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M.T. ISLAM

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WATER STRESS TOLERANCE IN HYBRID RICE

M.T. ISLAM

Crop Physiology Division, Bangladesh Institute of Nuclear Agriculture, Mymensingh-2202, Bangladesh.

Corresponding author & address: Dr. Md. Tariqul Islam, E-mail: islamtariqul05@yahoo.com
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ABSTRACT

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Climate changes are causing frequent and severe droughts. Such circumstances emphasize the need to understand the response of plants to drought stress, especially in rice, one of the most important grain crops. Therefore, a pot experiment was carried out in Aman season at Bangladesh Institute of Nuclear Agriculture, Bangladesh under drought to find out drought tolerant rice genotypes based on yield and yield attributes. Three treatments (40, 60 and 100% FC) were imposed on five hybrid rice (Dhanigold, BRRI Hybrid-6, Binadhan-7, Agrodhan-12 and Arize-7006) at booting stage and continued to maturity where data on yield and yield attributes were recorded. Growth and yield attributes were significantly (P>0.05) decreased at both 40 and 60% FC. At 40 and 60% FC, drought tolerance mechanism(s) was done based on effective tillers plant^{-1}, filled and unfilled grains panicle^{-1}, 1000-grain weight, yield and total dry matter plant^{-1}. The rice genotypes Arize-7006 and Dhanigold showed less reduction in yield and yield attributes compared to other genotypes. Therefore, based on yield and yield attributes Arize-7006 and Dhanigold showed tolerance in compare to other genotypes.

Key words: *drought, booting stage, hybrid, rice, yield*

INTRODUCTION

Producing more rice (*Oryza sativa* L.) with less water is a formidable challenge for the food, economic, social and water security (Singh *et al*. 2010). Climate model predicts 33% rice yield decrease in 2100 (Karim *et al*. 2012). Hybrid rice provides an option for achieving high yield potential under favorable conditions, shows variability in drought response but the performance of hybrids under drought stress has not yet been fully evaluated (Joselito *et al*. 2011). Grain filling is the final stageof growth in cereals where fertilized ovaries develop into caryopses. In today's cropproduction systems with high yield outputs, improvement in grain filling has becomemore challenging than ever before (Saini and Westgate, 2000). Grain filling in cerealsdepends on carbon from two sources: current assimilates transferred directly to thegrain and assimilates redistributed from reserve pools in vegetative tissues either priorpost-anthesis (Schnyder 1993). Under adequate moisture conditions, pre-anthesisassimilate, reserves of rice (*Oryza sativa)* contribute 10–40% of the final grain weight (Schnyder 1993). Water stress occurringduring early grain development curtails the kernel sink potential by reducing thenumber of endosperm cells and amyloplasts formed (Saini and Westgate, 2000), thusreducing grain weight as a result of a reduction in the capacity of the endosperm toaccumulate starch, in terms of both rate and duration. Rice grain dry weight increased from fertilization to 18-21 days and water stress decreased the rate of accumulation and finally produced decreased grain weight under water stress (Moonmoon *et al*. 2020a; Hafiz *et al*. 2015; Islam 2010; Islam and Gretzmacher, 2001).The yield of rice is an integratedresult of various processes including canopy photosynthesis, conversion of assimilatesto biomass, and partitioning of assimilates to grains (Jeng *et al*. 2006). Drought stressaffects plant growth and development, and ultimately reduces grain yield of rice (Moonmoon *et al*. 2020b; Islam *et al*. 2005a; Zohora *et al*. 2016; Islam *et al*. 1994b). The response of rice yield to drought varies with growth stagebeing most sensitive at booting followed by flowering and or grain filling stage (Islam *et al*. 1994a). The early reproductive growth period, encompassing tetrad-formation stage of miosis (i.e., about 10-15 d prior to heading), was found to be the most sensitive and critical to water deficit resulting in up to 59% grain sterility that caused similar magnitude of yield reduction. As the grain formation progressed further, the early period of grain-filling was found to be more vulnerable to water stress than the late-milk stages (Singh *et al*. 2010). Amanrice is rain fedcultivated during June–December. It passes through vegetative stage during August to September when rainfall is usually sufficient. The crop suffers from moisture stresswhen the rainfall usually ceases by the first week of October in Bangladesh. By thistime, it passes through reproductive. The total rainfall in these two months is veryirregular and often inadequate which fails to meet the evapotranspirational demand of Aman rice consequently develops water stress and affects translocation of assimilatesand grain development in rice (Rahman *et al.* 2002). With all those factors above in mind, this study was carried outdetermining the drought tolerant rice genotypes in drought prone areas under droughtconditions imposed at booting stage with particular emphasis on yield and yieldattributes.

