Ann. Bangladesh Agric. (2021) 25 (1) : 89-104
www.doi.org/10.3329/aba.v25i1.58158

ISSN 1025-482X (Print)
2521-5477 (Online)

EVALUATION OF MOISTURE REGIME ON AGRONOMIC TRAITS OF RICE GENOTYPES

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Abstract

Drought stress is a major constraint to the production and yield stability of crops. Rice (*Oryza sativa* L.) is one of the most important cereals and considered as a drought sensitive crop species. A field experiment was conducted in the vinylhouse of the Department of Agronomy, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Bangladesh, during March - August 2018 to evaluate the performance of 38 rice genotypes under control and drought conditions. The experiment was laid out in a completely randomized design containing two water regimes with three replications. The water regimes were well-watered and induced moisture stress conditions. Multivariate and principal components analyses revealed that different plant characters, viz. plant height, total tillers hill^{-1}, panicle number hill^{-1}, length of panicle, filled grains panicle^{-1}, 1000-grain weight, grain yield plant^{-1} and straw weight plant^{-1} showed a wide range of variation due to variation in moisture level. Correlation study and biplot analysis considering PC1 and PC2 explained that grain yield was positively correlated with filled grain panicle^{-1}, total tiller hill^{-1}, panicle number hill^{-1} and 1000-grain weight. Based on the grain yield plant^{-1} (g) and others agronomic characters, the genotypes BU Acc 33 (26.68 g), BU Acc 30 (21.81 g), and BU Acc 21 (20.58 g) were identified as promising genotypes for developing drought tolerant variety (ies).

Keywords: Rice genotypes, moisture stress, variability, biplot, yield.

Introduction

Rice (*Oryza sativa* L.) is one of the most widely consumed cereal crops across the globe, providing a staple diet for almost half of the human population (IRRI, 2013). As an annual C_3 crop of the Poaceae family, rice is diverse in adaptation, occupying large growing areas in the tropics, subtropics, semiarid tropics, and temperate regions of the world (Muthayya *et al.*, 2014). It provides 27 percent of dietary energy and 20 percent of dietary protein in the developing countries (Singh and Singh, 2007). It is cultivated in at least 114 developing countries and the primary source of income and employment for more than 100 million households in Asia (Singh *et al.*, 2015). It is being cultivated under diverse ecologies ranging from irrigated to rain-fed, and upland to lowland or deep water system.

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With the onset of climate change-related challenges, the intensity and frequency of drought are predicted to increase in most of the rice-growing areas. Drought could extend further into water-limited irrigated areas with greater severity. For example, water scarcity already affects more than 23 million hectares of rain-fed rice production area in South and Southeast Asia alone (Lone *et al.*, 2019). According to Singh *et al.* (2018), drought is the single largest yield reducing factor in rain-fed areas of South and Southeast Asia.

Inhibition of rice production by natural disaster is however common in Bangladesh. Almost every year, the country experiences several disasters, such as droughts, tropical cyclones, storm surges, coastal erosion, and floods (Rakib *et al.*, 2019). Drought is a recurrent phenomenon in some parts of Bangladesh. Nonetheless, water deficit commonly occurs during the growing season, and the intensity of stress depends on the duration and frequency of water deficit. The most drought-prone area of Bangladesh is the north-western part including the entire Barind and Madhupur tracts. Drought has been identified as one of the main constraints for improving yield of rice in drought-prone area of Bangladesh.

Rice is sensitive to drought and shows several morphological changes at different growth stages in response to drought stress (Henry *et al.*, 2016). These variations involve plant height reduction, leaf rolling, leaf senescence, stomatal closure, decreased leaf elongation and lower dry matter production (Kumar *et al.*, 2015). Though, rice plants require water throughout their growth period, there are certain critical growth stages when drought stress can dramatically reduce the seed yield (Bajji *et al.*, 2001; Zhou *et al.*, 2007). During vegetative stage, drought stress decreases the leaf and tiller formation, which ultimately reduce yield by affecting panicle development (Swain *et al.*, 2017; Singh *et al.*, 2017). However, when drought stress occurs during reproductive growth phase, it remarkably reduces rice seed yield due to abortion of ovule and formation of partially filled grains (Pantuwan *et al.*, 2002). However, the sensitivity of rice to drought or water stress varies with timing, duration, and severity of drought stress, variety, and the growth stage of rice (Sokoto and Muhammad, 2014).

Proper screening of rice genotypes is considered as an important tool for easy selection of tolerant rice genotype(s) under drought stress, because it undoubtedly differentiates drought susceptible genotypes from drought tolerant one (Swamy and Kumar, 2012). Consequently, identification of rice varieties and breeding lines with promising levels of drought tolerance for using as donors in breeding and gene discovery is one of the main challenges for rice research (Serraj *et al.*, 2008). However, little is known on how different traits express and respond to drought stress. Therefore, selection of rice genotypes that could better tolerate drought stress and produce economic yield is imperative to alleviate the future predicted food crisis. With that view the present study was implemented to evaluate the agronomic traits of 38 rice genotypes for selecting the relatively drought tolerant one.

Materials and Methods

Experimental site

The experiment was conducted in the vinylhouse of the Department of Agronomy, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Bangladesh, during March - August 2018. The experimental site is situated in a sub-tropical climatic zone, characterized by scanty rainfall during October to May and heavy rainfall from June to September.

Pot preparation

The soil of experimental pot was collected before sowing of seeds. Soil used in the plastic pot was silty clay. Each pot (30 cm length and 24 cm diameter) was filled with 12 kg mixture of soil and cow-dung at 1: 0.25 ratio. Weight of each individual empty pot was measured. Amount of the air dried soil of each individual pot was measured by deducting the weight of the empty pot. After that oven dried weight of this soil was measured. Weight of the air dried soil at 100% field capacity was also measured. Then amount of water at control (100% field capacity) and 50% field capacity of that soil was measured. Finally pot weight was measured at control (100% field capacity) and 50% field capacity. The mean monthly maximum air temperature of this area varies between 29°C to 34°C and minimum between 18°C to 26°C.

