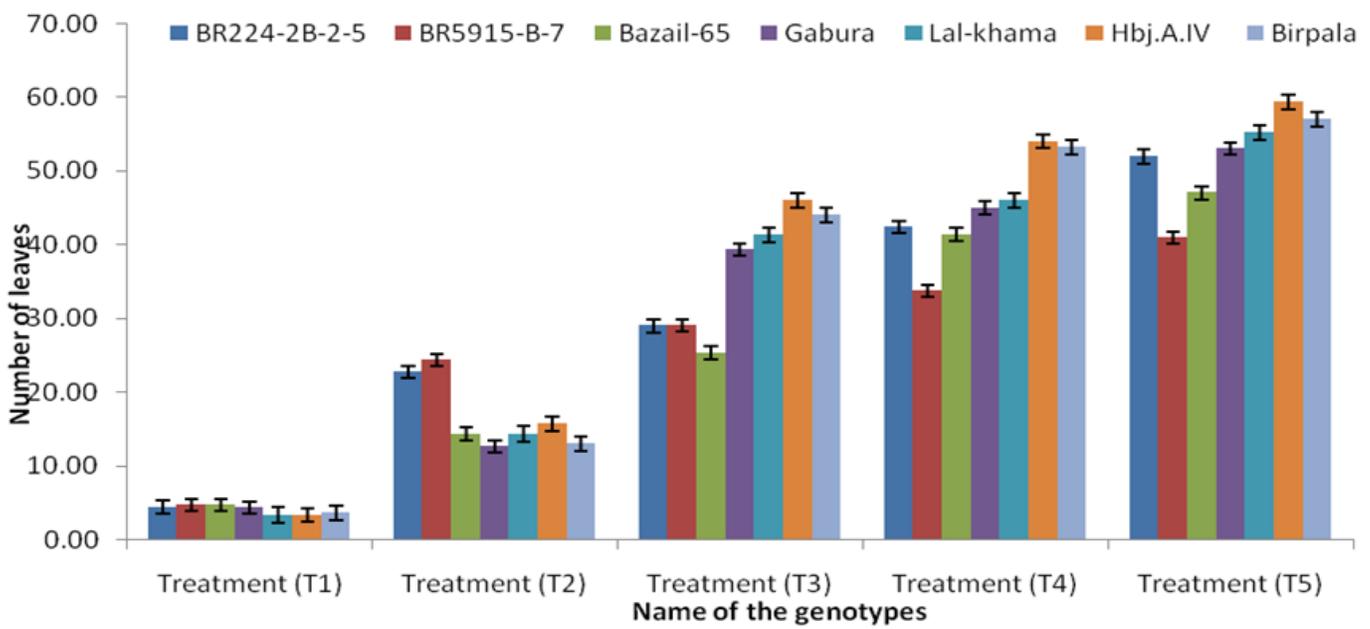
Mean squares due to interaction (variety x treatment) were significant (Table 4.5). Interaction effects of genotype and treatment (DAS) on plant characters are presented in Figures 1, 2, 3, and 4. The genotypes BR224-2B-2-5, BR5915-B-7, Bazail-65, and Gabura showed maximum plant height at T<sub>1</sub> and T<sub>2</sub> but HBJ.A.IV and Bazail-65 showed maximum plant height at T<sub>3</sub> and T<sub>4</sub> (Figure 4.8). In case of number of leaves all the genotypes were same at T<sub>1</sub> but BR224-2B-2-5, and BR5915-B-7 recorded the highest number of live leaves at 60 DAS (T<sub>2</sub>) (Figure 4.9). HBJ.A.IV and Birpala showed more leaves at T<sub>3</sub>, T<sub>4</sub>, and T<sub>5</sub> (Figure 2). No tiller was observed at 30 DAS (T<sub>1</sub>). BR224-2B-2-5, and BR5915-B-7 showed maximum effective tillers at 60 DAS (T<sub>2</sub>) (Figure 4.10). Like number of leaves HBJ.A.IV and Birpala showed maximum effective tillers at T<sub>3</sub>, T<sub>4</sub>, and T<sub>5</sub> (Figure 2 & 3). The cultivar Gabura showed more non-effective tillers at T<sub>3</sub> but HBJ.A.IV showed more number of non-effective tillers at T<sub>4</sub> and T<sub>5</sub> (Figure 4). The genotypes BR224-2B-2-5, BR5915-B-7, Bazail-65, and Gabura showed maximum plant height at 30 DAS and 60 DAS. HBJ.A.IV and Bazail-65 showed maximum plant height at 90 DAS and 120 DAS (Figure 4.8). In case of number of leaves all the genotypes were same at 30 DAS. BR224-2B-2-5, and BR5915-B-7 showed maximum leaves at 60 DAS (T<sub>2</sub>) but HBJ.A.IV and Birpala showed maximum leaves at later stages (120 DAS and 150 DAS) (Figure 4.9). No tiller was observed at 30 DAS (T<sub>1</sub>), BR224-2B-2-5 and BR5915-B-7 showed maximum effective tillers at 60 DAS (T<sub>2</sub>) (Figure 4.10). Like number of leaves HBJ.A.IV and Birpala showed maximum effective tillers at later stages (120 DAS and 150 DAS) as shown in Figure 4.9 and 4.10. Sanchez, et al. [17] reported that taller rice plants produce fewer tillers than shorter plants which are similar to the present study. Ashfaq, et al. [15] also observed that plant height and number of tillers are essential traits in boosting yield performance.

