Oryza Vol. 48. No. 4, 2011 (366-369)

Response of rice genotypes to water stress imposed at early seedling stage

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ABSTRACT

Twenty genotypes of rice were studied in response to water stress imposed at early stage seedling stress. The varietal variations and interactions differed significantly and the genotype Lakhokunwar highly maintained its water content followed by Banspor (68.26%). During recovery period, the genotypes Lakhokunwar reached to its maximum value (84.36 %) as that of control (irrigated) followed by Banspor (81.43%) and Uraibuta (81.16 %). The maximum chlorophyll stability index (CSI) was observed in Safrideshi (0.93) and minimum in Desilaldhan (0.71) under early seedling water stress condition.

Key words : *rice, water, stress, leaf rolling, seedling*

Rice is a semi aquatic monocot, grown in a wide range of ecological conditions. Upland rice cultivars suffer from intermittent moisture stress during critical growth stages especially during germination, tillering, panicle initiation and grain filling period leading to yield loss to a considerable extent. Plants under drought condition survive by doing a balancing act between maintenance of turgor and reduction of water loss (Yue, Bing *et al.* 2005). Plant expression during drought depends on action and interaction of different morphological, physiological and biochemical traits i.e. earliness, reduced leaf area, leaf rolling, efficient rooting system, high water use efficiency and stable chlorophyll content. Leaf rolling under water deficit is an indication of cultivars ability to continue to maintain a favourable water status under stress. Thus, the present study was carried to find out the response of rice genotypes to water stress imposed at seedling stage

MATERIALS AND METHODS

The experiments were conducted with twenty germplasm lines viz. Banspor Bewara, Hayagoda, Charida, Desilaldhan, Dhansafed, Dagadeshi, Bhejari, Ranikajar, Uraibuta, Safrideshi, Lakhokunwar, Dhour, Kanakchudi, Luchai, Bhatagurmatia, Mahamaya, Bas-370 , Poornima and Chiggi. Completely factorial randomized block design was adopted. Direct sowing was adopteed. After the emergence of the seedlings one uniform plant was maintained in each plot and other interculture operations were carried out from time to time when required. Pots were divided into three sets. The first set was normally irrigated whereas, second and third were subjected to moisture stress at 30 DAS by withholding water for a period of 10 days. For recovery the plants were irrigated after 10 days of withholding stress period. The observations on RWC, Chlorophyll stability index, leaf area , shoot length and root length were taken.

Shoot length was measured from the base to the tip of longest leaf at seedling stage and expressed in cm. Root length was also measured from the cut end to the base of longest root with cm scale and expressed in cm. To calculate the flag leaf area, the length and maximum width of leaves were recorded and a factor of 0.75 was used. It was expressed as cm^2.

Flag leaf area = Length x Width x K (Factor 0.75)

Visual observations for leaf rolling were taken from the leaves of stressed plant according to IIRI (SES) standard evaluation system given by Turner *et al.* (1986).

Relative water content was calculated according to the method given by Weatherly and Slatyer, (1957) as follows:

$$\text{RWC (\%)} = \frac{\text{Fresh weight} - \text{Oven dry weight}}{\text{Turgid weight} - \text{Oven dry weight}} \times 100$$

The chlorophyll stability index (CSI) was calculated by using the formula given by Yoga Meenakshi *et al* (2004).

$$\text{CSI} = \frac{\text{Chlorophyll content of stress leaf}}{\text{Chlorophyll content of normal leaf}} \times 100$$

All observations were taken at seedling stage under contol and stress condition and were statistically analysed.