Experimental design and treatment

The experiment was laid out in a completely randomized design (CRD) with two regimes and three replications. Experimental variables were thirty eight rice genotypes, and two moisture regimes, i.e. well-watered (95-100% field capacity; control) and simulated water stress conditions (45-50% field capacity). The rice genotypes were BU Acc1, BU Acc2, BU Acc3, BU Acc4, BU Acc5, BU Acc6, BU Acc7, BU Acc8, BU Acc9, BU Acc10, BUAcc11, BU Acc12, BU Acc13, BU Acc14, BU Acc15, BU Acc16, BU Acc17, BU Acc18, BU Acc19, BU Acc20, BU Acc21, BU Acc22, BU Acc23, BU Acc24, BU Acc25, BU Acc26, BU Acc27, BU Acc28, BU Acc29, BU Acc30, BU Acc31, BU Acc32, BU Acc33, BU Acc34, BU Acc35, BU Acc36, BU Acc37 and BU Acc38. The rice genotypes were collected from Genetic Resources Unit of BSMRAU and Bangladesh Rice Research Institute (BRRI).

Five healthy seeds were sown maintaining uniform spacing in each pot. The seeds were surface sterilized with 0.2% $HgCl_2$ solution for 5 min and thoroughly rinsed with tap water. Light irrigation was given by using the water cane to ensure uniform germination of seeds after sowing. After seedling establishment, one healthy plant was kept in each pot for subsequent treatment imposition. Soil moisture meter was used to assess the field capacity of the soil (Stevens, Field pogo; Canada). Up to four-leaf stage, all the plants were well watered (maintained at 100% field capacity). One day before treatment imposition, 500 ml of water was applied to each pot to maintain equal soil moisture content of all the pots. During treatment imposition, 95-100% of field capacity (FC) was maintained for control and 45-50% FC was maintained for moisture stress condition. Moisture stress was maintained at 45-50% of field capacity by water supply whenever needed. In control treatment, water was applied to maintain 95-100% of field capacity. Soil moisture meter was used to maintain the field capacity of the soil.

Fertilizer management

Pots were kept at uniform distance from each other. Fertilizers were applied at the rate of 1.26-0.45-0.67-0.21-0.078 g urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum and zinc sulphate per pot, respectively (BRRI, 2017). One third of urea, total amount of TSP, MP, Gypsum and Zinc sulphate was applied at the time of final pot preparation. Rest of urea was applied into two splits. The first split was applied at the maximum tillering stage and another at panicle initiation stages of rice. Intercultural operations were done uniformly in each pot to ensure normal growth of the crop. Weeding was done intensively to keep the pots weed free. For control insect diazinon was applied. A net was set around the experimental field to protect the crop from bird. When the flag leaf and panicle turned yellow the crops were harvested. Threshing, cleaning and drying of grain were done separately pot by pot. The data such as plant height, total tiller hill^{-1}, panicle number hill^{-1}, panicle length, filled grains panicle^{-1}, 1000-seed weight, seed yield plant^{-1}, and straw weight plant^{-1} were recorded from each plant of two water regime and three replications.

Data analysis

The Microsoft Excel and SPSS 20 software programs were used to perform statistical analysis. Relationships among the parameters were established through correlation and regression analysis.

Results and Discussion

Plant height

At control condition, plant height ranged from 93.50 to 191.33 cm with a mean of 162.78 cm. The frequency distribution of plant height showed normal distribution with skewed towards left (α = - 1.855) indicating that most of the genotypes were more than median and few of them were around median (Fig. 1a). Among the thirty eight genotypes, the plant height of eight genotypes ranged from 93.5 to 150.0 cm, twenty-six genotypes ranged 150.0 to 180.0 cm another four genotypes showed plant height more than 180 cm (Fig. 1a). At drought condition, plant height ranged from 92.0 to 167.5 cm with a mean of 145.22 cm (Fig. 1b). The frequency distribution of plant height showed normal distribution with skewed towards left (α = - 1.623) indicating that most of genotypes were more than median and few of them were around median (Fig. 1b). Among the 38 genotypes, plant height of nine genotypes ranged from 92.0 to 140.0 cm, 23 genotypes ranged from 140.0 to 160.0 cm, another six genotypes showed plant height more than 160.0 cm (Fig. 1 b). In comparing the results of drought and control it showed that plant height was decreased due to drought stress. Water stress markedly decreases the photosynthetic rate, reduces transportation of compatible nutrients, arrested cell division, which ultimately restricted the shoot growth rate (Islam *et al.,* 2018; Sahoo *et al.,* 2020). Wu *et al.* (2011) also observed that the height of rice plant decreased under water stress condition.

Total tillers hill^{-1}

Number of total tillers hill^{-1} under control condition ranged from 8.33 to 29.33 with a mean of 17.00. Frequency distribution of the tiller showed normal distribution with slightly skew towards right (α = 0.533) indicating that few of the genotypes were more than median and most of the genotypes were around median (Fig. 2a). Out of 38 genotypes, nine showed 8.33 to 15.0 tillers hill^{-1}, 22 showed 15.0 to 20.0 tillers hill^{-1} and the rest seven genotypes showed 20.0 to 30.0 tillers

