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# Evaluation of Some HYV Boro Rice Varieties for Drought Tolerance Based on Morpho-Biochemical Traits

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**ABSTRACT**

An experiment was conducted to study the drought tolerance in selected boro rice varieties in pots at the Farm Research Laboratory of Dept. Genetics and Plant Breeding, Bangladesh Agricultural University, Mymensingh in Rabi season of 2014-2015. In this experiment, drought was induced by manipulating the field capacity (30-35% FC as drought, 95-100% FC as control) and moisture content of the soil in the pot. Drought treatment was started 36 days after transplanting and continued till harvest. The work was comprised based on several morphological and biochemical approaches *viz*. days to 50% flowering, plant height, panicle length, no of total tillers hill$^{-1}$, no of effective tiller hill$^{-1}$, days to maturity, no of filled grains panicle$^{-1}$, no of unfilled grains panicle$^{-1}$, grain panicle$^{-1}$, 100 seed weight, grain yield panicle$^{-1}$, yield hill$^{-1}$, spikelet fertility, proline and L-ascorbic acid were found to be changed significantly in drought stress as compared to the control. In drought conditions, the highest yield performance was showed in BRRI dhan29 by changing 33.11% compared to its control. Due to drought induction proline accumulation was significantly upregulated by 2.53 and 2.10 folds in BRRI dhan36 and BINA dhan5, respectively and L-ascorbic acid was decreased lowest in BINA dhan10, BRRI dhan50, and BRRI dhan29 by 27.29%, 41.31%, and 43.91%, respectively. This study produced substantial information about the drought tolerance status of the selected boro rice varieties, and therefore, can be an aid for any future attempt to improve the drought tolerance of the studied varieties.

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## INTRODUCTION

Rice is the most dominant crop in Bangladesh which covers about 77% of the total cropped area and grown in all the three cropping seasons of the year (Ahmed *et al*., 2013). The economy of Bangladesh is remarkably influenced by rice and it was grown in about 11.70 million hectares of land with total production of about 37.96 million tons of yield (FAO, 2022). The population of Bangladesh is still growing by two million every year and may increase by another 30 million over the next 20 years. Thus, Bangladesh will require about 57.26 million tons of rice by the year 2020 (BRRI, 2011). To reach the goal, it is necessary either to increase the crop area or to increase yield per unit area. But due to high population pressure, horizontal expansion of land is not possible. Therefore, increasing yield per unit area is the only means. Among different rice groups of Bangladesh, *Boro* is the most important that covers an area of 4.72 million hectares with a production of 13.73 million tons of grains (BBS, 2011). But water stress or drought is the main problem in boro rice production in Bangladesh. To overcome this problem, development of drought tolerant boro rice variety is prioritized over the years.

Drought is a major abiotic stress that limits rice productivity in rainfed and upland ecosystems (Bimpong *et al*., 2011). Worldwide, drought affects approximately 27 million hectares of rainfed area (IRRI, 2011). Drought reduces the yield by 15 to 50 percent depending on the stress intensity and crop growth period at which the stress occurs in rice (Srividhya *et al*., 2011). Developing high yielding and drought resistant varieties for rainfed area is priority for improving rainfed rice production. However, plant response to drought stress is one of the most complex biological processes, and it involves numerous changes at the physiological, cellular, and molecular levels. The effect of drought on rice plants considerably varies with genotypes, developmental stages, duration and degree of drought stress (Wang *et al.* 2011).

Physiological and biochemical basis of yield gap between drought stress and irrigated condition has not been studied extensively (Abid *et al*., 2018). Understanding of physiological and biochemical mechanisms that enable plants to adapt to water deficit, maintaining growth and productivity during stress period could help in screening and selection of tolerant genotypes in breeding program (Zaharieva *et al*. 2001). It has been suggested that accumulation of proline contributes to maintain proper balance between extra and intra-cellular osmolality under condition of water stress (Madhusudan *et al*., 2002). Although, ascorbic acid plays an important role in the metabolism of plants, but drought resistant plants contained higher ascorbic acid than the susceptible varieties (Anwar, 1986). Therefore, along with morpho-physiological traits, proline and ascorbic acid content can be considered as effective criteria to evaluate rice genotypes for drought stress. In this context, the objective of the present study was to evaluate and identify boro rice genotypes having high yield potential and tolerance status under drought stress conditions, particularly at reproductive stage by analyzing drought tolerant parameters and to investigate the effect of drought stress on physio-morphological and biochemical traits associated with drought tolerance.

## MATERIALS AND METHODS

### Plant materials

Ten popular boro rice varieties namely BR14, BR16, BRRI dhan29, BRRI dhan36, BRRI dhan45, BRRI dhan47, BRRI dhan50, BINA dhan5, BINA dhan10 and BINA dhan14 were used in this study.

### Experimental site and time

The experiment was set at the Farm Research Laboratory of Dept. of Genetics and Plant Breeding, Bangladesh Agricultural University, Mymensingh during the period of during the period from December’2014 to May’2015.

