J. Sher-e-Bangla Agric. Univ., 10(1 & 2): 27-34, January & July 2019 ISSN 1997-6038

STUDY ON THE LEAF TRAITS OF AUS RICE GENOTYPES IN VARIOUS SOIL MOISTURE LEVELS

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ABSTRACT

An experiment was carried out at Sher-e-Bangla Agricultural University farm, Dhaka, Bangladesh during the period from March to July 2013. Plants were grown in the rain protected polyethylene shelter or shed in earthen pots to avoid rain under natural conditions. The experiment was conducted on the leaf traits of aus rice varieties in various soil moisture levels. The ten rice genotypes were used as treatment i.e. BR21, BR24, BRRI dhan42, BRRI dhan43, BRRI dhan48, BRRI dhan55 and lines BR6976-11-1, OM1490, BR6976-2B-15 and water deficit tolerant variety Hashikalmi were treated with different duration of water deficiency such as continuously irrigated throughout the experimental period, normal irrigation up to 30 days and after that no irrigation for 7 days, then irrigated continuously and normal irrigation up to 30 days and after that no irrigation for 15 days and then irrigated continuously. Our findings suggest that BRRI dhan55 and Hashikalmi produced the highest leaf areas, comparatively higher SPAD value and low leaf rolling. Low leaf rolling score is considered as comparatively resistant to water deficit condition. It was revealed that BRRI dhan55 and Hashikalmi showed comparatively higher leaf investment under water deficit condition among the rice genotypes.

Keywords: genotypes, leaf rolling, water deficit

INTRODUCTION

Water deficit is a major problem of growing rice, especially in low rainfall season (Usman *et al.*, 2013). It was also reported that water deficit is one of the major environmental threat to rice cultivation and production (IRRI 2005). Rice is more susceptible to drought than any other crops. It is estimated that the world needs to produce 40% more rice to feed the population by 2025 (FAO, 2002).

The leaf area is an important trait which is related to plant canopy photosynthetic and dry matter production. Leaf is the main light harvesting organ. Biswal and Kohli (2013) observed a positive correlation between leaf traits and yield under drought. Zubaer *et al.* (2007) stated that the interaction effect of different moisture levels and rice genotype of leaf area per hill at all growth stages was significant and the highest leaf area at booting stage was found. The leaf area was reduced with the reduction of moisture levels in the soil. It was also reported that the reduced soil moisture levels produced lower leaf area; might be due to inhibition of cell division of meristematic tissue under water starved condition (Aggarwall and Kodundal, 1988 and Hossain, 2001). The leaf rolling under water stress condition was observed by Zulkarnain *et al.* (2009) and found that the sensitive rice varieties showed higher leaf rolling score and the tolerant cultivars showed lower leaf rolling. It was reported that the exposure of plants to drought stress substantially decreased the leaf water potential, relative water content and transpiration rate, with a concomitant increase in leaf temperature (Siddique *et al.*, 2001). Jaleel *et al.* 2008 reported that although components of plant water relations are affected by reduced availability of water. Severe water stress may result in the arrest of photosynthesis in leaf, disturbance of metabolism and finally the death of plant. Therefore, to our knowledge little or no study has conducted to find the effects of water deficit on rice genotypes with reference to changing leaf morphology. Considering the above mentioned facts, the present research work was undertaken to achieve the following objectives to study on the leaf traits of aus rice varieties under various water deficit condition and to identify the drought tolerant rice varieties suitable for cultivation in drought-prone areas of Bangladesh.

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MATERIALS AND METHODS

The experiment was conducted at Botany research field and plant physiology laboratory of Agricultural Botany Department of Sher-e-Bangla Agricultural University, Dhaka-1207 under polythene shed controlling the intrusion of rainfall during the period from March to July 2013. A total of ten rice genotypes as BR21, BR24, BRRI dhan42, BRRI dhan43, BRRI dhan48, BRRI dhan55 and lines BR6976-11-1, OM1490, BR6976-2B-15 and water stress tolerant variety Hashikalmi were collected from Genetic Resource and Seed Division, Bangladesh Rice Research Institute (BRRI).

Seed treatment and sowing

Seeds of uniform size and shape of each genotype were treated with Bavistin 5g for 20 minutes. The solution was prepared by dissolving 5 g of Bavistin in 1/2 liter of water. Treated seeds were place in the Petridis with water. Pre-soaked sprouted seeds were sown on March, 2013 in earthen pots under the rain protected polyethylene shade. The sprouted seeds were normally irrigated for ensuring normal growth of seedlings.