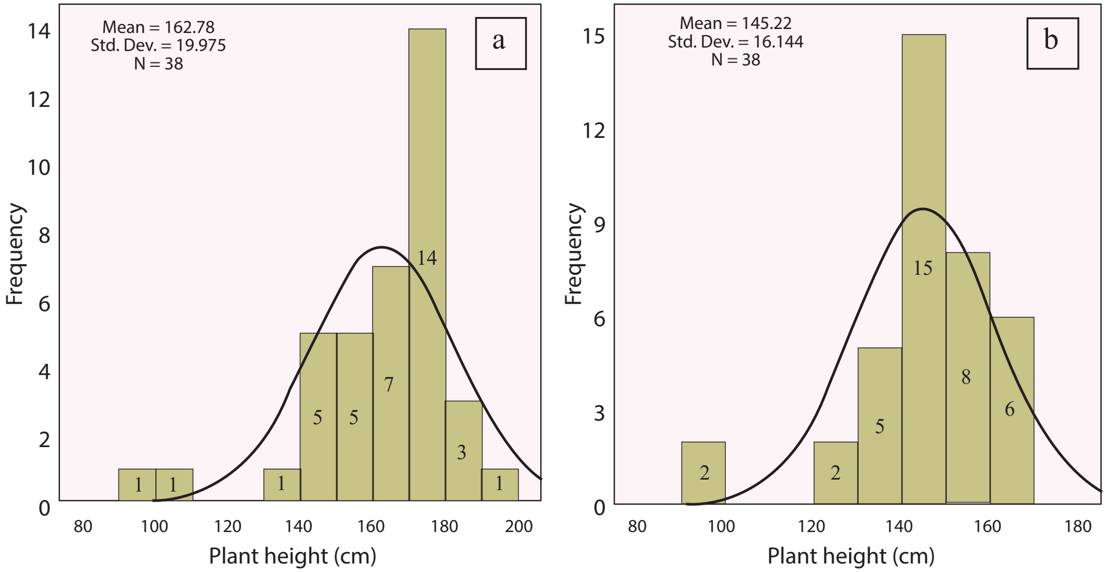

Fig. 1. Frequency distribution of plant height of rice genotypes under (a) control and (b) drought condition.

hill^{-1} (Fig. 2a). Under drought condition, total tillers hill^{-1} exhibited a wide range of variation among the genotypes. The variation ranged from 7.0 to 29.67 with a mean of 15.17 (Fig. 2b). Frequency distribution of the total tiller showed normal distribution with skewed towards right ($\alpha = 1.079$) indicating that most of the genotypes were more than median and few of the genotypes were around median. Out of 38 genotypes, 19 showed 7.0 to 15.0 tillers hill^{-1}, 16 genotypes showed 15.0 to 20.0 tillers hill^{-1} and only three genotypes showed more than 20.0 tillers hill^{-1} (Fig. 2b). These results showed that drought stress decreased the number of total tillers hill^{-1}. Table 1 showed that total tillers hill^{-1} has a positive and significant correlation with seed yield plant^{-1} under drought stress. Since, rice plants require water throughout their growth period, there are certain critical growth stages when drought stress can dramatically reduce the seed yield (Bajji *et al*., 2001; Zhou *et al*., 2007). During vegetative stage, drought stress decreased the leaf, photosynthesis which ultimately reduced the tiller formation (Swain *et al*., 2017; Singh *et al*., 2017).

Panicle number hill^{-1}

Number of panicle hill^{-1} under control condition ranged from 7.33 to 26.0 with an average 14.87 (Fig. 3a). Frequency distribution showed normal distribution with slightly skew towards right ($\alpha = 0.442$) indicating that few of the genotypes were more than median and most of the genotypes were around than median. Among the 38 genotypes, panicle number hill^{-1} of 17 genotypes ranged from 7.33 to 15.0, 18 genotypes ranged from 15.0 to 20.0 and three genotypes showed more than 20.0 panicle number hill^{-1}. Under drought condition, the number of panicle hill^{-1} ranged from 7.0 to 25.33 with an average of 11.88. Figure 3b showed a distinct variability in panicle number hill^{-1} of the rice genotypes and exhibited a normal distribution with highly

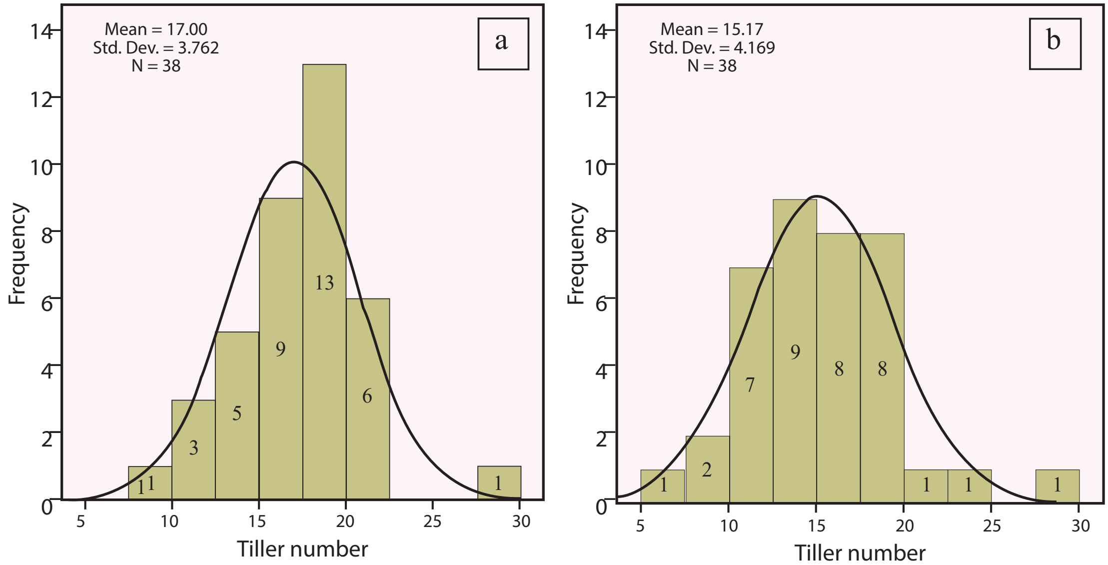

Fig. 2. Frequency distribution of total tillers hill^{-1} of rice genotypes under (a) control and (b) drought condition.