### Preparation of pots and plant culture

A total number of 120 pots having the diameter of 50 cm and 30 cm depth were collected from the local market and cleaned. The collected soils were dried under the sun. Clods were broken, and weeds and stubbles were removed. The soil was then properly manured and fertilized following recommended dose. Pots were then filled with soil (8.3 kg per pot) and tested for 100% field capacity with 2.8 L water. Thirty-five days old seedlings were then transplanted pot, maintaining 3 plants per pot, with three replications in RCB design.

### Induction of drought stress

Drought stress was induced by manipulating the filed capacity of the soil in pot from 36 days of transplanting till harvesting according to procedure followed by Samarah *et al*. (2005). For inducing drought stress, 840 mL of water was added at 72 hours interval to keep 30-35% field capacity *i.e.* drought stress, whereas, 2.8 L water was added regularly at 72 hours interval to keep 95-100% field capacity *i.e.* optimum as considering as control. During rainy day the pots were covered with transparent polythene sheet to avoid the pouring of rainwater.

### Harvesting and collection of morphological data

The genotypes were harvested after 122 days of transplanting and morphological data on days to 50% flowering, plant height, panicle length, no of total tillers hill$^{-1}$, no of effective tiller hill$^{-1}$, days to maturity, no of filled grains panicle$^{-1}$, no of unfilled grains panicle$^{-1}$, grain panicle$^{-1}$, 100-seed weight, grain yield panicle$^{-1}$, yield hill$^{-1}$ and spikelet fertility were recorded.

### Estimation of proline and L-ascorbic acid

The 1$^{st}$ and 2$^{nd}$ leaves descending from the flag leaf of ten rice genotypes were collected at the panicle initiation stage. For composite sampling, collection was made from each plant of the individual pot. Immediately after collection, the leaf samples were partially macerated in cold condition and freeze-dried at the Biotechnology lab, BINA in -80 $^{o}$C refrigerator. Freeze-dried samples were ground properly and subjected to analysis for Proline. Proline content of leaves was determined according to the method developed by Bates *et al.* (1973). L-ascorbic acid was determined from fresh leaf immediately after collection. L-ascorbic acid was extracted with 6% Metaphosphoric acid from the leaf of rice was estimated by titrimatric method (Reo, 1954). Both the Proline and L-ascorbic acid extraction and estimation were done at the Dept. of Biochemistry and Molecular Biology

### Statistical Analysis

MSTAT-C was used for analyzing the data. Data management and graph preparation were done using MS Office Excel®

## RESULTS AND DISCUSSION

### Morphological performance of rice genotypes in drought stress

The analysis of variance revealed that the genotypes under study differed significantly even at 1% level of probability for all the quantitative characters under study (Table 1). The mean performances of ten rice genotypes for their morphological characters are shown in Table 2.

#### *Days of 50% flowering*

Flowering time is an important trait related to drought adaptation, where a short life cycle can lead to drought escape (Araus *et al*., 2002). BINA dhan10 showed the highest days of 50% flowering, whereas BRRI dhan45 took lowest days of 50% flowering. Under drought condition, days to 50% flowering of most of the varieties was decreased with a higher reduction in BR16 (13.87%) compared to the control (Figure 1). Due to impose of drought stress, BRRI dhan45 took only 115.50 days to mature.

#### *Plant height*

In rice breeding, lower plant height is desirable because of avoiding strong wind in the field and more transpiration loss under drought stress (Kumar *et al*., 2007). BRRI dhan36 showed the lowest plant height which is desirable. The plant height was decreased under drought stress compared to the control plant (Figure 1).

**Table 1.** Analysis of variance (mean square) of 15 characters of 10 rice genotypes

| Traits | Source of variation | | | | |
|---|---|---|---|---|---|
| | Replication | Genotypes(A) | Treatment(B) | A*B | Error |
| df | 2 | 9 | 1 | 9 | 38 |
| Days of 50% flowering | 0.117 | 588.63** | 1622.4** | 53.844** | 2.538 |
| Plant height (cm) | 6.431 | 971.733** | 1955.104** | 32.29** | 4.38 |
| Panicle length (cm) | 0.407 | 27.443** | 356.241** | 3.234** | 0.567 |
| No. of total tillers/plant | 0.45 | 43.23** | 1480.067** | 21.03** | 1.082 |
| No. of effective tillers/plant | 0.817 | 33.407** | 1126.667** | 19.037** | 0.975 |
| Days to maturity | 2.317 | 283.526** | 2184.067** | 7.252$^{NS}$ | 4.369 |
| No. of filled grains/panicle | 6.05 | 5421.817** | 25502.82** | 167.52** | 12.103 |
| No. of unfilled grains/panicle | 10.48 | 202.75** | 198.017** | 67.831** | 5.821 |
| No. of grains/panicle | 13.217 | 5922.993** | 30826.67** | 381.037** | 18.62 |
| 100 seed weight (g) | 0.001 | 0.443** | 0.98** | 0.011** | 0.001 |
| Grain yield/panicle (g) | 0.004 | 1.713** | 20.557** | 0.052** | 0.002 |
| Yield/hill (g) | 3.119 | 313.588** | 12210.27** | 71.065** | 2.465 |
| Spikelet fertility (%) | 2.769 | 193.321** | 563.776** | 25.084** | 4.537 |
| Proline (mg/100g) | 0.023 | 33.327** | 552.067** | 55.716** | 0.823 |
| Ascorbic acid mg/100g) | 0.022 | 8.993** | 155.429** | 1.856** | 0.109 |