Pot preparation and fertilizer management

Earthen pots of 38 cm x 25 cm in size were used and filled up with 10 kg sandy loam soil. The soil of the pot was fertilized uniformly with 0.9, 0.8, 0.8 g urea, triple super phosphate and muriate of potash corresponding to 160-150-150 kg urea, triple super phosphate and muriate of potash per hectare, respectively. (BRRI, 2008)

Design and drought treatments were

The experiment was laid out in Randomized Complete Block Design (RCBD) considering three replications, ten rice genotypes (90 pots) were used as treatments with different duration of water deficiency.

Thinning, intercultural operations, and weeding

Seedlings were thinned out after two weeks of establishment and five healthy seedlings of uniform size were kept for growth per pot. Normal agricultural practices were applied for all treatments. Intercultural operations, weeding, top dressing was done whenever it was necessary. Adequate plant protection measures were taken to keep the plants free from diseases and pests.

General observation and detailed procedures of the experiment

All the pots were irrigated up to thirty days of seedlings age for ensuring normal growth. Water deficit was imposed on 31 days old seedlings. A total of ten rice genotypes were used as treatment. Ten treatments with different duration of water deficiency i.e. normal irrigation throughout the experimental period, water deficit was imposed for 7 days on 31 days old seedlings in 10 genotypes and after that irrigation was done continuously until harvest and water deficit was imposed for 15 days in 10 genotypes on 31 days old seedlings and after that the plants were irrigated continuously until harvest.

Detailed procedures of recording data

Different leaf traits parameters leaf area, SPAD value, plant height and leaf rolling were recorded at different stages of plant.

Plant height at maturity

Plant height (cm) was determined by measuring from the joint of root and stem to the tip of flag leaf.
SPAD value (Soil Plant Analysis Development) SPAD value was recorded using SPAD meter.

Leaf area
Ten leaves were selected from plant samples and their length and breadth were measured and was multiplied by a factor of 0.75 (Yoshida, 1981). Leaf area was measured with the following formula: Leaf area (L) = k x l x w where, k = adjustment factor (0.75), l = length of a leaf blade, w = breadth of a leaf blade. The Leaves were packed with brown paper and oven dried for 72 hours at 72^0C. Dry weight of leaves was recorded.

Leaf rolling
Leaf rolling was assessed visually in each pot, in all the treatment. The pots were given mean leaf rolling score, ranging from 1 to 5 with 1 being flat and 5 a tightly rolled (O'Toole *et al.*, 1978).

Statistical analysis
The data were statistically analyzed following MSTAT-C software package and the mean differences were adjusted by Duncan's Multiple Range Test (DMRT) at 5% level of significance, (Russell, 1986).

RESULTS AND DISCUSSION

Plant height
Plant height of different rice genotypes under water deficit condition have been shown in the table 1. Significant differences were found among the varieties and the treatments for the character of plant height. At 7 days duration of water deficiency, the highest plant height found was 112 cm in BRRI dhan55, the second highest was found 108.7 cm in Hashikalmi and the lowest plant height found was 70 cm in BR6976-2B-15. At 15 days duration of water deficiency, the highest plant height was found 96 cm in Hashikalmi and the lowest was found 67.33 cm in BR6976-2B-15. At no stress the highest plant height found was 115 cm in Hashikalmi and the second highest plant height was found 114 cm in BRRI dhan55 and the lowest plant height was 74.67 cm in BR6976-2B-15.

When water stress was applied at early stage of plant growth, the plant height was retired. Plant height of different rice genotypes under water stress condition found significant reduced compared with the control. Variation in plant height among the genotypes also indicates that different genotypes had different water requirement. The results has the similarity with the results of Bokul *et al.* (2009) who stated that plant height is affected by drought stress. This reduction in growth might be due to low osmotic potential as well as a decrease in wall extensibility and cellular expansion (Mohammadkhani and Heidari, 2008). Zubaer *et al.* (2007) found that under water stress plant height affected at booting, flowering and maturity stages.

Leaf area
Leaf area of different rice genotypes under water stress conditions have been shown in the table 2. Significant differences were found among the varieties and the treatments for leaf area. At 7 days water stress the highest leaf area was found 47.27 cm^2 in BRRI dhan55 and the lowest was 36.96 cm^2 in BRRI dhan42. At 15 days drought stress the highest leaf area found was 39.34 cm^2 in BRRI dhan55 and the lowest was 28.93 cm^2 in BR21. At control the highest leaf area found was 59.78 cm^2 in Hashikalmi and 58.44 in BRRI dhan55 and the lowest was 40.69 cm^2 in BR24.