Table 1. Correlation coefficient of ten plant characters of thirty-eight rice genotypes under drought condition

Traits	PHT	TTH	ETPH	PL	FGPP	TSW	SYPP	SW
PHT	1							
TTH	-0.165	1						
ETPH	-0.1	0.824**	1					
PL	-0.078	-0.596**	-0.579**	1				
FGPP	-0.28	0.074	0.109	0.204	1			
TSW	0.054	0.054	-0.064	0.282	-0.045	1		
SYPP	-0.365*	0.337*	0.332*	0.126	0.795**	0.216	1	
SW	0.322*	0.411*	0.370*	-0.429**	-0.199	-0.146	-0.229	1

*. Correlation is significant at the 0.05 level (2-tailed)

**. Correlation is significant at the 0.01 level (2-tailed)

Note: PHT = Plant height (cm), TTH = Total tiller hill^{-1}, ETPH = Effective tiller hill^{-1}, PL = Panicle length (cm), FGPP = Filled grain panicle^{-1}, TSW = 1000-Grain weight (g), SYPP = Grain yield plant^{-1} (g), SW = Straw weight (g).

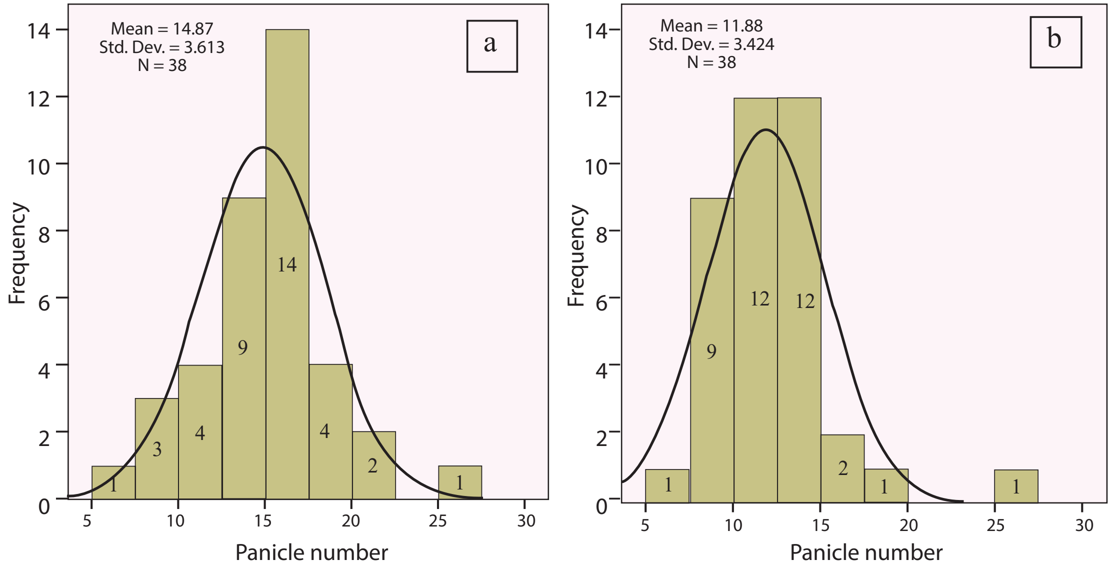

Fig. 3. Frequency distribution of panicle number hill^{-1} of rice genotypes under (a) control and (b) drought condition.

skewed towards right (α = 1.746). Among the 38 genotypes, 34 genotypes showed 7.0 to 15.0, three genotypes showed 15.0 to 20.0 and only one genotypes showed more than 25.0 panicle number hill^{-1}. The results clearly revealed that number of effective tillers plant^{-1} decreased due to drought stress. Table 1 shows that effective tiller hill^{-1} has a positive and significant correlation with seed yield plant^{-1} under drought stress.

Panicle length

Panicle length of the rice genotypes ranged between 20.13 and 32.13 cm with a mean of 27.03 cm under control condition. Figure 4a showed a distinct variability in panicle length of the genotypes and exhibited nearly a normal distribution with slightly skewed towards left (α = - 0.419) indicating that few of the genotypes were more than median and most of the genotypes were around median. Among 38 genotypes, 11 genotypes showed 20.13 to 25.0 cm panicle length, 23 genotypes showed 25.0 and 30.0 cm panicle length and four genotypes showed more than 30.0 cm panicle length. Under drought condition, panicle length ranged between 18.16 and 28.23 cm with a mean of 24.01cm. Frequency distribution of the panicle length showed normal distribution with very slightly skewed towards left (α = - 0.273) indicating that few of the genotypes were more than median and most of the genotypes were around median (Fig. 4b). Among the 38, 22 genotypes showed 18.16 to 24.0 cm panicle length and 16 genotypes showed 24.0 to 29.0 cm panicle length. No genotype was found with panicle length more than 30.0 cm. From the result we found that panicle length of rice decreased due to drought stress. Drought stress reduces growth by causing premature senescence of plant parts and hence reduced supply of