** and ns indicate significant at 1% level of probability and non-significant, respectively.

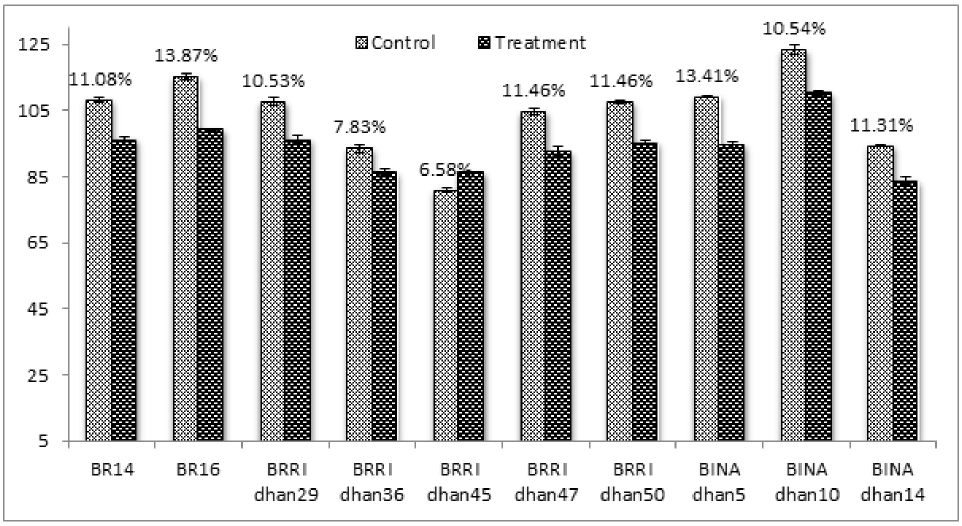


**Figure 1.** Percent change in days of 50% flowering in 10 rice genotypes under drought stress compared to control.

***Panicle length (cm)***

Panicle length is also an important yield contributing character since higher panicle length could provide higher grain numbers. However, panicle usually reduced due to drought stress in rice (Kumar *et al*., 2007). Here, longer panicle was possessed by BRRI dhan29 (Table 2). Panicle length was found decreased under impose of drought as compared to the control. A higher reduction in panicle length (26.19 %) was observed in BR14. Mirza *et al.* (1992) suggested that panicle length is positively correlated with number of grains per panicle.

***Number of total tillers plant$^{-1}$***

The higher number of tillers plant$^{-1}$ is preferable for achieving high yield (Liu *et al*., 2001). In this study, the average number of tiller plant$^{-1}$ ranged from 12.33 to 20.50 with a mean value of 17.60 (Table 2). BINA dhan5 showed the highest number of tillers and due to drought effect, tillers number were decreased in BRRI dhan45 (55%) compared to the control of the same genotype.

***Number of effective tillers plant$^{-1}$***

The number of effective tillers plant$^{-1}$ is directly related to grain yield. The yield of the plant has positive relationship of number of effective tillers plant$^{-1}$ (Kumar *et al*., 2007). The highest number of effective tillers plant$^{-1}$ was recorded in BRRI dhan45 (Table 2). Due to drought effect, number of effective tillers plant$^{-1}$ were decreased with a higher reduction in BRRI dhan45 (60.27%) compared to the control. Miller *et al*. (1991) also reported that the number of fertile tillers is the most important yield components, which includes 86% of yield changes. A drought tolerant variety might have the feature of lower reduction of effective tiller number under drought stress.

***Days of maturity***

Early maturity is the most desirable character of rice variety in present situation, which further ensures drought escape for the crop (Kumar *et al*., 2007). BRRI dhan45 was the most short-duration genotypes (Table 2). Due to drought effect, days of maturity of the most of the genotypes were decreased with a higher reduction in BR 14 by 12.66% compared to the control (Figure 2).

***Number of filled grains panicle$^{-1}$***

The yield of the plant is related to number of filled grains panicle$^{-1}$. A drought tolerant variety should have lowest reduction of filled grain under drought stress compared to susceptive variety (Abashahr *et al*., 2011). The highest number of filled grains panicle$^{-1}$ was found in BRRI dhan29 and the lowest in BRRI dhan36 (Table 2) under drought stress. Due to drought effect, number of filled grains panicle$^{-1}$ of the most of plants were decreased with a higher rate in BRRI dhan50 (50.00 %).

