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STUDY ON THE LEAF TRAITS OF AMAN RICE VARIETIES IN VARIOUS SOIL MOISTURE LEVELS

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ABSTRACT

An experiment was carried out at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from July to November 2014 to study the performance of four transplanted aman rice varieties (BRRI dhan56, BRRI dhan57, Binadhan-7 & BRRI dhan49) under three different soil moisture levels (100% field capacity moisture content or control, 70% of the control moisture and 40% of the control moisture). The experiment was carried out in a polythene shed controlling the intrusion of rainfall. The results indicated that leaf area, specific leaf area and relative water content were found to be the highest at 100% FC condition and the lowest at 40% FC condition; but the reduction was comparatively lower in BRRI dhan56 and BRRI dhan49. No leaf rolling was recorded in 100% field capacity moisture level and the highest leaf rolling was recorded at 40% field capacity moisture level. 70% field capacity moisture did not give any remarkable effect on BRRI dhan56 and BRRI dhan49. These varieties could be cultivated in drought-prone areas of Bangladesh providing 70% field capacity moisture.

Keywords: field capacity, leaf rolling, leaf traits, soil moisture

INTRODUCTION

In Bangladesh, rice is the key staple crop and there is no alternative of increasing rice production to feed the ever increasing population of Bangladesh. The second largest production of rice in Bangladesh comes from *aman* season after boro. Now a day, drought is one of the major problems in *aman* season due to prevailing climatic changes. After October, rainfall is not sufficient for potential yield of rice and most of the *aman* rice remains at the flowering and grain filling stage at that period. If water is not supplied on those farms rice yield will be reduced drastically (Sattar and Parvin, 2009).

Leaf is the main light harvesting organ. Biswal and Kohli (2013) observed a positive correlation between leaf traits and yield under drought. The leaf area is an important trait which is related to plant canopy photosynthetic and dry matter production. 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. They also reported that at booting stage, the highest leaf area was found at 100% FC in different rice genotypes and the leaf area was reduced with the reduction of moisture levels. It was reported that the effect of drought stress on leaf area at flowering and maturity stages was more or less similar as booting stage. They also found that the flowering stage was more critical than other stages. 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). Relative water content of leaves is higher in the initial stages of leaf development and declines as the dry matter accumulates and leaf matures. RWC related to water uptake by the roots as well as water loss by transpiration. It was also 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).

It was reported that although components of plant water relations are affected by reduced availability of water, stomatal opening and closing is more strongly affected by the extent of moisture supply. Zulkarnain *et al.* (2009) also observed that the relative water contents of different rice varieties were similar under the well-watered condition. However, RWC declines progressively in stressed plots with the development of severe water deficit. They also reported that the tolerant has relatively higher water content than the other varieties, even after 10 days of exposure to soil drying. Sinclair and Ludlow

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(1985) proposed that RWC is a better measure for plant's water status than thermodynamic state variables (water potential, turgor potential and solute potential). 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 also reported that after a long time drought condition the leaves of all rice cultivars (tolerant and sensitive) were rolled at mid day. Based on the above discussion, the experiment was designed to study the leaf traits of different *aman* rice varieties under various soil moisture levels and to identify the strongly drought tolerant rice varieties suitable for cultivation in drought-prone areas of Bangladesh.

MATERIALS AND METHODS

The experiment was conducted at the research farm and Plant Physiology Laboratory, Dept. of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka-1207 under polythene shed. The experimental field was situated in the sub-tropical region characterized by heavy rainfall during the month from May to September (above 1800 mm) and scantly rainfall in the rest of the year. The experiment was carried out in a factorial Randomized Complete Block Design (RCBD) with four replications. Soil moisture level such as 100% FC (field capacity) moisture = S_0 ii) 70% of the FC moisture = S_1 ii) 40% of the FC moisture = S_2 and rice varieties i.e. - i) BRRI dhan56 ii) BRRI dhan57 iii) Bina dhan7 and iv) BRRI dhan49 used as traditional varieties. The fertilizers were applied as per recommendation. The experiment was carried out in a polythene shed controlling the intrusion of rainfall. Data were collected during germination, seedling stage, at anthesis, during grain filling and at maturity. The Leaf area, specific leaf area, leaf weight ratio, relative water content and leaf rolling were computed as follows:

$\text{Leaf area} = k \times l \times w$, Where, k = adjustment factor, l = length of leaf blade and w = breadth of leaf blade.

$$\text{Specific leaf area (SLA)} = \frac{\text{Leaf area}}{\text{Dry weight of leaf}}\ (\text{cm}^2/\text{g})$$

The fresh, turgid and dry weights of the leaves were used to calculate the relative water content of leaves according to Ghannoum *et al.* (2002) as follows-

$$\text{RWC} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Turgid weight} - \text{Dry weight}} \times 100$$

Leaf rolling was assessed visually from each treatment as O'Toole and Moya (1978). The data were analyzed and the means were separated by DMRT at 5% level of significance using the statistical computer package program MSTAT-C (Russell, 1986). Correlation analysis was also done.

