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SHORT COMMUNICATION

PHYSIOLOGICAL CHARACTERIZATION OF RICE GENOTYPES UNDER PERIODIC WATER STRESS

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A field experiment was conducted with six *indica* rice genotypes to evaluate the suitability under periodic water stress or aerobic conditions. Genotypes were characterized by various physiological and biochemical parameters at various growth stages. Amongst the genotypes DRRH-1 had maximum RWC (%) with maximum grain yield under periodic water stress. The total protein content decreased in almost all the six genotypes under periodic water stress. Jaya had maximum protein & proline content. The total chlorophyll content decreased in almost all the genotypes under periodic water stress and higher chlorophyll stability index was recorded in Pant Dhan 4. The maximum photosynthetic efficiency (Fv/Fm) was found in Kasturi which indicate minimum photosynthetic damage in these genotypes. Amongst these genotypes DRRH-1 showed very mild effect of stress on yield potential, however, Jaya exhibited good proline & RWC content with poor yield under stress condition. Therefore, DRRH –1 might be recommended for aerobic cultivation.

Key words: **Aerobic rice, CSI , proline, protein, RWC**

Water is one of the most vital natural resource of the world. According to UNO, water crisis is the major threat for mankind in 21st century. From the total available water 85% is used by Agriculture sector alone of which 75% is used for rice cultivation (Kirloskar, 2003). Irrigated rice requires lot of water, about 3,000-5,000 liter of water is used to produce 1 kg of grain (IRRI 2001). This high requirement of water for rice cultivation is because rice is generally grown under lowland conditions. In lowland rice fields, seepage and percolation account for 50-80% of the total water outflow from the field (Sharma 1989). Evaporation makes up about 30% of evapotranspiration and only 13-33% of total water flow is consumptive water use by transpiration. To mitigate the increasing water scarcity in Asia it is necessary to develop a new way of growing rice that use less water while maintaining high yields. Aerobic rice cultivation requires aerobic soil conditions with intermittent irrigation in non-puddled and non-flooded conditions (Wang *et al*. 2002). China has already developed nutrient-responsive aerobic rice cultivars for temperate climate (Wang *et al.* 2002). International Rice Research Institute (IRRI) has identified some existing improved upland and lowland cultivars for aerobic conditions (Laffitte *et al.* 2002). Belder *et al.* (2005) observed that in the cultivar Apo grown under flooded and aerobic conditions at 0 and at 150 kg fertilizer N ha^{-1} the yield was 15 and 39% lower and the irrigation water use 36 and 41% lower in aerobic plots in two successive years respectively.

Rice cultivation in aerobic condition may lead to unknown challenges with respect to productivity, weed infestation, availability of nitrogen, micronutrients and pest

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and disease incidence (Belder *et al*. 2005 and Zhao *et al*. 2006). Therefore, the present study has been undertaken to find out the suitability of the rice genotypes under aerobic cultivation on the basis of some physiological and biochemical parameters.

A field experiment was conducted during kharif season with six rice (*Oryza sativa* L.) genotypes viz IR-72176-307-4-2-2-3 (New plant type, abbreviated as IR-72176 in fig. For the sake of convenience), DRRH-1 (hybrid), Kasturi (aromatic), BPT-5204 (high yielding variety), Jaya and Pant Dhan-4 (local check). Field experiment was setup in two separate independent plots with three replicates with a randomized block design at Crop Research Center, Pantnagar. Normal irrigated (control) block was laid in a separate field. Aerobic plots were laid out with double channels around all the experimental plots to prevent sub soil lateral water flow. In an aerobic set, mid season drainage was given with effect from 15 days after planting (DAP). After first cycle of drainage for 10 days, irrigation was given once and second cycle of drainage commenced on 7th day after rewatering. This periodicity of cyclic drainage cum rewatering was continued until maturity with 10 days and 7 days alternate dry and wet conditions respectively. In normal irrigated control plots, a thin film of water (2-3cm) was maintained during the initial stage up to seedling establishment, thereafter, the water level was gradually raised to 3-5 cm up to the flowering stage. Relative water content (%) was estimated according to Slatyar and Barrs (1965). Chlorophyll content was estimated according to Hiscox and Israelstam (1979), chlorophyll fluorescence variable yield (Fv/Fm) was recorded by portable Plant Efficiency Analyzer (Handy, PEA, Hansatech, UK). Proline content was estimated as per Bates *et al*. 1973 and soluble protein content as per Lowry *et al.* (1951) just before re watering. Chlorophyll stability index was calculated by using formula given by Yogameenakshi *et al*. (2004). The above observations at flowering stage were statistically analysed to assess the treatment effects.