***Number of unfilled grains panicle$^{-1}$***

Less number of unfilled grains panicle$^{-1}$ is a positive attribute towards higher yield. However, under drought stress, number of unfilled grains get increased and drought tolerant genotype must have the ability to decrease the number of unfilled grain (Abashahr *et al*., 2011). Under drought condition, the number of unfilled grains panicle$^{-1}$ was increased in some varieties (BRRI dhan50, BR14 and BINA dhan5) and decreased in BRRI dhan36, BINA dhan10 and BRRI dhan29 as compared to their corresponding controls.

***Grains panicle$^{-1}$***

Grains per panicle is directly positively related to grain yield, which usually get compromised due to drought stress (Kumar *et al*., 2014). The average range of grains panicle$^{-1}$ was 79.67 to 184.50 with a mean value of 107.13 (Table 4.2). Under drought stress a higher grains panicle$^{-1}$ was observed in BRRI dhan29, followed by BRRI dhan50 and BINA dhan5 compared to their corresponding controls (Table 2).

***Seed weight (n=100)***

There was a significant difference in 100 seed weight among the varieties depending on the size and shape of grains. Nevertheless, due to drought stress, photosynthesis and transportation of food to the grain has severely impaired (Kumar *et al*., 2014), therefore, genotype with drought tolerance should have less compromised grain filling ability. The highest 100 seed weight was recorded in BINA dhan10 and the lowest in BRRI dhan50 (Table 2) under drought stress. However, a higher change in 100 seed weight was observed in BINA dhan14 by 15.66% under drought condition.

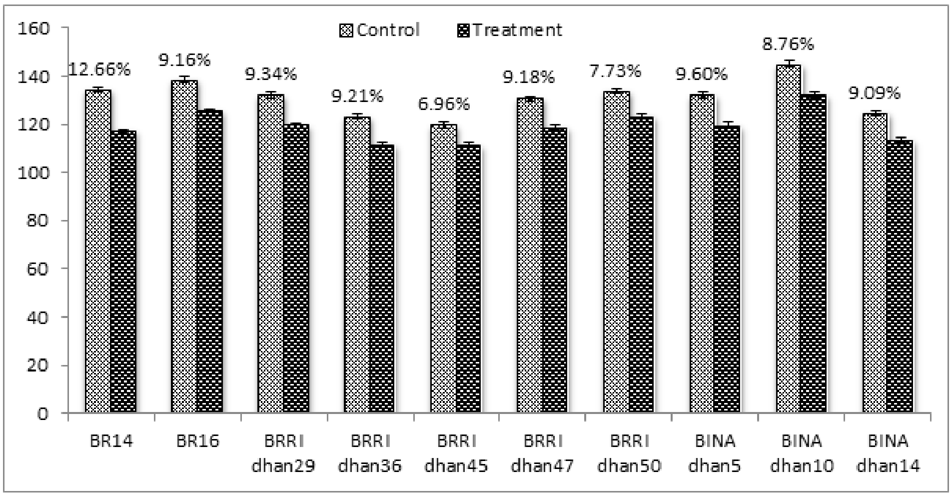


**Figure 2.** Per cent change in days to maturity in 10 rice genotypes under drought stress compared to control

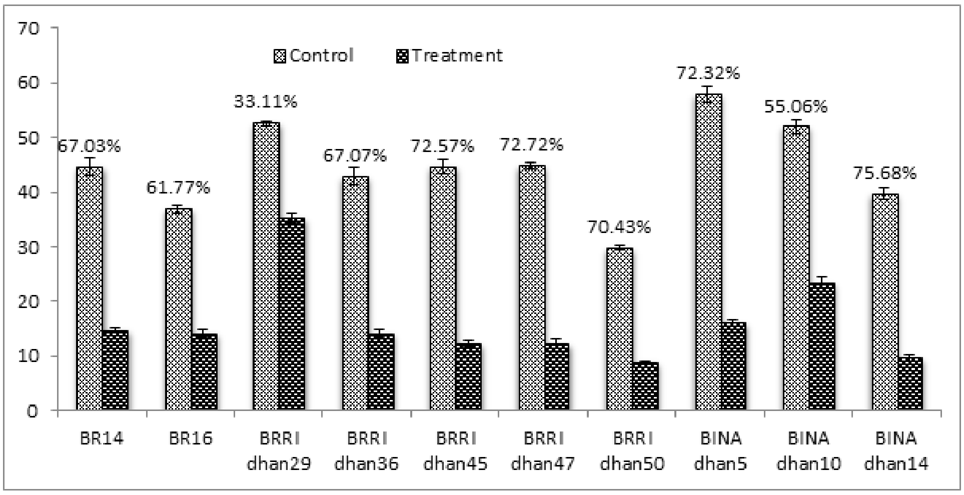


**Figure 3.** Per cent change in yield/plant (g) in 10 rice genotypes under drought stress compared to control

### *Grain yield panicle$^{-1}$(g)*

Grain yield per panicle was varied among the studied varieties due to the imposition on drought stress. Drought stress brings reduction in grain yield of rice plants (Kumar *et al*., 2007) due to detrimental effect of drought stress on several yield contributing traits related to photosynthesis and grain filling duration. BRRI dhan-29 showed the maximum grain yield (3.24g) under drought stress. Due to drought effect, grain yield panicle$^{-1}$ of the most of the genotypes was decreased compared to the control plants (Figure 5).