RESULTS AND DISCUSSION

Leaf area and specific leaf area

The results showed that leaf area was affected due to water stress treatment. Water stress decreased the leaf area in all the varieties. But there were no significant difference among the treatments in each variety. In all the varieties, S_0 (control treatment) produced the highest leaf area (Table 1). Considering all the varieties and soil moisture treatment, the leaf area was found the maximum (48.06 cm^2) in S_0 treatment of rice variety BRRI dhan57 which was statistically similar to other soil moisture treatments of those varieties except Binadhan-7 in all soil moisture levels. 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%).

Considering all the varieties and soil moisture treatment the SLA was significantly highest (276.88 cm^2/g) in S_0 treatment of BRRI dhan49 than any other treatments and lowest SLA (176.29 cm^2/g) was recorded in S_1 treatment of BRRI dhan56 which was statistically similar to the S_2 treatment of the same variety and with S_2 treatment of Binadhan7 (Table 1). The specific leaf area (SLA) was recorded the highest at control (S_0) treatment in all the varieties. The S_2 treatment produced the lowest SLA in all the variety also.

The overall results indicated that the SLA was decreased under drought treatment. The reduction in SLA under severe water stress is an adaptive mechanism to water stress helps in reducing water loss from the evaporative surfaces (Hayatu and Mukhtar, 2010) and the reduction in transpiration under water stress treatment. Farooq *et al.* (2010) stated that broader leaves result in better performance of *indica* rice under drought stress.

Table 1. Effect of different soil moisture levels on leaf area and specific leaf area of transplanted aman rice varieties

Varieties	Soil moisture Levels	Leaf area (cm^2)	Specific leaf area (cm^2/g)
BRRI dhan56	S_0	36.55±2.31 ab	221.52±8.67 bc
	S_1	36.14±2.32 ab	176.29±6.23 e
	S_2	35.09±2.31 ab	183.00±6.53 de
BRRI dhan57	S_0	48.06±2.42 a	246.46±9.89 b
	S_1	36.85±2.33 ab	223.33±8.56 bc
	S_2	35.33±2.30 ab	220.12±8.86 bc
BINA dhan7	S_0	33.81±2.28 b	220.98±8.77 bc
	S_1	25.18±2.12 b	209.83±7.53 cd
	S_2	33.45±2.21 b	199.11±6.83 c-e
BRRI dhan49	S_0	38.21±2.37ab	276.88±10.38 a
	S_1	34.24±2.25 ab	244.57±9.87 b
	S_2	37.41±2.39 ab	226.70±8.76 bc
$LSD_{(0.05)}$		12.06	29.88
CV (%)		23.38	9.41

S_0=100% FC (field capacity) moisture, S_1= 70% of the FC moisture, S_2= 40% of the FC moisture. Values followed by same letter (s) did not differ significantly at 5% level of probability.

Relative water content (RWC) of flag leaf during anthesis

The relative water content of leaf depends on the moisture content of the soil and the water absorbing capacity of the root. The result showed that the relative water content of flag leaf recorded at anthesis had significant difference among the soil moisture treatments for relative water content in each variety. The relative water content of leaf gradually decreased with decreasing soil moisture from control to S_2 treatment in all the rice varieties (Fig. 1). But the difference of RWC between S_0 and S_2 was lower in BRRI dhan49 and higher in BRRI dhan56. Considering all the varieties and soil moisture treatments, the highest RWC (96.43%) was recorded in S_0 treatment of BRRI dhan56 followed by Binadhan-7 and higher than other treatments. The lowest RWC (74.55%) was recorded in S_2 treatment of BRRI dhan56. It is also suggested that the high relative water content could help the tolerant variety to perform physio-biochemical processes more efficiently under water stress treatments than susceptible variety (Moussa and Aziz, 2008). Zulkarnain *et al.* (2009) stated that the relative water contents of different rice varieties were similar under the well-watered treatment on different measurement occasions and it declined progressively in stressed plots with the development of severe water deficit. The differences among the rice varieties in terms of the rate of decline in the leaf RWC could also be associated with the variations in other physiological responses to water stress, such as reduction in stomatal conductance. Kumar *et al.* (2014) was found a significant difference in RWC among different rice varieties between drought stress and irrigated treatment.