### 3.4. Yield Performance

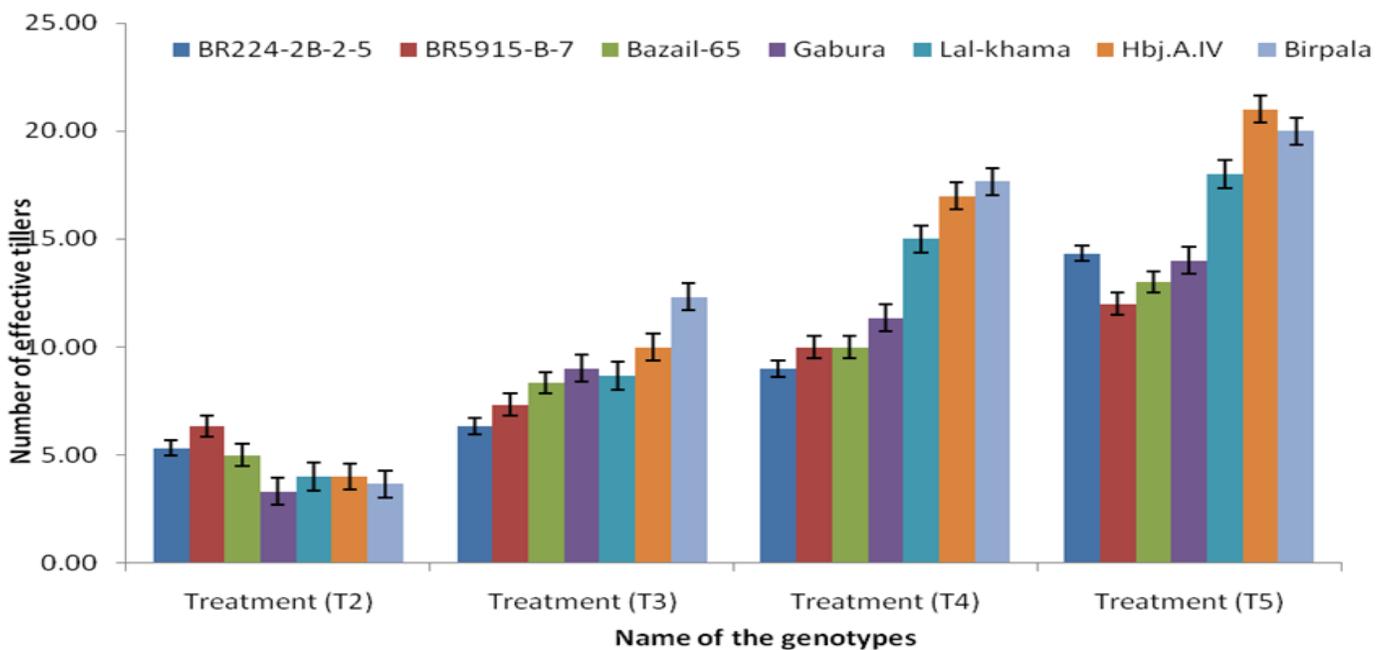
After yield estimation of seven deepwater genotypes it was found that BR224-2B-2-5 has the highest yield performance (3.07 t ha<sup>-1</sup>) and Birpala showed the lowest yield (2.30 t ha<sup>-1</sup>) among all the genotypes (Table 3 and Figure 5). The yield also varied significantly in relation to different genotypes and the highest yield was found for the genotype BR224-2B-2-5 (3.07 t ha<sup>-1</sup>) and lowest for Birpala (2.30 t ha<sup>-1</sup>) (Table 3). Similar results were reported by several authors [18, 19] to describe yield potentiality of rice in a continuously flooded ecosystem.