### *Yield hill$^{-1}$ (g)*

A significant difference exists in yield per hill among the studied varieties due to the imposition on drought. In general, drought stress compromises several yield contributing traits related to tiller, panicle and grain filling and number *etc.* (Abashahr *et al*., 2011; Kumar *et al*., 2007; Kumar *et al*., 2014). The highest yield was recorded in BRRI dhan29 (43.92g) and the lowest in BRRI dhan50 under drought stress (Table 2). Due to drought effect, yield hill$^{-1}$ of the most of plants was decreased with a higher reduction in BINA dhan14 (75.68%) as compared to the controls (Figure 3). Nevertheless, in previous attempts the grain yield of rice was reduced by 5 to 38 percent under mild water stress while severe water stress reduced grain yield by 25 to 67 percent (Yang *et al.* 1995). Besides, Babu *et al.* (2003) also reported 67 % reduction in grain yield due to drought stress.

**Table 2**. Mean performance of 10 rice genotypes for 15 morphological and biochemical traits over drought stress condition

| Genotypes | DTF | PH (cm) | PL (cm) | NTTP | NETP | DTM | NFGP | NUGP | GP | 100 SW (g) | GYP (g) | YH (g) | SF (%) | Proline (mg/100g) | L-ascorbic acid (mg/100g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **BR14** | 102.3 c | 83.7 cd | 20.0 de | 17.5 bc | 14.6 cd | 125.8 cd | 71.3 ef | 26.8 b | 98.1 cd | 2.5 b | 1.7 de | 29.6 c | 71.8 fg | 12.7 b | 3.6 de |
| **BR16** | 107.3b | 78.9 e | 18.9 ef | 15.3 d | 13.5 de | 132 b | 71.6 ef | 26.3 b | 96.3 cd | 2.3 c | 1.8 cd | 25.5 d | 74.5 ef | 9.4 cd | 4.8 c |
| **BRRI dhan29** | 102 c | 81.7 de | 25.5 a | 15.5 d | 13.3 de | 125.8 cd | 162.8 a | 21.6 cd | 184.5 a | 1.9 f | 3.2 a | 43.9 a | 88.1 a | 8.6 de | 7.1 a |
| **BRRI dhan36** | 90 e | 63.5 g | 18.5 f | 19.6 a | 16.8 a | 117.3 ef | 63 g | 18.5 d | 81.1 fg | 2.3 c | 1.4 f | 28.4 c | 76.5 de | 9.2 cd | 4.6 c |
| **BRRI dhan45** | 83.6 f | 80.1 e | 19.6 ef | 20.3 a | 17 a | 115.5 f | 62.6 g | 24.8 bc | 87.8 ef | 2.3 c | 1.5 f | 28.4 c | 70.4 g | 11.9 b | 3.7 d |
| **BRRI dhan47** | 98.6 d | 86.0 c | 20.9 cd | 18.8 ab | 15.1 bc | 124.6 d | 74 e | 17.8 d | 91.8de | 2.5 b | 1.8 c | 28.3 c | 79.2 cd | 14.4 a | 3.8 d |
| **BRRI dhan50** | 101.5 c | 71.3 f | 22.1 bc | 12.3 e | 9.6 f | 128.5 c | 93 c | 32.1 a | 125.1 b | 1.7 g | 1.7 e | 19.2 e | 73.7 e-g | 10.3 c | 3.6 de |
| **BINA dhan5** | 102 c | 109.9 a | 22.5 b | 20.5 a | 17 a | 125.6 cd | 100.6 b | 24.1 bc | 124.8 b | 2.2 d | 2.3b | 36.9 b | 80.1 c | 13.3 ab | 3.7 de |
| **BINA dhan10** | 116.8 a | 89.6 b | 20.1 de | 19.6 a | 16.5 ab | 138.3 a | 83.5 d | 18.3 d | 101.8 c | 2.7 a | 2.2 b | 37.6 b | 81.3 bc | 7.2 e | 5.7 b |
| **BINA dhan14** | 89 e | 70.4 f | 19.2 ef | 16.3 cd | 13 e | 119 e | 67.8 fg | 11.8 e | 79.6 g | 2.21 e | 1.5 f | 24.6 d | 84.6 ab | 8.8 d | 3.1 e |
| **$LSD_{0.05}$** | 2.63 | 3.45 | 1.24 | 1.08 | 1.63 | 3.45 | 5.75 | 3.98 | 7.13 | 0.05 | 0.07 | 2.59 | 3.52 | 1.50 | 0.54 |
| **Level of significance** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** |
| **CV(%)** | 1.60 | 2.57 | 3.62 | 5.91 | 6.73 | 1.67 | 4.09 | 10.8 | 4.03 | 1.60 | 2.5 | 5.1 | 2.7 | 8.5 | 7.4 |
| **Minimum** | 83.6 | 63.5 | 18.5 | 12.3 | 9.6 | 115.5 | 62.6 | 11.8 | 79.6 | 1.7 | 1.4 | 19.2 | 70.4 | 7.2 | 3.1 |
| **Maximum** | 116.8 | 109.9 | 25.5 | 20.5 | 17 | 138.3 | 162.8 | 32.1 | 184.5 | 2.7 | 3.2 | 43.9 | 88.1 | 14.4 | 7.1 |
| **Mean** | 99.3 | 81.5 | 20.7 | 17.6 | 14.6 | 125.2 | 85.0 | 22.2 | 107.1 | 2.3 | 1.9 | 30.3 | 78.0 | 10.6 | 4.4 |