At 7 and 15 days water stress the reduction percent of leaf area were found 18.94 and 48.55 in BRRI dhan55 respectively compared to control. In this study, leaf area varied significantly in different genotypes under different duration of water stress condition. The results has been agreement with the results of Wullschleger *et al.* (2005) who reported that water deficit stress mostly reduced leaf growth and in turn the leaf areas in many species of plant like Populus. Drought stress suppresses leaf expansion and midday photosynthesis and reduces photosynthesis rate and leaf area due to early senescence (Kramer and Boyer, 1995). It was reported that reduced soil moisture levels produced lower leaf area and this might be due to inhibition of cell division of meristematic tissue under water starved treatment (Zubaer *et al.*, 2007). These results are also in agreement with Aggarwall and Kodundal

(1988) and Hossain (2001). Gloria *et al.* (2002) also reported that the water deficit in rice caused a larger reduction in leaf area than shoot dry matter, greater sensitivity of leaf enlargement to water stress than dry matter accumulation. Kumar *et al.* (2014) was found that drought stress at reproductive stage caused reduction in leaf area (34.87%). Therefore, all together it suggested that the leaf area of rice genotypes decrease under water deficit conditions in the soil.

SPAD value after anthesis

The SPAD value of different rice genotypes under water stress condition have been shown in the Table 3. SPAD reading was recorded from the flag leaf of all tillers after anthesis. At 7 days duration of water deficiency, the significant highest SPAD value found was 46.17 in BRRI dhan55 and the lowest was 38.47 in OM1490. At 15 days duration of water deficiency gave the highest SPAD value found was 45.50 in BRRI dhan55, the lowest was 38.03 in OM1490. At control the highest SPAD value found was 46.67 in BRRI dhan55 and the lowest was found 41.33 in OM1490.

Table 1. Effect of different duration (days) of water deficit on plant height of different rice genotypes

Genotypes	Plant height (cm)		
	No water deficiency	7 days water deficiency	15 days water deficiency
BR21	102.0 c	95.00 bc	75.33 c
BR24	105.0 c	98.33 b	95.67 a
BRRI dhan42	101.0 c	96.00 bc	77.50 c
BRRI dhan43	102.7 c	94.67 bc	85.50 b
BRRI dhan48	103.0 c	99.00 b	95.33 a
BRRI dhan55	114.0 b	112.0 a	94.07 a
OM 1490	103.0 c	90.33 c	81.00 bc
BR 6976-2B-15	74.67 e	70.00 e	67.33 d
BR 6976-11-1	86.00 d	77.33 d	75.00 c
Hashikalmi	115.0 a	108.7 a	96.00 a

Values followed by different letter(s) indicate significantly different from each other by DMRT at 5% level.

Table 2. Effect of different duration (days) of water deficiency on leaf area of different rice genotypes

Genotypes	Leaf area (cm^2)		
	No water deficiency	7 days water deficiency	15 days water deficiency
BR21	41.16 d	39.64 b-d	28.93 c
BR24	40.69 d	39.13 b-d	30.79 bc
BRRI dhan42	46.33 cd	36.96 d	29.88 bc
BRRI dhan43	46.74 cd	38.48 b-d	29.39 bc
BRRI dhan48	54.31 a-c	44.60 a-c	34.86 a-c
BRRI dhan55	58.44 ab	47.27 a	39.34 a
OM 1490	53.00 a-c	37.52 cd	31.92 bc
BR 6976-2B-15	41.74 d	39.59 b-d	31.15 bc
BR 6976-11-1	48.01 b-d	39.97 b-d	29.54 bc
Hashikalmi	59.78 a	44.85 ab	35.63 ab
CV (%)	11.67	8.90	0.27

Values followed by different letter (s) indicate significantly different from each other by DMRT at 5% level

Table 3. Effect of different duration (days) of water deficiency on SPAD value of different rice genotypes

Genotypes	SPAD value		
	No water deficiency	7 days water deficiency	15 days water deficiency
BR21	45.07	41.63 b	40.20
BR24	44.67	42.70 b	40.89
BRRI dhan42	43.40	42.30 b	41.67
BRRI dhan43	43.33	42.50 b	40.37
BRRI dhan48	43.83	40.77 b	38.30
BRRI dhan55	46.67	46.17 a	45.50
OM 1490	41.33	38.47 d	38.03
BR 6976-2B-15	43.83	41.67 b	41.10
BR 6976-11-1	42.33	41.37 b	40.67
Hashikalmi	46.67	42.97 b	41.20
CV (%)	7.64	5.99	9.72

Values followed by different letter(s) indicate significantly different from each other by DMRT at 5% level.