The rice genotypes showed considerable variation in grain yield under periodic water stress conditions. All the genotypes produced significantly higher grain yield (g/m^2) in normal irrigated than periodic water stressed conditions (Table 1). DRRH1 (675g/m^2) showed higher yield under aerobic conditions as well as in normal irrigated condition. The genotypic differences for grain yield has also been reported by Bouman and Toung 2001. However, as compared to normal irrigated condition thousand grain weight decreased in all the cultivars (Saxena *et al.*,1996). DRRH1 had the maximum grain yield under aerobic conditions due to its ability to maintain high relative water content (Fig. 1).

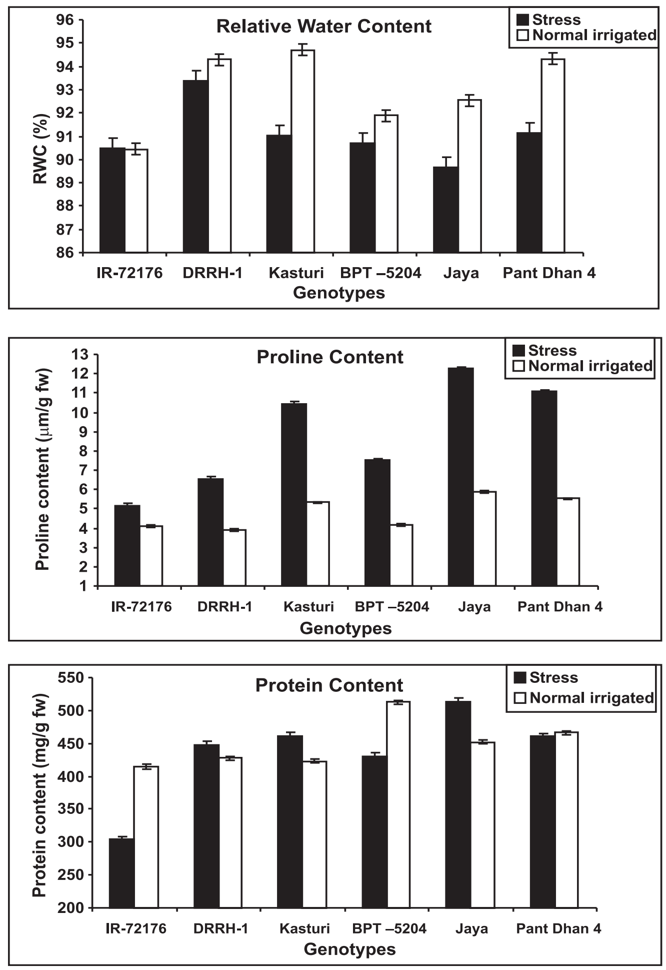

Fig. 1. Effect of periodic water stress on relative water content along with proline and total protein in different genotypes of rice at flowering stage (vertical bars indicate SEm±)

The maximum chlorophyll content under periodic water stress at flowering (1.57 mg g^{-1}fr.wt) stage was in IR-72176-307-4-2-3. However, Jaya had the minimum (1.35 mg g^{-1}fr.wt) at flowering stage (Table1). Under periodic water stress, the decrease in chlorophyll content was from 1.81mg g^{-1}fr.wt at vegetative stage to 1.17 mg g^{-1}fr-wt at grain filling stage. Similar decrease in chlorophyll content due to water stress in rice has been reported by earlier workers (Deka and Baruah 2000).

Almost all the genotypes had higher CSI value at flowering stage compared to vegetative and grain filling stage except Jaya and Kasturi. In Jaya there was increase in CSI value from 0.990 to 1.210 and in Kasturi it was 0.646 to 0.899. Amongst all the genotypes DRRH1 showed about 1.9 times more CSI at flowering stage. The highest CSI was observed in Pant Dhan 4 (1.146), (Table 1). Similarly the higher CSI in drought tolerant genotype of wheat has been reported by Sairam (1996). The high CSI value means that the stress did not have much effect on chlorophyll content of plants. A higher CSI help to plants withstand stress through better availability of chlorophyll. This leads to increased photosynthetic rate, more dry matter production and higher productivity (Mohan *et al*. 2000).

Chlorophyll florescence (Fv/Fm) indicates the photosynthetic efficiency of plants and it is a valuable indicator of water stress. The Fv/Fm values decreased under water stress compared to normal in almost all the six genotypes (Table 1). This decrease in Fv/Fm values could be due to the effect of water stress on partial breakdown of the photosynthetic apparatus. The Fv/Fm values under normal irrigated condition showed significant variation however, under stress condition it was non-significant. The maximum Fv/Fm values at flowering stage were observed in Jaya (0.712) during periodic water stress. In normal irrigated condition Kasturi had highest ratio (0.814) at flowering stage. Although Kasturi had higher photosynthetic efficiency but it had low yield this might be due to poor translocation of the photosynthates as indicated by low thousand-grain weight.