** indicate 1 % level of significance. Varieties with different letter are significantly different.

Legend:

DTF= Days to flowering, PH= Plant height, PL= Panicle lenght, NTTP= No. of tiller per plant, NETP= No. effective tiller per plant, DTM= Days to maturity, NFGP= No. of filled grain per panicle, NUGP= No. of unfilled grain per panicle, GP= Grain per panicle, 100 SW=100 seed weight, GYP= Grain yield per panicle, YP= Yield per hill, SF= Spikelet fertility

**Table 3.** Ranking of the genotypes based on the performances for fifteen traits under drought condition

| Genotypes | Ranking | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DTF | PH (cm) | PL (cm) | NTTP | NETP | DTM | NFGP | NUGP | GP | 100 SW (g) | GYP (g) | YH (g) | SF | Proline (mg/100g) | L-Ascorbic acid(mg/100 g) | Total Rank | Position |
| **BR14** | 3 | 3 | 3 | 5 | 4 | 3 | 3 | 2 | 4 | 7 | 3 | 4 | 1 | 5 | 2 | 52 | 5 |
| **BR16** | 2 | 5 | 1 | 1 | 3 | 2 | 3 | 4 | 4 | 6 | 5 | 4 | 4 | 3 | 2 | 49 | 7 |
| **BRRI dhan29** | 3 | 4 | 6 | 5 | 5 | 3 | 6 | 3 | 6 | 2 | 8 | 6 | 5 | 2 | 3 | 67 | 1 |
| **BRRI dhan36** | 5 | 7 | 1 | 5 | 5 | 4 | 2 | 4 | 3 | 5 | 2 | 4 | 2 | 4 | 1 | 54 | 4 |
| **BRRI dhan45** | 5 | 5 | 2 | 4 | 3 | 4 | 1 | 4 | 2 | 5 | 1 | 3 | 1 | 5 | 2 | 47 | 8 |
| **BRRI dhan47** | 4 | 5 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 6 | 4 | 3 | 3 | 1 | 2 | 51 | 6 |
| **BRRI dhan50** | 3 | 6 | 4 | 1 | 1 | 2 | 4 | 1 | 5 | 1 | 2 | 1 | 3 | 4 | 2 | 40 | 9 |
| **BINA dhan5** | 4 | 1 | 4 | 5 | 5 | 3 | 5 | 4 | 5 | 4 | 6 | 4 | 4 | 6 | 1 | 61 | 2 |
| **BINA dhan10** | 1 | 2 | 3 | 5 | 5 | 1 | 5 | 4 | 5 | 8 | 7 | 5 | 4 | 1 | 3 | 59 | 3 |
| **BINA dhan14** | 6 | 6 | 3 | 2 | 2 | 4 | 2 | 5 | 1 | 3 | 2 | 2 | 5 | 3 | 1 | 47 | 8 |

Legend:
DTF= Days to flowering, PH= Plant height, PL= Panicle lenght, NTTP= No. of tiller per plant, NETP= No. effective tiller per plant, DTM= Days to maturity, NFGP= No. of filled grain per panicle, NUGP= No. of unfilled grain per panicle, GP= Grain per panicle, 100 SW=100 seed weight, GYP= Grain yield per panicle, YP= Yield per hill, SF= Spikelet fertility