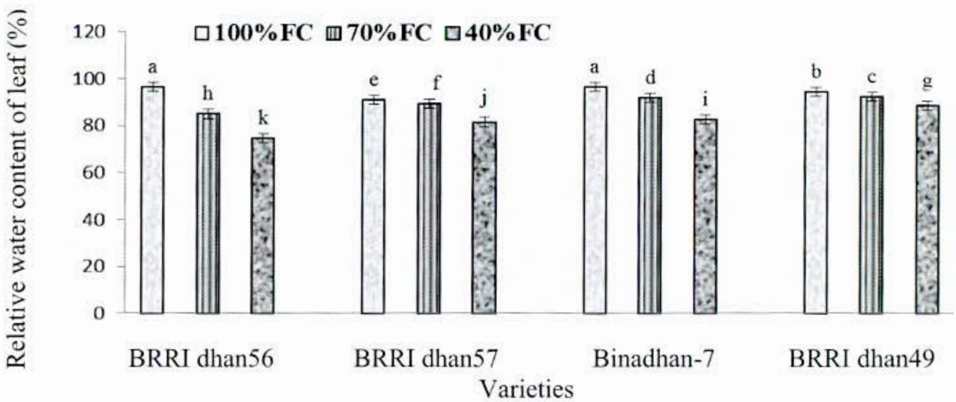

Fig. 1. Relative water content of leaf of different rice varieties under various soil moisture treatments. S_0=100% FC (field capacity) moisture, S_1= 70% of the FC moisture, S_2= 40% of the FC moisture. LSD = 0.17, values followed by same letter(s) did not differ significantly at 5% level of probability.

Leaf rolling score

The result showed that leaf rolling was not observed at S_0 or control treatment (Fig. 2) in all the varieties. The highest leaf rolling score was recorded at S_2 treatment in all the varieties. Under S_1 treatment, the score recorded was the highest (3.0) in Binadhan-7 which was significantly higher than any other varieties and the lowest (1.34) score was observed in BRRI dhan56 which was statistically similar to other varieties. Leaf rolling under water stress condition helps plant to minimize transpiration loss and protect the plants from drying.

The highest leaf rolling at S_2 treatment in all the varieties might be due to the lowest RWC of leaf under this treatment. But in BRRI dhan49, the leaf rolling was relatively lower in S_2 treatment compared to others and this might be due to higher proline accumulation in this variety under S_2 treatment. But in Binadhan-7, the highest leaf rolling under S_2 treatment might be due to lower proline accumulation as well as lower RWC under this treatment. Therefore, leaf rolling is commonly used as an important criterion during screening of varieties for drought tolerance (Cutler *et al.*, 1980; Sloane *et al.*, 1990; Rosario *et al.*, 1992; Lilley and Fukai, 1994). Accordingly, rice variety Binadhan-7 was found to be sensitive and BRRI dhan49 was found tolerant to drought. Leaf rolling and leaflet closure during periods of soil moisture depletion have also been observed in other varieties of rice (Lilley and Fukai, 1994). These leaf movements, such as the adjustment of leaf angle or modification of leaf orientation to reduce the interception of solar radiation and, thus, decrease leaf temperature and water loss by transpiration, are regarded as one of the drought avoidance mechanisms evolved in plants (Pugnaire *et al.*, 1999; Carr, 2001). The leaf rolling score of different rice varieties under drought stress was also stated by Zulkarnain *et al.* (2009). 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 dhan49. 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).

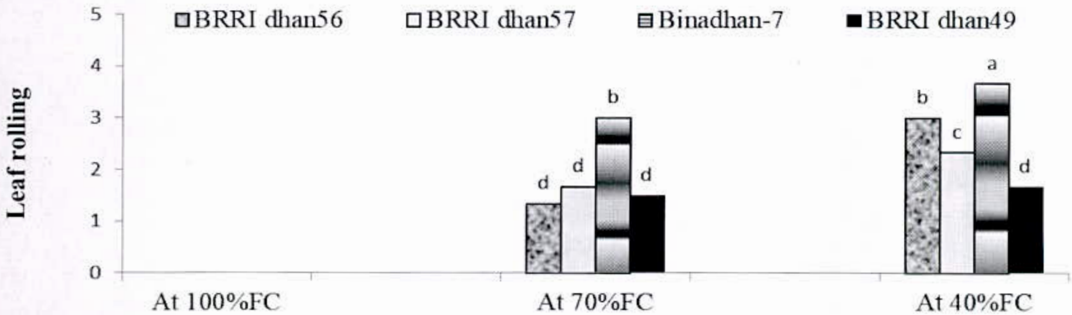

Fig. 2. Leaf rolling score of different rice varieties as influenced by various soil moisture levels. S_0=100% FC (field capacity) moisture, S_1= 70% of the FC moisture, S_2= 40% of the FC moisture. LSD = 0.45, values followed by same letter(s) did not differ significantly at 5% level of probability.

In all the variety, 100% FC condition produced the highest leaf area. The specific leaf area (SLA) was recorded highest at 100% FC in all the genotypes except BRRI dhan57 and 40% FC produced the lowest SLA in all the variety except BRRI dhan57. No leaf rolling was observed at 100% FC condition but the highest leaf rolling was observed at 40% FC condition. The relative water content of leaf gradually decreased with increasing water stress from 100% FC to 40% FC condition. Considering the above statement, it may be concluded that lower soil moisture content (40% of the field capacity) affected different morpho-physiological processes. It was revealed that BRRI dhan49 and BRRI dhan56 showed lower leaf rolling, relatively higher leaf area and specific leaf area, comparatively higher leaf investment and relative water content of leaf under water stress condition. These varieties could be cultivated under low soil moisture level (under 70% of the field capacity moisture) without any remarkable effect on different mopho-physiological processes.

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