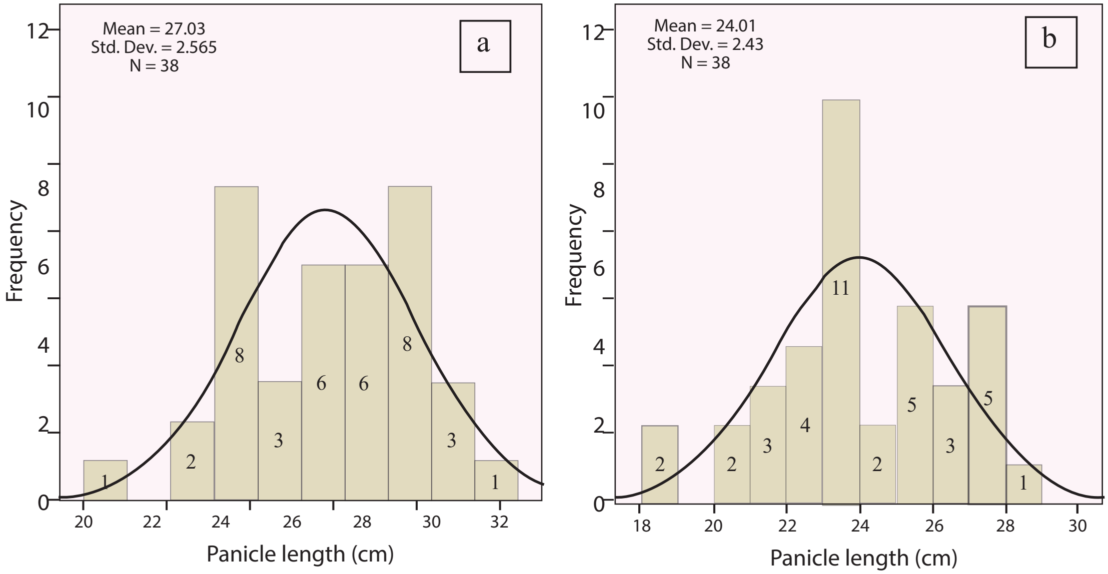

Fig. 4. Frequency distribution of panicle length of rice genotypes under (a) control and (b) drought condition.

assimilates to growing regions ultimately reduce the length of panicle. These results of this study are also supported by the findings of Wu *et al.* (2011) and Singh *et al.* (2012) who stated that water stress decreased dramatically the panicle length of rice.

Filled grains panicle^{-1}

Under control condition, the number of filled grains panicle^{-1} ranged between 45.33 and 174.33 with an average of 101.42. Frequency distribution of the filled grains panicle^{-1} showed normal distribution with very slightly skewed towards right ($\alpha = 0.289$) indicating that few of the genotypes were more than median and most of the genotypes were around median (Fig. 5a). Out of 38 genotypes, 20 genotypes showed 45.33 to 100.0, 15 genotypes showed 100.0 to 161.0 and three genotypes showed more than 161.0 filled grain panicle^{-1}. Under drought condition, the number of filled grains panicle^{-1} ranged between 13.0 to 98.33 with an average of 53.94. Frequency distribution of the filled grain panicle^{-1} showed normal distribution with very slightly skewed towards right ($\alpha = 0.352$) indicating that few of the genotypes were more than median and most of the genotypes were around median. Out of 38 rice genotypes, 24 genotypes showed 13.0 to 60.0 and 14 genotypes showed 50.0 to 100.0 filled grain panicle^{-1}. None of the genotypes showed grain panicle^{-1} more than 100. Hence the above results clearly showed that drought significantly decreases the number of filled grains panicle^{-1}. Table 1 shows that filled grains panicle^{-1} has a positive and significant correlation with grain yield plant^{-1} under drought stress. When drought stress occurs during reproductive growth phase, formation of partially filled grains occurred due to abortion of ovule. Water stress causes spikelet

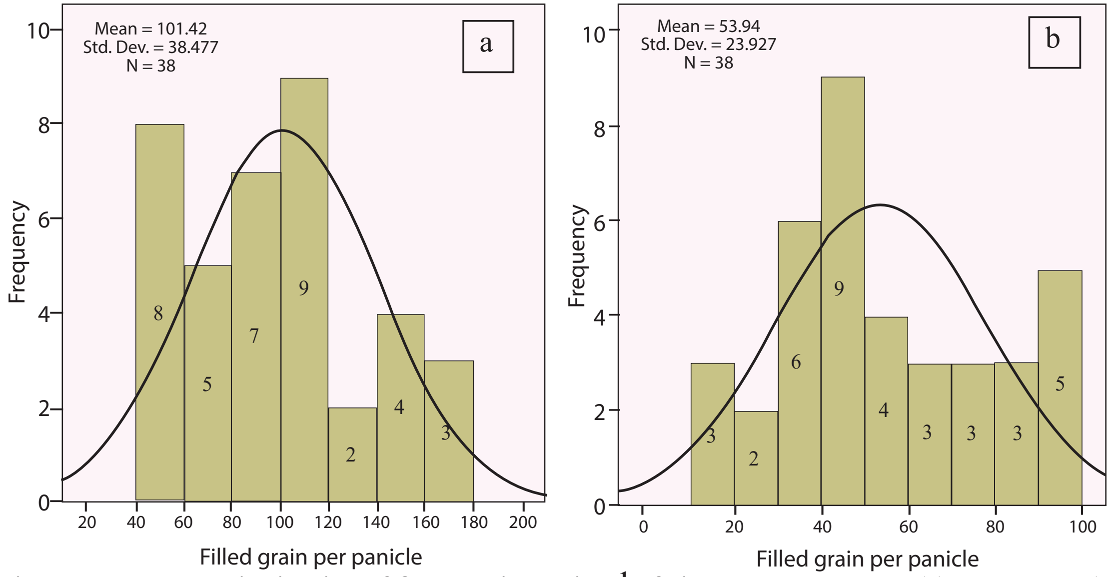

Fig. 5. Frequency distribution of filled grain panicle^{-1} of rice genotypes under (a)control and (b) drought condition.

sterility and reduces filled grain number when it occurred at anthesis and grain filling stages (Wu *et al*., 2011). Drought stress suppressed the reproductive development of rice, which ultimately reduced the grain formation.