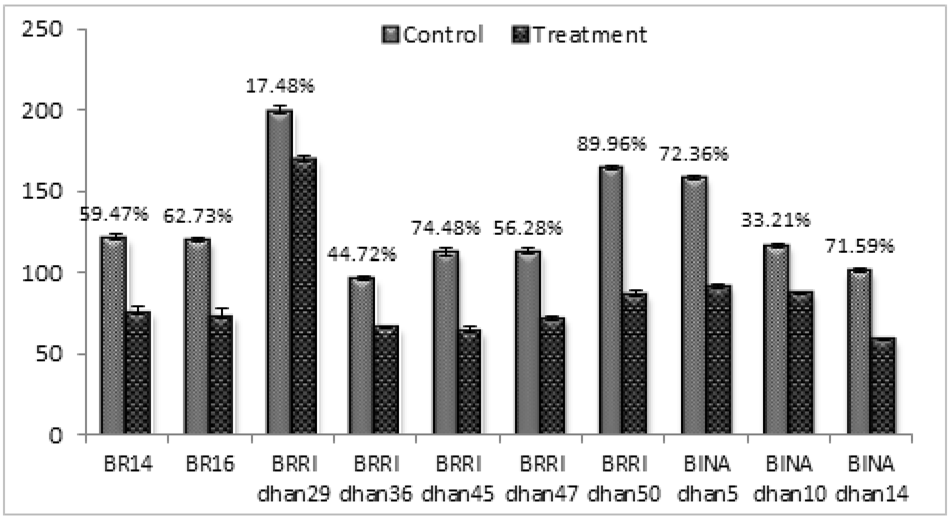


**Figure 4.** Percent change in grain yield panicle$^{-1}$(g) in 10 rice genotypes under drought stress compared to control

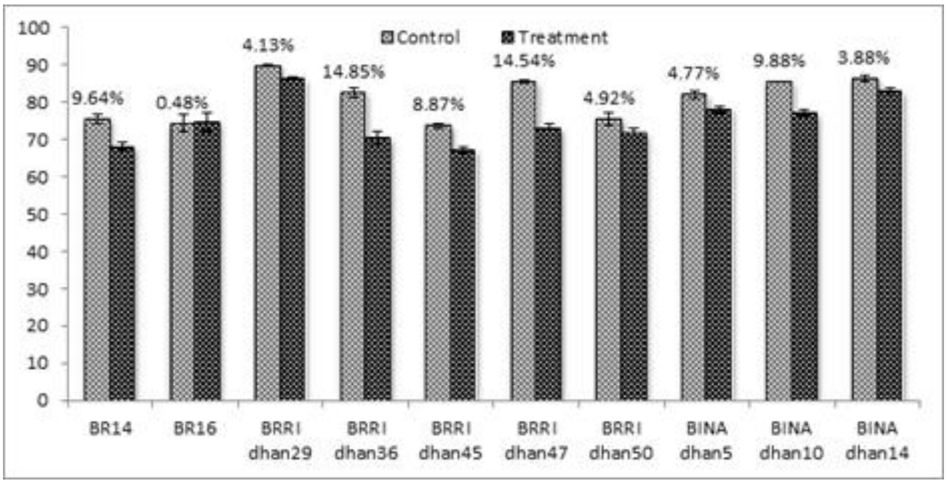


**Figure 5.** Percent change in spikelet fertility in 10 rice genotypes under drought stress compared to control

***Spikelet fertility (%)***

As a yield contributing factor, a significant difference in spikelet fertility was observed among the varieties under drought stress. The highest fertility (%) was recorded in BRRI dhan29. Due to drought effect, spikelet fertility of the most of genotypes was decreased with a higher reduction in BRRI dhan36 (14.85%) (Figure 5). Selote *et al*. (2004) showed that the drought resistant cultivar had higher spikelet fertility than the drought-sensitive cultivar as a result of increased antioxidant enzyme activities in the panicles under water stress.

## Biochemical traits of rice genotypes under drought stress

***Proline***

Proline is the most widely studied compatible solute synthesized from L-glutamic acid via pyrroline-5-carboxilate (Yoshiba *et al*., 1995). In the present investigation, the highest proline accumulation was recorded in BRRI dhan47 and the lowest in BINA dhan10 (Table 2). Under water deficit condition the accumulation of proline was increased (Figure 5). Due to drought strees, BRRI dhan36 showed the maximum increment of proline while the minimum accumulation was observed in BINA dhan10 (Figure 6). It is an established fact that water stress induces numerous metabolic alterations in plants. Free proline accumulation is one of the most dramatic stress characteristics. Investigation conducted by Goyal *et al.* (1985), Sudhakar *et al.* (1989) and Jha and Singh (1997) showed that drought tolerant rice varieties had positive correlation with the proline accumulation in the leaves in water stress condition. Under water stress, increment in proline accumulation often did occur due to onset of adaptive process (Aspinall and Paleg, 1981). Many others reported that increase in proline accumulation might occur from cellular injury as well (Hanson and Nelson, 1978). Osmotic adjustment through the accumulation of cellular solutes, such as proline, has been suggested as one of the possible means for overcoming osmotic stress caused by the loss of water (Caballero *et al.* 2005). In addition to acting as an osmo-protectant, proline also serves as a sink for energy to regulate redox potentials, as a hydroxyl radical scavenger (Sharma *et al.* 2000), as a solute that protects macromolecules against denaturation and as a means of reducing acidity in the cell (Kishor *et al.* 2005). Therefore; it seems that the accumulation rate was correlated with drought tolerance.