**Figure-1.** Plant height of different rice genotypes at different treatments. Mean ( $\pm$ SE) was calculated from three replicates from each treatment. T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub> and T<sub>5</sub> indicate 30 DAS, 60 DAS, 90 DAS, 120 DAS and 150 DAS respectively. Bars with different letters are significantly different at P<0.05 applying LSD test.



**Figure-2.** Number of leaves of different rice genotypes at different treatments. Other details as in Figure 4.8



**Figure-3.** Number of effective tillers of different rice genotypes at different treatments. Other details as in Figure 4.8

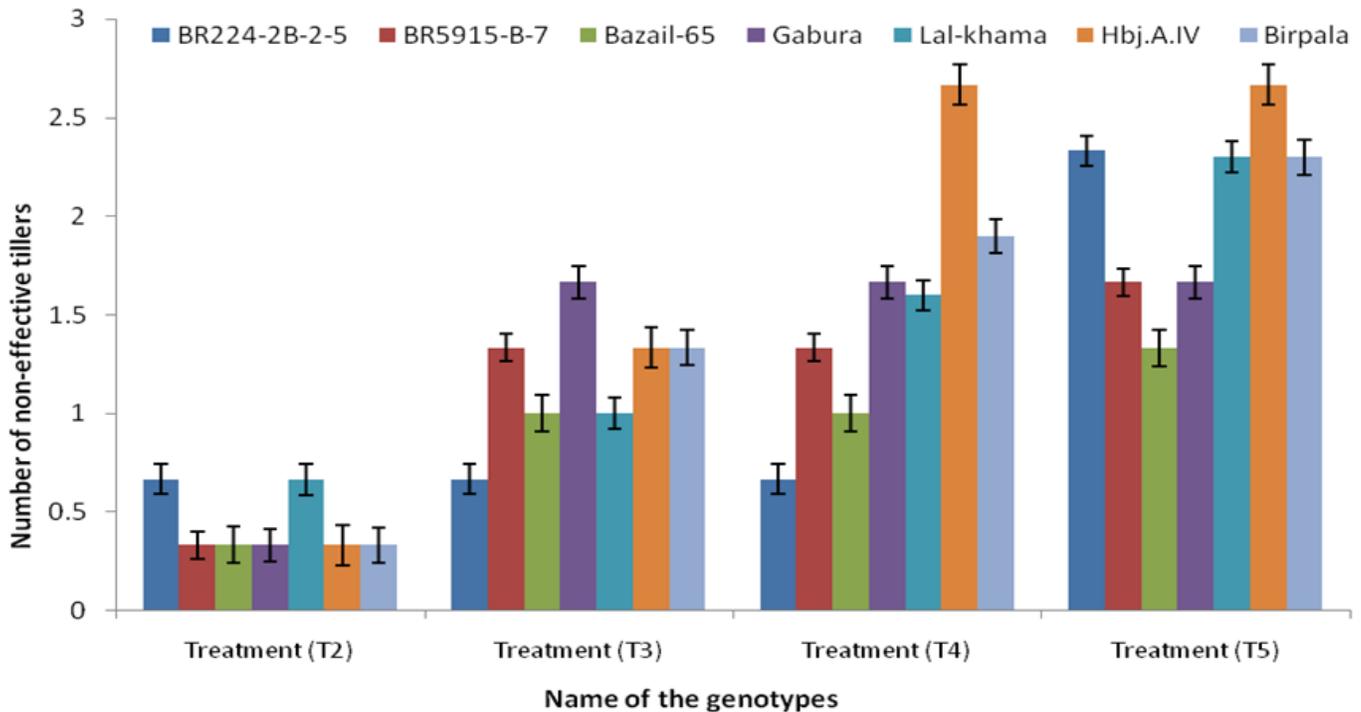


Figure-4. Number of non-effective tillers of different rice genotypes at different treatments. Other details as in Figure 4.8.