Almost all the genotypes showed considerable reduction in RWC at the flowering stage under periodic water stress as compared to normal irrigated condition which might be due to variation in the increasing transpiration rate and decreasing water uptake capacity (Fig. 1). The genotypic variability in RWC, water potential and their mutual association under soil water status have been reported earlier in rice (Sai Ram and Dube 1984). The maximum RWC was observed in DRRH1 (93.36%) under stress condition. Amongst the different growth stages reproductive stage is known to be sensitive for

Table 1. Effect of periodic water stress on grain yield, chlorophyll fluorescence, total chlorophyll content and chlorophyll stability index (CSI) in different genotypes of rice.

Genotypes	Grain yield (g/m^2)		Chaffy grains (%)		Chlorophyll fluorescence (Fv/Fm)			Clorophyll content (mg g^{-1} fw)		CSI
	Stress cycle (A)	Normal irrigated (B)	Stress cycle (A)	Normal irrigated (B)	Stress cycle (A)	Normal irrigated (B)	Mean	Stress cycle (A)	Normal irrigated (B)	
IR-72176-307-4-2-2-3	525.0	558.33	22.83	10.00	0.650	0.711	0.680	1.57	1.52	1.030
DRRH-1	675.0	683.33	29.89	25.79	0.692	0.780	0.736	1.55	1.43	1.080
Kasturi	441.66	525.0	30.59	26.85	0.704	0.814	0.759	1.49	1.77	0.840
BPT –5204	541.66	608.33	13.45	19.71	0.645	0.807	0.726	1.41	1.52	0.923
Jaya	525.0	650.0	20.95	15.0	0.712	0.792	0.752	1.35	1.55	0.870
Pant Dhan 4	550.0	658.33	36.72	20.06	0.700	0.738	0.719	1.56	1.35	1.146
Mean	543.0	613.88	25.74	19.60	0.684	0.773	0.728	1.49	1.52	0.98
	SEM±	CD at 1%	SEM±	CD at 1%	SEM±	CD at 1%		SEM±	CD at 1%	CD at 1%
(A)	29.67	118.27	3.55	NS	0.029	NS		0.016	0.06	0.0845
(B)	17.13	68.28	2.05	NS	0.017	0.068		0.009	NS	
AxB	41.96	NS	5.02	NS	0.041	NS		0.023	0.09	

water stress. Thus the maximum RWC maintained by DRRH1 has positive effect on grain yield (675 g/m^2). The higher RWC in drought tolerant and lower in drought susceptible genotypes have also reported earlier in rice (Tyagi and Sairam 2001).

One of the important consequences of water stress is the accumulation of proline in rice. Proline acts as a compatible solute and a protective agent for cytoplasmic enzymes and structures. In the present study proline content increased under periodic water stress compared to normal irrigated conditions. All the genotypes showed significant variation for proline content at all the three growth stages. However, the proline accumulation under stress was about two folds more in almost all the genotypes compared with normal irrigated except in IR72176-307-4-2-2-3 (Fig. 1). However, under irrigated conditions similar trend had also observed i.e. maximum proline accumulation was 3.38 to 9.68 for Jaya and minimum 2.84 to 5.07 for IR72176-307-4-2-2-3. The differences in proline content in rice cultivars at flowering stage might be due to rapid hydrolysis of storage protein or synthesis of amino acids like proline for adaptation to stressed condition (Shankhdhar *et al.* 2000).

The capacity for protein synthesis also decreases considerably in response to water stress. In the present study also a significant reduction in total soluble protein content was observed under periodic water stress compared to normal irrigated condition. Jaya had maximum (498.30 to 514.0 mg g^{-1} Fr. wt.) whereas the minimum soluble protein content under periodic water stress was observed in IR72176-307-4-2-2-3 (288.60 to 304.0 mg g^{-1} Fr. wt.). Almost similar trends had also been observed under normal irrigated condition (Fig. 1). The maximum reduction in total protein content compared with normal irrigated conditions was observed in IR72176-307-4-2-2-3 at flowering and minimum in DRRH1. The decreased protein content could be due to decrease in protein synthesis and oxidative injury in response to water stress, which involves the formation of activated oxygen species and its subsequent reaction with macromolecules such as proteins and lipids. A reduction in protein content has been shown to be associated with sensitivity of the cultivars to drought (Deka and Baruah 2000). Based on these observations, DRRH1 performed better in terms of yield but due to high percentage of chaffy grains (Table 1) it could not be recommended for aerobic conditions. However, from existing genotypes Jaya and BPT-5204 might be recommended for aerobic conditions.

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