RESULTS AND DISCUSSION

The results related to shoot length has been presented in Table 1. Under Rainfed condition, the highest shoot length was observed in Bhatagurmatia (23.80) followed by Hayagoda (23.10) and the lowest in Kanakchudi

Table 1. Impact of early seedling water stress on leaf area, shoot length, root length, chlorophyll stability index and relative water content of rice genotypes

	Leaf area		Shoot length		Root length		CSI	Relative water content		
Genotypes	Control	Stress	Control	Stress	Control	Stress		Control	Stress	Recovery
Banspor	17.03	15.06	26.00	22.00	17.40	17.33		87.20	68.26	81.43
Bewara	15.83	10.66	24.50	22.13	15.20	12.83		81.66	62.00	77.33
Hayagoda	17.06	13.70	25.70	23.10	16.16	14.00		82.00	63.00	70.00
Charida	17.13	13.63	24.43	20.33	16.30	13.73		83.00	68.10	73.00
Chiggi	9.63	7.06	24.30	17.83	10.66	9.03		78.66	60.00	64.00
Desi lal dhan	9.63	6.96	18.50	16.10	10.80	8.20		78.00	60.06	63.46
Dagad deshi	17.50	14.10	27.26	22.00	15.96	14.33		86.00	67.26	74.00
Dhan safed	17.53	11.70	25.80	22.20	17.40	14.20		85.00	68.00	74.00
Bhejari	16.90	11.10	24.80	21.10	15.53	12.50		85.00	67.20	72.00
Ranikajar	9.56	6.83	25.13	21.20	9.23	9.13		76.66	50.06	59.46
Urai buta	17.10	16.00	22.00	15.86	17.10	17.33		88.00	68.10	81.16
Safrideshi	16.83	13.66	24.16	18.20	11.80	11.90		79.06	61.00	68.00
Lakhokunwar	17.53	14.70	26.80	21.33	17.60	17.66		89.10	69.00	84.36
Dhour	12.36	8.90	21.50	15.60	13.03	13.00		80.20	62.00	70.00
Kanakchudi	9.53	7.00	20.33	15.30	9.73	10.70		78.00	52.00	56.00
Luchai	9.46	6.20	21.00	18.33	10.03	10.10		80.66	59.66	65.33
Bhatagurmatia	15.30	12.06	24.26	23.80	17.20	16.96		83.20	64.00	74.10
Mahamaya	15.63	11.13	18.16	16.56	14.90	15.10		80.33	64.00	70.13
Bas-370	17.13	15.36	26.00	22.00	16.50	16.83		84.06	67.43	78.00
Poornima	11.70	9.83	19.50	17.00	14.90	12.00		80.10	61.00	69.00
Mean	14.51	11.28	23.5	19.59	14.37	13.34		82.29	63.10	71.23

	Leaf area		Root length		Shoot length		Relative water content		Chlorophyll stability index	
Treatments	SEm	CD (p=0.05)	SEm	CD (p=0.05)	SEm	CD (p=0.05)	SEm	CD (p=0.05)	SEm	CD
Moisture level	0.06	NS	0.12	0.33	0.06	0.19	0.23	0.66	0.08	0.24
Genotypes	0.20	0.56	0.38	1.06	0.21	0.60	0.61	1.72	0.28	0.78
Moisture level x Genotypes	0.28	0.79	0.53	1.51	0.30	0.86	1.06	2.99	0.39	1.11

(15.30). The maximum difference among the genotypes under both the environment was observed in Chiggi (6.5) while the minimum by Mahamaya (1.6). Early seedling water stress condition reduced the shoot length by 0.16 percent. Singh (2000) reported that plant height reduced significantly due to drought in rice cultivars. The maintenance of plant height was directly proportional or related to the leaf water status, which favours the shoot growth through cell enlargement and cell division (Boyer, 1968).Reduction in leaf area under stress ranges from 1.10 to 5.83 percent. Under Rainfed condition, the highest leaf area was observed in Uraibuta (16.00) followed by Banspor (15.66) and the lowest was observed in Luchai (6.20). The stress reduced leaf area by 22.10 percent. Gloria *et al.* (2002) reported that the water deficit in rice caused a larger reduction in leaf area than shoot dry matter demonstrating the greater sensitivity of leaf enlargement to water stress than dry matter accumulation. Optimum leaf area provides the mean for intercepting the light and carrying out photosynthesis and ultimately the dry matter production.Findings are in close collaboration with the work of (Naidu *et al.*, 2001). The root length was reduced during early stress by 0.07 percent. The maximum difference among genotypes under both environments was observed in Dhansafed (3.20 cm). Kato *et al.* (2007) reported that the genotypes, which had deep root development, also had primarily advantageous for soil water extraction and plant water status under stress. The leaf rolling helps to conserve water by exposing less leaf surface to the environment. Ranikajar, Bewara, Desilal dhan and Bas-370 completely rolled their leaves during water stress period. Lafitte *et al.* (2002) reported that the rice leaves roll readily under water deficit and rolling has been noticed as an indication of a cultivar's ability to continue to maintain a favorable water status under stress condition.