Thousand grain weight

Under control condition, 1000-grain weight of rice genotypes ranged between 14.62 and 27.13 g with a mean of 21.58 g. Figure 6a showed a distinct variability in 1000- grain weight of the genotypes and exhibited nearly a normal distribution with skewed towards left (α = - 0.746). Out of 38 genotypes, eight genotypes showed 14.62 to 20.0 g, 22 genotypes showed 20.0 to 24.0 g and eight genotypes showed more than 24.0 g 1000- grain weight. Under drought condition, 1000 grain weight ranged between 10.75 and 26.21 g with a mean of 18.94 g. Frequency distribution of the 1000 grain weight showed normal distribution with very slightly skewed towards left (α = - 0.336) indicating that most of the genotypes were around median (Fig. 6b). Out of 38 genotypes, 23 genotypes showed 10.75 to 20.0 g, 12 genotypes showed 20.0 to 24.0 g and only three genotypes showed more than 24.0 g 1000-grain weight. It is clear from the above results that 1000-grain weight was decreased due to drought stress. Drought stress reduces the maturation and grain filling period of some cereal crops. Therefore, reduction of grain weight at drought stress might be due to the result of shortened grain filling period. Rahman *et al*. (2002) reported that thousand grain weight decreased under drought condition due to decrease in translocation of assimilates towards reproductive organs.

Grain yield plant^{-1}

Grain yield plant^{-1} ranged between 9.05 and 35.65 g with a mean of 25.29 g under control condition. Frequency distribution of the grain yield plant^{-1} showed almost normal

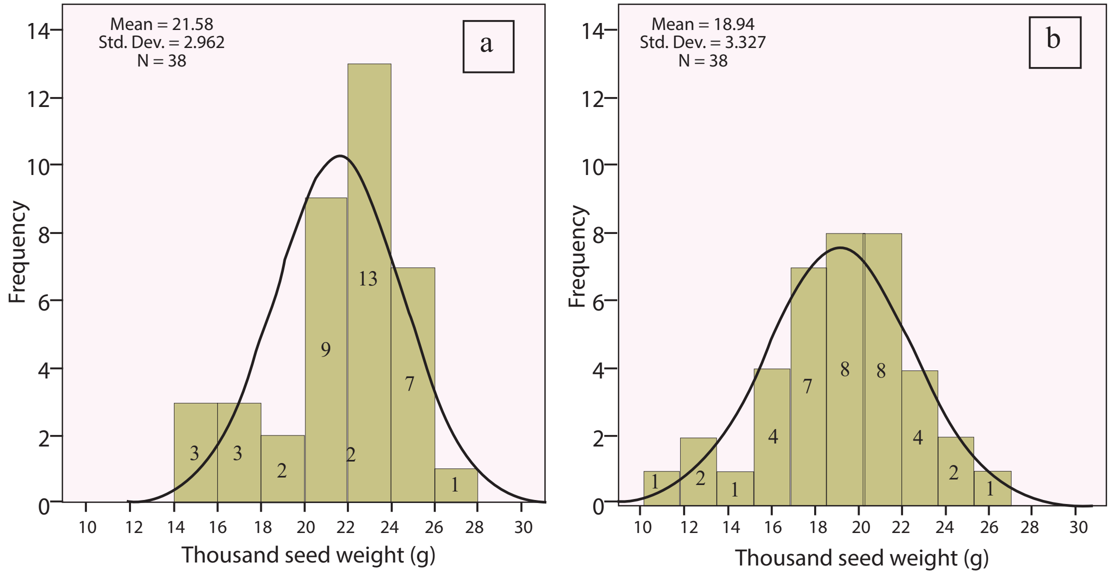

Fig. 6. Frequency distribution of 1000-grain weight of rice genotypes under (a) control and (b) drought condition.

distribution with skewed towards left (α = -0.531) indicating that most of the genotypes were more than median (Fig. 7a). Among the 38 genotypes, 11 genotypes showed 9.05 to 20 g grain yield plant^{-1}, 16 genotypes showed 20.0 to 30.0 g grain yield plant^{-1} and 11 genotypes showed more than 30.0 g grain yield plant^{-1}. Under drought condition, grain yield plant^{-1} ranged between 2.31 and 26.68 g with an average of 10.18 g. Frequency distribution of the grain yield plant^{-1} showed almost normal distribution with skewed towards right (α = 0.981) indicating that most of the genotypes were more than median and few of the genotypes were around median (Fig. 7b). Out of 38 genotypes, 23 genotypes showed 2.31 to 10.0 g, 12 genotypes showed 10.0 to 20.0 g and only three genotypes showed more than 20.0 g grain yield plant^{-1}. This result revealed that grain yield of all the rice genotypes was reduced due to drought stress. Under drought condition, minimum yield reduction was found in BU Acc 33 (25.15%) followed by BU Acc 21 (33.94%), BU Acc 30 (34.72%), and BU Acc 6 (37.54%) (Table 2). Based on yield plant^{-1} (g) and others factors the genotypes BU Acc 33, BU Acc 30, BU Acc 21 were identified as promising genotypes for developing drought tolerant variety (ies).

The reduction in grain yield might be due to shortening the grain filling period of rice (Shahryari *et al.*, 2008), causing spikelet sterility and low grain filling (Kamoshita *et al.*, 2004) and disrupting leaf gas exchange properties, impaired phloem loading and assimilate translocation (Farooq *et al.*, 2009). Table 1 shows that total tillers hill^{-1}, effective tillers hill^{-1} and filled grains panicle^{-1} has a positive and significant correlation with grain yield plant^{-1} under drought stress. Under drought stress, grain yield is one of the important selection criterions and it is determined by several phenological and yield