***L-ascorbic acid***

L-Ascorbic acid plays an important role in the plant metabolism. The levels of L- ascorbic acid in leaves of studied genotypes at panicle initiation stage were presented in Table 2. Although less than control, but highest L-ascorbic acid content was recorded in BRRI dhan29 and the lowest in BINA dhan14 under drought stress (Figure 7). Ascorbic acid content was also been reported to decrease with age and water stress condition in rice, Sorghum and maize (Anwar *et al*., 1986). L-Ascorbic acid works as free radical scavenger and protect the plant from oxidative stress resulted from drought. In drought tolerant varieties more L-ascorbic acid might has been used up for scavenging the reactive oxygen species to protect the plant, which can justify the reduction of L-ascorbic acid content in BRRI dhan29 compared to control under water deficient condition. This observation may be utilized in screening purpose to select drought tolerant genotypes.

An overall ranking of the varieties has been computed based on performances of the varieties for the fifteen traits considered under drought stress (Table 3). It is evident that, along with the agronomic performances, BRRI dhan29 also ranked top although not performed for all the traits related to drought tolerance in rice. The other varieties have cumulative higher performances under drought stress were BINA dhan5, BINA dhan10 and BRRI dhan36.

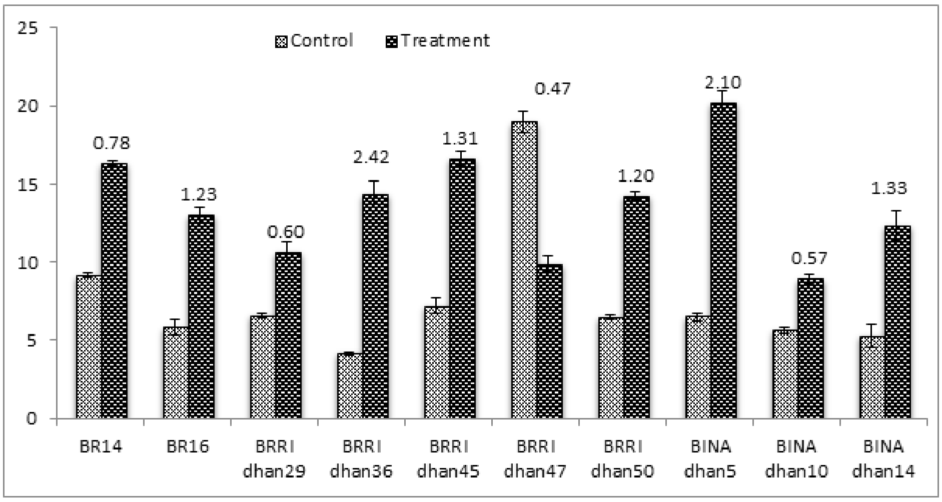


**Figure 6.** Change (Fold) in proline (mg/100g) in 10 rice genotypes under drought stress compared to control

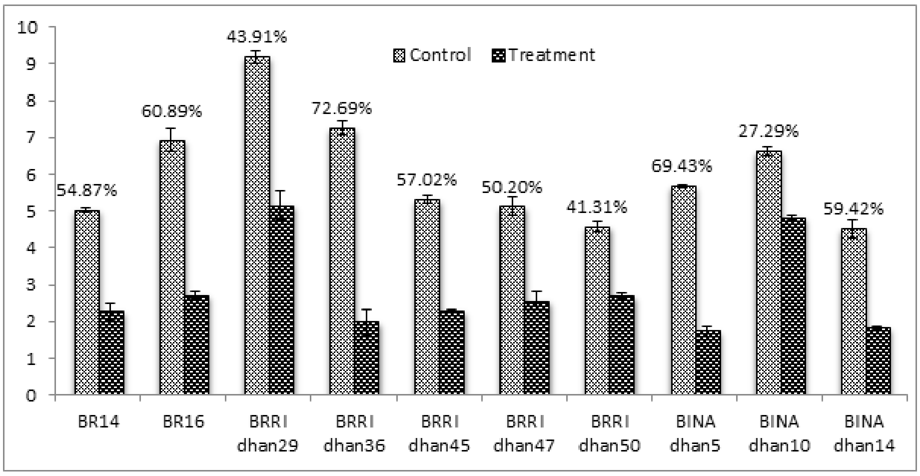


**Figure 7**. Per cent change in L-ascorbic acid (mg/100g) in 10 rice genotypes compare to their control

## CONCLUSION

In this study, the morphological and biochemical performances of ten popular boro rice varieties were assessed under drought condition. Considering all the traits under drought stress, BRRI dhan29 showed the maximum performance for primary yield contributing characters like the number of grains, number of filled grains and 100 seed weight resulting in higher yield per plant. Regarding the duration, BRRI dhan45 showed the lowest days of 50% flowering and it took minimum days to mature. Proline and L-ascorbic acid has a vital role under drought condition. Under water deficit condition the accumulation of proline was increased. On the other hand, L-ascorbic acid content in plant in water stress condition could be decreased. BRRI dhan47, BRRI dhan45, BR14 and BINA dhan5 showed the maximum increment of proline. On the contrary, BRRI dhan29 and Binadhan-10 showed maximum increase of L-ascorbic acid under the drought condition. The present investigation elucidated the level of drought tolerance of some popular boro rice varieties of Bangladesh. This information can be a great help if any breeding program is taken in future to improve drought tolerance of the varieties used in the study.

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## CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this paper.

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