Table 2. Leaf rolling of rice genotypes under rainfed condition at early water stress.

Genotypes	45	47	49	51	53	Mean
Banspor	1.0	1.8	2.1	2.2	2.2	1.9
Bewara	1.6	2.3	2.6	4.0	5.0	3.1
Hayagoda	2.0	2.0	2.6	3.0	4.0	2.7
Charida	1.6	2.0	2.3	3.0	3.0	2.4
Chiggi	1.6	2.0	2.3	3.0	3.0	2.4
Desi lal dhan	2.0	2.6	3.0	3.3	5.0	3.2
Dagad deshi	1.0	1.6	2.0	2.0	2.0	1.7
Dhan safed	2.0	2.6	3.0	3.3	3.9	3.0
Bhejari	2.0	2.0	2.6	3.0	4.0	2.7
Ranikajar	2.0	2.0	2.7	3.5	5.0	3.0
Urai buta	1.0	1.1	1.5	2.0	2.5	1.6
Safrideshi	1.0	1.6	2.1	2.3	3.3	2.1
Lakhokunwar	1.0	1.3	2.0	2.0	2.0	1.7
Dhour	1.0	1.6	2.5	2.8	3.3	2.2
Kanakchudi	1.0	1.8	2.1	2.3	3.0	2.0
Luchai	2.0	2.0	2.6	3.0	4.2	2.8
Bhatagurmatia	1.0	1.6	1.9	2.0	2.0	1.7
Mahamaya	1.6	2.0	2.3	3.0	3.1	2.4
Bas-370	1.0	2.0	2.5	3.5	5.0	2.8
Poornima	1.0	1.3	2.0	3.0	3.0	2.1

Soil moisture stress significantly lowered the RWC. The varietal variations and interactions differed significantly. During imposed stress period, genotype Lakhokunwar highly maintained its water content followed by Banspor (68.26%). As the stress progresses, the genotypes Ranikajar (50.00 %), kanakchudi (52.00 %) and Luchai (59.66 %) exhibited lowest percent of water content in their leaves. On rewatering of the plant i.e. after revival of moisture content after fifteen days, the RWC of leaves recovered but could not reach the values of irrigated (control) ones for some days. During recovery period, the genotypes Lakhokunwar reached to its maximum value (84.36 %) as that of control (irrigated) followed by Banspor (81.43%) and Uraibuta (81.16 %). The genotypes Ranikajar, kanakchudi and Luchai showed minute variation from their stress value, hence attained the lowest recovery rate. Further the findings revealed that the relative water content of all genotypes reduced significantly under water stress condition as compared to normal control condition. The genotype which maintained high RWC and positive turgor during water stress had optimum photosynthesis under water limiting condition. Higher internal water status during period of drought is the key element of drought resistance. These results are in consistency with the findings of (Jongdee, 1998). Recovery was dependent on the age of plant at the time when stress was applied. It appears that these damages might be reversible to some extent and do not realize permanent effect on the efficiency of water conductivity in the plant either due to formation of new tissues in the vascular architecture of plant or through selective blockage of xylem as suggested by Newmann (1987).

The maximum chlorophyll stability index (CSI) was observed in Safrideshi (0.93) and minimum in Desilaldhan (0.71) under early seedling water stress condition. Higher CSI helps the plants to with stand stress through maintenance and functioning of PS I and PS II. which leads to sustain the photosynthetic rate, more dry matter production and higher productivity. Findings are in close collaboration with the work of Mohan *et al.* (2000).

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