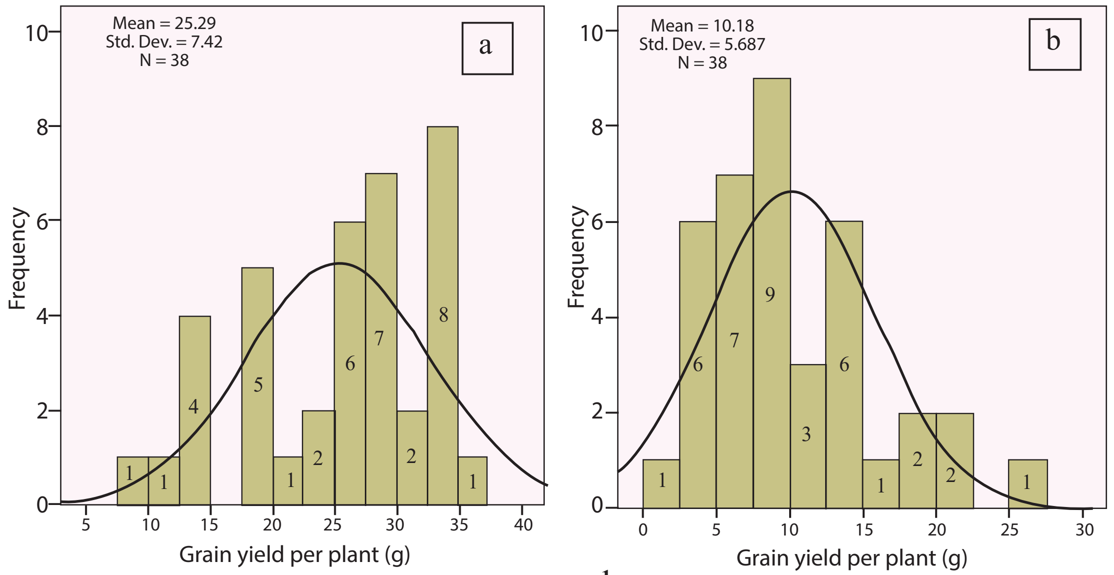

Fig. 7. Frequency distribution of grain yield plant^{-1} of rice genotypes under (a) control and (b) drought condition.

attributes such as flowering duration, plant height, tiller numbers, panicle numbers, grain filling percentage and 1000-grain weight. Drought stress at vegetative stage reduces water content and lower leaf water potential, leading to reduce turgor, stomatal conductance, and photosynthesis, and ultimately reduce grain yield (Akbarian *et al.*, 2011; Amini *et al.*, 2014).

Straw weight plant^{-1}

Under control condition, straw weight of rice genotypes ranged between 22.01 to 97.70 g plant^{-1} with a mean of 50.19 g. The frequency distribution of plant straw showed almost normal distribution with skewed towards right (α = 0.667) indicating that few of the genotypes were around median and most of them were more than median (Fig. 8a). Among the 38 genotypes, plant straw of 27 genotypes ranged from 22.01 to 60.0 g, straw weight of nine genotypes ranged from 50 to 80 g and another two genotypes showed plant straw weight more than 80 g (Fig. 8a). Under drought condition, plant straw weight ranged between 20.0 and 70.0 g with a mean of 44.97 g. The frequency distribution showed almost normal distribution with slightly skewed towards right (α = 0.109) indicating that most of the genotypes were more than median (Fig. 8b). Among the 38 genotypes, plant straw weight of 16 genotypes ranged from 20.0 to 40.0 g, straw weight of 18 genotypes ranged from 40.0 to 60.0 g and another four genotypes showed plant straw more than 60.0 g (Fig. 8b). The above results indicated that plant straw was decreased due to drought stress. This may reflect the impact of water stress on root cell development, which would likely impair nutrient uptake as well as having detrimental effects on photosynthesis, which is essential for biomass accumulation and

Table 2. Effect of drought stress on grain yield and yield reduction (%) of 38 rice genotypes

Genotypes	Grain yield at control (g/plant)	Grain yield at drought (g/plant)	% yield reduction
BRRI dhan 43(check)	34.18	18.08	47.10
BU Acc 2	34.29	5.84	82.97
BU Acc 3	34.54	11.37	67.08
BU Acc 4	32.56	4.06	87.52
BU Acc 5	14.71	4.91	66.62
BU Acc 6	25.33	15.82	37.54
BU Acc 7	19.03	9.09	52.22
BU Acc 8	29.69	6.11	79.41
BU Acc 9	25.47	7.53	70.43
BU Acc 10	27.11	13.79	49.13
BU Acc 11	23.15	12.13	47.60
BU Acc 12	27.68	12.72	54.04
BU Acc 13	34.28	6.75	80.31
BU Acc 14	27.62	9.64	65.10
BU Acc 15	25.63	14.25	44.39
BU Acc 16	29.13	8.71	70.10
BU Acc 17	24.73	7.44	69.91
BU Acc 18	17.73	2.62	85.22
BU Acc 19	27.96	13.53	51.61
BU Acc 20	32.72	19.12	41.56
BU Acc 21	31.16	20.58	33.94
BU Acc 22	28.99	5.5	81.02
BU Acc 23	14.04	8.56	39.04
BU Acc 24	19.67	9.18	53.32
BU Acc 25	20.72	10.21	50.72
BU Acc 26	18.38	8.93	51.40
BU Acc 27	13.85	5.17	62.67
BU Acc 28	29.60	13.99	52.73
BU Acc 29	11.82	2.84	75.97
BU Acc 30	33.41	21.81	34.72
BU Acc 31	31.73	9.77	69.20
BU Acc 32	9.05	2.31	74.46
BU Acc 33	35.65	26.68	25.15
BU Acc 34	18.84	7.1	62.32
BU Acc 35	13.07	4.91	62.44
BU Acc 36	25.47	13.47	47.10
BU Acc 37	32.93	7.71	76.58
BU Acc 38	25.21	4.73	81.24

Averages from three independent experiments are shown.