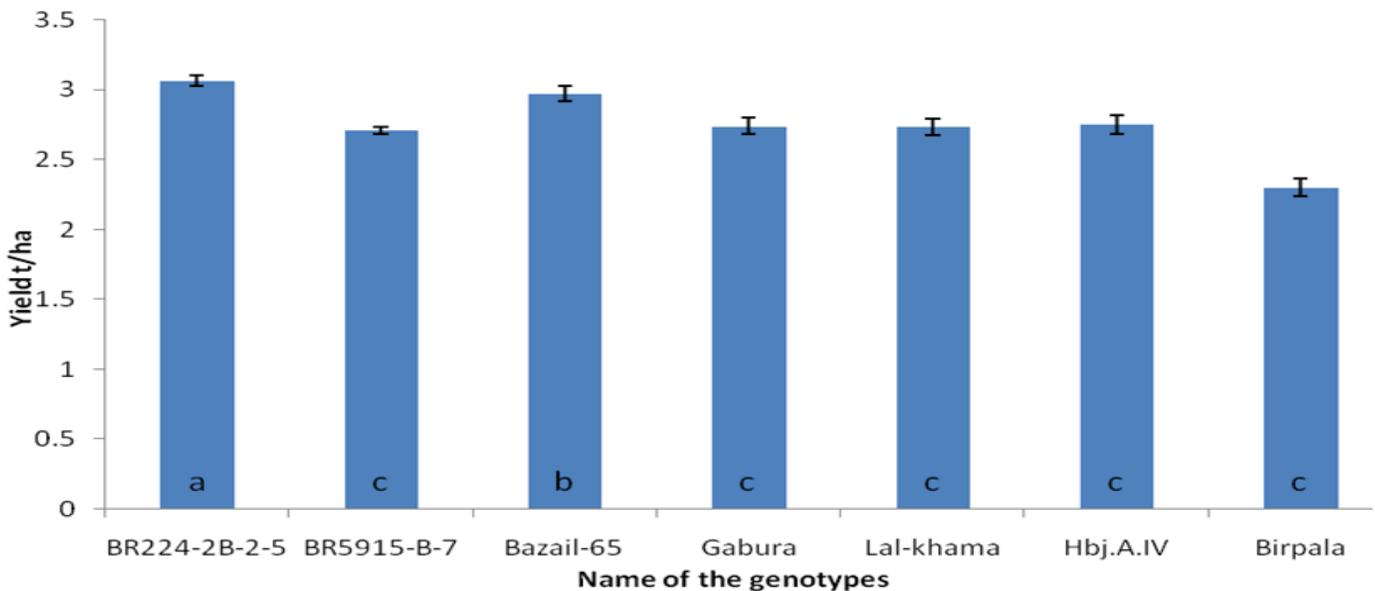


Figure-5. Mean yield of different rice genotypes. Mean ( $\pm$ SE) was calculated from three replicates. Bars with different letters are significantly different at  $P < 0.05$  applying LSD test.

#### 4. Conclusion

In the study, seven advanced DWR genotypes were grown at field condition to evaluate their yield and yield contributing characters. The results indicated that advanced genotypes BR224-2B-2-5, BR5915-B-7, and Bazail-65 showed early growth status in case of plant height, number of leaves, and even number of tillers. But later on, HBJ.A.IV and Bazail-65 recorded the highest plant height at T<sub>3</sub> (90 DAS) and T<sub>4</sub> (120 DAS). In case of number of leaves BR224-2B-2-5 and BR5915-B-7 has maximum number of leaves and tillers at 60 DAS. But HBJ.A.IV and Birpala showed more leaves and tillers at later stages (T<sub>3</sub>, T<sub>4</sub> and T<sub>5</sub>). The cultivar Gabura showed more non-effective tillers at early (T<sub>3</sub>) but HBJ.A.IV showed more number of non-effective tillers at T<sub>4</sub> and T<sub>5</sub>. The highest yield was found for the genotype BR224-2B-2-5 (3.07 t ha<sup>-1</sup>) and the lowest for Birpala (2.30 t ha<sup>-1</sup>). We summarize that the advanced genotype BR224-2B-2-5 is able to establish significantly at early stage as it showed vigorous growth against stress condition present at early stage. HBJ.A.IV and Birpala have potential of producing more leaves and tillers throughout the growth stages and HBJ.A.IV and Birpala is the tall type DWR cultivar as it produced more seedling height and plant height than others. The yield of the genotype BR224-2B-2-5 and BR5915-B-7 are 3.07 t ha<sup>-1</sup> and 2.71 t ha<sup>-1</sup> respectively. Finally, the advanced genotype BR224-2B-2-5 may be a good source to meet the future challenge.

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