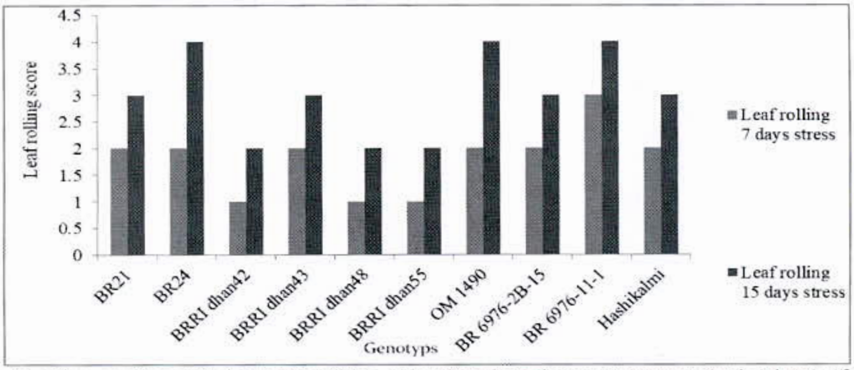

Fig 1. Leaf rolling scoring at 7 days stress (blue colour) and 15 days water stress (red colour) of different rice genotypes under water stress conditions.

SPAD value represents the greenness of the leaf SPAD value was recorded after anthesis. After anthesis SPAD value slightly increased and then gradually decreased with advanced towards maturity. In this study, at 7 days stress the highest SPAD value was found in BRRI dhan55 followed by Hashikalmi. This result has the similarity with the results of Zhang and Kirkham (1996) who advocated that decreased of chlorophyll content during drought stress depending on the duration and severity of drought level. Abaaszadeh *et al.* (2007) reported that chlorophyll concentration decreases under water stress condition. One of the most important changes under drought stress is the decrease in the total chlorophyll content reported by Begum and Paul (2007). Decreasing of chlorophyll content in plants such as *Paulownia imperialis* (Astorga, 2010) bean (Beinsan *et al.*, 2003) was reported under drought stress condition. The degradation of chlorophyll increases with the age towards maturity, as a result SPAD value gradually decreased from anthesis to maturity in all the genotypes.

Leaf rolling

Leaf rolling score is an eye estimation process of leaf rolling under water stress treatment. Leaf rolling score of different genotypes have been shown Fig. 1. At 7 days stress leaf rolling score was minimum and at 15 days stress leaf rolling score was recorded. It depends on intensity and duration of drought. At 15 days stress the highest leaf rolling score 4.1 was found in BR24, OM1490 and BR 6976-11-1 respectively, and the lowest leaf rolling scores 2 were found in BRRI dhan42, BRRI dhan48 and BRRI dhan55.

Leaf rolling may help in maintaining internal plant water status. Low leaf rolling score is considered as comparatively resistant to water stress. The results has the conformity with the results of Zulkarnain *et al.* (2009) who found that the sensitive rice varieties showed higher leaf rolling score and the tolerant cultivars showed lower leaf rolling. Leaf rolling under water stress condition helps plant to minimize water loss by transpiration, decreased leaf temperature and protect the plant from drying. After a long time, drought condition the leaves of all rice varieties (tolerant and sensitive) were rolled at midday. Higher proline content increased the RWC of the leaf and the leaf rolling was lower in this genotype. Ha *et al.* (2014) reported that the use of delayed leaf rolling under water stress as an important selection criterion for dehydration avoidance. Blum (1988) reported the use of delayed leaf rolling under water stress as important selection criteria for dehydration avoidance. Leaf rolling was considered to be a response to leaf water potential and has been found to correlate with leaf water potential in rice. Delayed leaf rolling was considered as a desirable character in rice (Maji, 1994) as also observed in BRRI dhan55. Mackill (1991) was reported that delayed leaf rolling positively related to drought resistance and recovery from drought. It was also reported that the leaf rolling is one of the acclimation responses of rice and is used as a criterion for scoring drought tolerance (Pandey and Shukla, 2015). However, it was also reported that increased leaf rolling under severe stress has the advantage of preventing water loss and radiation damage and variation in leaf rolling among varieties has a genetic basis (Subashri *et al.*, 2009; Salunkhe *et al.*, 2011). Thus, leaf rolling is an adaptive response to water deficit in rice, and leaf angle is a character usually associated with plasticity in leaf rolling when internal water deficit occurs (Chutia and Borah, 2012).

CONCLUSION

Based on the above discussion, the conclusion may be drawn as BRRI dhan55 and Hashikalmi showed better performance in all day's water deficit conditions. Under water stress conditions the highest leaf area, SPAD value was found in BRRI dhan55 and Hashikalmi. BRRI dhan55 and Hashikalmi showed comparatively higher leaf investment of leaf under water deficit condition.

ACKNOWLEDGEMENT

This Research was supported by Sher-e-Bangla Agricultural University Research System (SAURES) and HEQEP (Higher Education Quality Enhancement Project for providing financial support to conduct the research work.

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