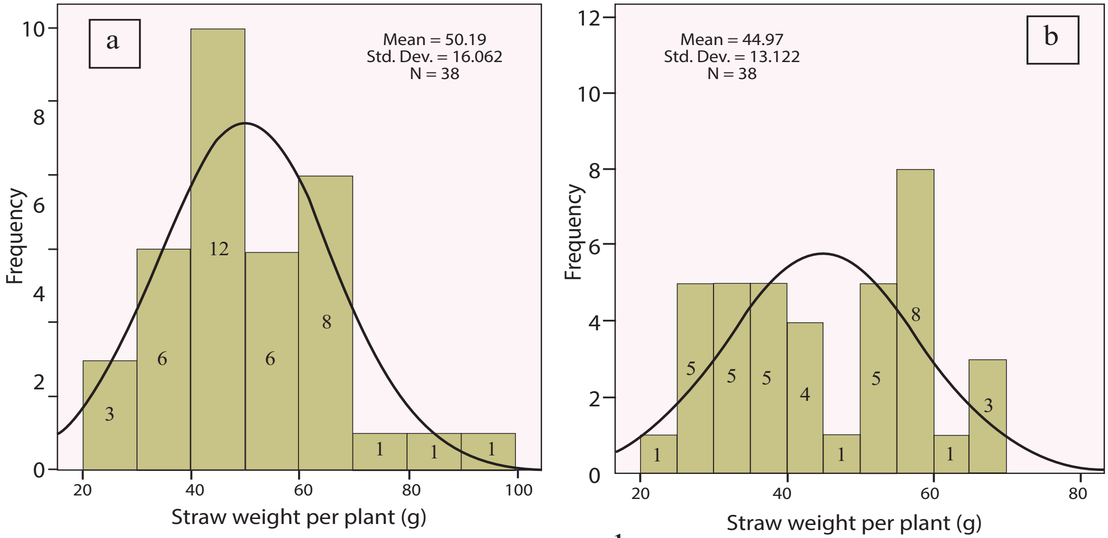

Fig. 8. Frequency distribution of straw weight plant^{-1} of rice genotypes under (a) control and (b) drought condition.

therefore on shoot and root elongation. Due to the reduction in turgor pressure under stress, cell growth is severely impaired and reduced straw weight of rice (Taiz and Zeiger, 2006). Table 1 shows that plant height, total tiller hill^{-1} and effective tiller hill^{-1} has a positive and significant correlation with straw weight plant^{-1} under drought stress. According to Blum (2005), some genotypes have the mechanism of maintaining high plant water status despite of having more biomass and plant height due to less water using ability and more water absorbing capacity. This mechanism provided a good explanation for the significant positive correlation between plant height and straw weight.-

Biplot analysis

PC1 and PC2 biplot graph clearly indicated that grain yield plant^{-1} showed more acute angle with filled grain panicle^{-1}, total tiller hill^{-1}, panicle number hill^{-1} and 1000-grain weight, whereas grain yield plant^{-1} showed

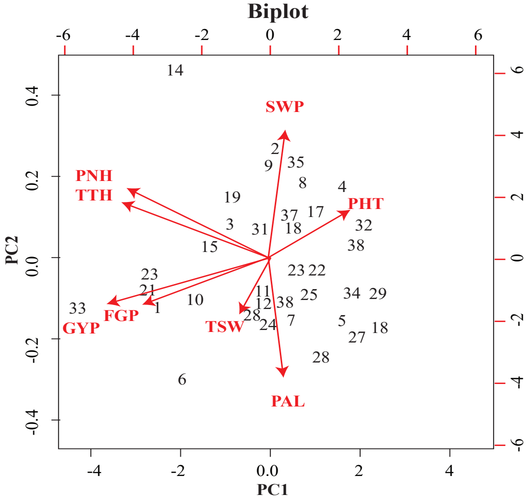

Fig. 9. Principal Components Analysis (PCA) ordination graph between PC1 and PC2. Position of rice genotypes from the selected germplasm pools along first two axes obtained from PCA, where PHT= Plant height (cm), TTH= Total tiller hill^{-1}, PNH= Panicle number hill^{-1}, PAL= Panicle length (cm), FGP= Filled grains panicle^{-1}, TSW= Thousand grain weight (g), GYP= Grain yield plant^{-1} (g), SWP = Straw weight plant^{-1}.

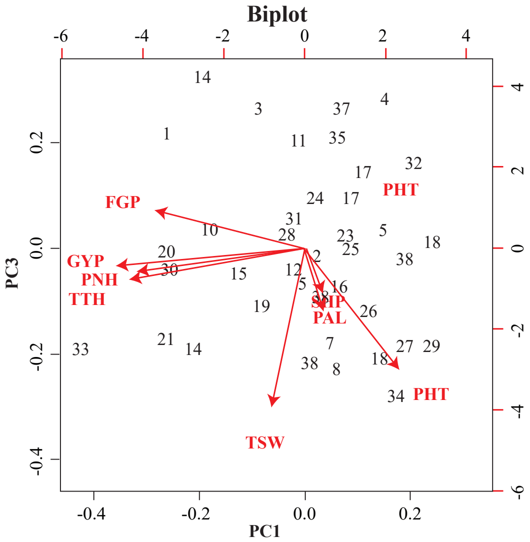

Fig. 10. Principal Components Analysis (PCA) ordination graph between PC1 and PC3. Position of rice genotypes from the selected germplasm pools along first and third axes obtained from PCA.

obtuse angle with plant height (Fig. 9). In PC1 and PC3 biplot graph, grain yield plant^{-1} showed strong correlation with panicle number hill^{-1}, total tiller hill^{-1}, filled grain panicle^{-1} and negative correlation with plant height and straw weight plant^{-1} (Fig.10).

Conclusion

Rice is one of the most important leading cereal crops in the world. Different plant characters rice viz. plant height, total tillers hill^{-1}, panicle number hill^{-1}, length of panicle, filled grains panicle^{-1}, 1000-grain weight, grain yield plant^{-1} and straw weight plant^{-1} showed wide range of variation under different water levels. However, under drought stress, the genotype BU Acc 33 showed the highest grain yield plant^{-1} (26.68 g) followed by BU Acc 30 (21.81 g), and BU Acc 21 (20.58 g). On the basis of the genotypic performance in relation to yield and yield attributes BU Acc 33, BU Acc 30 and BU Acc 21 were identified as promising genotypes for developing drought tolerant variety (ies).

Acknowledgements

The authors would like to acknowledge their gratitude towards university authority for the financial support from Research Management Wing (RMW) of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur 1706, Bangladesh.

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