MATERIALS AND METHODS

The experiment was conducted at the pot yard of the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, Bangladesh. The experimental site falls under the AEZ (Agro-Ecological-Zone)-9 (Old Brahmaputtra Floodplain) of Bangladesh andsituated at latitude 24.75°N and longitude of 90.50°E. The soils of the experimentwere collected from the field of BINA Farm. The top soil was non-calcareous DarkGrey Floodplain with loamy texture belonging to the AEZ Old Brahmaputtra Floodplain. The collected soil was pulverized, inert materials, visible insect pest andplant propagules were removed. Pots are filled with top soils. The pot was 25 cm deepwith 27 cm diameter at the top. The pots were placed under polythene sheet at the potyard of Crop Physiology Division, BINA, Mymensingh. The soil moisture stresseswere calculated based on field capacity (FC). Gravimetric Method determined FC. FCof the soil was used as 100% (control) and 40 and

60% of FC was used as drought stress. Each pot contained 12 kg soil. All soils pots were fertilized with urea, TSP, MP and gypsum @ 3.08, 0.70, 1.12 and 0.707 g pot^{-1}, respectively. All TSP, MP, Gypsum and one-third of the urea wereapplied as basal dose. The remaining two-thirds of the urea were applied in two equalsplits in each pot at 25 and 45 days after transplanting (DAT). One seedling was transplanted in a puddle pot. For gap filling there were extra seedlings preserved. Allnecessary intercultural operations, mainly weeding, and irrigation was done as andwhen necessary. The pot experiment was conducted with five hybrid rice *viz.* Dhanigold, BRRI Hybrid-6, Binadhan-7, Agrodhan-12 and Arize-7006. The experiment was set in a two factorial CRD with three replications in Aman season (2019-2020). The first factor was rice genotypes and the second factor wasirrigations: control (100% FC) and drought (40 and 60% FC) stressestreatments at Bangladesh Institute of NuclearAgriculture, Mymensingh, Bangladesh. Drought was imposed at booting stage andcontinued to maturity.At maturity, data on plant height, number total tillers, effective tillers plant^{-1}, filled grains and unfilled grains panicle, 1000-grain wt., yield and total dry matter plant^{-1} were recorded. Data were analyzed statistically following Completely Randomized Design by MSTAT-C computer package program.

RESULTS AND DISCUSSION

Results showed that plant height, number of total tillers, effective tillers plant^{-1}, filled grains panicle^{-1}, 1000-grain weight, yield and total dry matter plant^{-1} decreased but unfilled grains panicle^{-1} increased with water stress (Table 1). The results are in conformity with many researchers (Moonmoon *et al*. 2020c; 2017; Moonmoon and Islam 2017; Islam *et al*. 2012; 2005b; 2005c; Islam 2001). Among the genotypes, Arize-7006 produced higher yield followed by Dhanigold. These two genotypes also showed higher total dry matter. Other three genotypes showed similar yield and total dry matter under water stress treatments. Yield and total dry matter drastically reduced in all the varieties due to water stress (Table 2). However, Arize-7006 and Dhanigold reduced less yield and total dry matter under water stress treatments and showed tolerance to water stress.

Table 1. Effect of water stress on growth and yield of rice genotypes

Treatment	Plant height (cm)	Total tiller plant^{-1}	Effective tiller plant^{-1}	Filled grain panicle^{-1}	Unfilled grain panicle^{-1}	1000-grain wt. (g)	Yield plant^{-1} (g)	TDM plant^{-1} (g)
Control	107.7a	33.53a	30.33a	126.4a	21.92b	24.52a	31.47a	95.63a
60% FC	82.20b	29.27ab	20.47b	88.32b	40.69a	23.86b	23.53b	66.69b
40% FC	71.07c	26.33b	14.20c	70.52b	47.05a	23.70b	20.53b	67.91b
Variety								
Dhanigold	101.7a	37.44a	24.67a	115.1a	45.62a	25.11b	29.00ab	101.9a
BRRI Hybrid-6	89.67ab	30.33b	22.89b	88.18a	40.73ab	23.04c	22.56bc	59.93b
Binadhan-7	65.56c	29.33b	19.22b	51.02b	33.31b	22.23d	17.76c	51.73b
Agrodhan-12	80.56b	24.44b	18.33a	107.2a	39.91ab	26.76a	21.78bc	65.82b
Arize-7006	97.56a	27.00b	23.22a	113.9a	23.20c	23.01c	34.78a	104.3a

In a column, figure(s) with same letter or without letter do not differ significantly at P ≤ 0.05 by DMRT

Table 2. Interaction between variety and water stress on growth and yield of rice genotypes

Interaction	Plant height (cm)	Total tiller plant^{-1}	Effective tiller plant^{-1}	Filled grain panicle^{-1}	Unfilled grain panicle^{-1}	1000-grain wt. (g)	Yield plant^{-1} (g)	TDM plant^{-1} (g)
V1T1	113.07ab	44.00a	34.67a	139.2a	19.86de	25.60c	38.67b	128.9a
V1T2	100.3abc	37.33ab	19.67efg	108.2ab	54.93ab	24.87d	26.67bcd	83.27bcd
V1T3	91.0abc	31.0a-d	19.67efg	97.80abc	62.07a	24.86d	21.67cde	93.60b
V2T1	103.3abc	3.33abcd	27.33bcd	126.2ab	21.53de	23.53e	26.67bcd	68.80b-f
V2T2	85.67c	34.67abc	25.33de	84.0a-d	36.33cd	22.94f	21.67cde	59.53d-g
V2T3	80.00cd	26.0bcd	16.00fgh	54.33bcd	64.33a	22.64fgh	19.33cde	51.47efg
V3T1	97.33abc	38.67ab	31.67abc	100abc	31.33cde	22.90ghi	26.67bcd	76.50b-e
V3T2	42.67e	28.67bcd	15.67gh	30.07cd	32.67cde	22.09i	15.0de	43.47fg
V3T3	56.67de	20.67cd	10.33hi	23.00d	35.93cd	22.20hi	11.67e	35.23g
V4T1	107.3abc	28.33bcd	26.00cd	133.80a	19.27de	27.50a	13.67de	66.17b-f
V4T2	86.67bc	25.33bcd	19.67efg	101.90abc	44.47bc	26.57b	30.0bc	62.27c-g
V4T3	47.67e	19.67d	9.33i	85.93a-d	56.00ab	26.22b	21.67cde	69.03b-f
V5T1	117.0a	26.33bcd	32.00ab	132.80a	17.60e	23.59e	51.67a	137.8a
V5T2	95.67abc	20.33cd	22.00def	117.5ab	35.07cd	22.84fg	24.33b-e	84.93bcd
V5T3	80.00cd	34.33abc	15.67gh	91.53a-d	16.93e	22.59fgh	28.33bcd	90.23bc

In a column, figure(s) with same letter or without letter do not differ significantly at P ≤ 0.05 by DMRT

Where, V1=Dhanigold, V2=BRRI Hybrid-6, V3=Binadhan-7, V4=Agrodhan-12, V5=Arize-7006, T1=Control, T2=60% FC and T3=40% FC.

CONCLUSION

Water stress decreased plant height, number of total tillers, effective tillers plant^{-1}, filled grains 1000-grain wt., yield, total dry matter plant^{-1} and harvest index and increased and unfilled grains panicle^{-1}. Arize-7006 and Dhanigold reduced less yield and total dry matter under water stress treatments and showed tolerance to water stress.

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