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SHORT COMMUNICATION

PHYSIO-MORPHOLOGICAL AND BIOCHEMICAL CHARACTERIZATION OF SELECTED RECOMBINANT INBRED LINES OF RICE FOR DROUGHT RESISTANCE

BEENA R., V. THANDAPANI AND R. CHANDRABABU

Department of Crop Physiology, Tamil Nadu Agricultural University, Coimbatore-641003

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The effect of water deficit on various physio-morhological and biochemical traits were studied during panicle initiation stage using selected recombinant inbred lines (RIL's) of IR20 x Nootripathu and their parents under glasshouse conditions. A pot culture experiment was conducted using tolerant and susceptible RIL's (Ten each). Significant variation was observed for leaf rolling, leaf drying, stress recovery, canopy temperature, relative water content, cell membrane stability, chlorophyll stability index, soluble protein content, proline content, lipid peroxidation and plant production traits such as plant height, number of tillers and biomass under water stress and irrigated conditions between the parents and among the RIL's. The tolerant lines maintained high leaf water status under drought condition. Significant positive correlations were found between proline content, soluble protein content, membrane stability index, chlorophyll stability index, stress recovery and relative water content with biomass under water stress. Negative correlations were found between leaf rolling, leaf drying and lipid peroxidation with biomass under water stress.

Key words: Cell membrane stability, chlorophyll stability index, drought, proline, relative water content, rice

Drought is one of India's foremost constraints to increased and stable rice production. The 2002 drought ranks as one of the most severe in India's recorded history. The lack of rain caused a 15% drop in food grains and a 19% drop in rice production. Selection using physio-morphological characters can improve the drought tolerance in rice. Variations in maintaining internal plant water status at flowering was associated with grain yield under drought (Pantuwan *et al.* 2001). The maintenance of plant water status, more than plant functions, controls crop performance under drought (Blum 2002).

Leaf rolling is one of the visible physiological responses to plant water deficit. It is an adaptive response to water deficit which helps in maintaining favourable water balance within plant tissues with resultant benefit to plants under conditions of water scarcity and depleting soil moisture (Singh and Singh 2000). Plant recovery from desiccation in agricultural crops is primarily a function of the capacity for maintaining higher RWC during desiccation (Blum *et al.* 1999). Plant canopy temperature is considered as an index of water stress in many crop species (Chaturvedi *et al.* 1999). Cell membrane stability (CMS) is a physiological index widely used for the evaluation of drought and temperature tolerance (Blum and Ebercon 1981). Chlorophyll stability index (CSI) is a measure of integrity of membrane and heat stability of pigments under stress conditions (Murthy and Majumdar 1962). It has been suggested that accumulation of proline contributes to maintain proper balance between extra- and intra- cellular osmolarity under conditions of water stress (Madhusudhan *et al.* 2002). The SPAD chlorophyll meter reading (SCMR) has been proposed

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*Corresponding author: beenaajithkumar@gmail.com to determine leaf nitrogen content nondestructively in a number of crops (Nageswara Rao *et al.* 2001). The current study examines the role of various secondary traits in improving the drought tolerance in rice at flowering stage.

A study was carried out in the glasshouse of Department of Crop Physiology, Tamil Nadu Agricultural University. The experiment was conducted with 10 tolerant (65, 113, 143, 149, 178, 198, 258, 299, 310 and 384) and 10 susceptible (121, 157, 175, 193, 195, 200, 234, 248, 343 and 362) RIL's of IR20 x Nootripathu using completely randomized design. There were total of six replicates, three for control and three for stress treatment. Thirty days old seedlings were planted in pots. The plants were uniformly watered daily. Water stress treatment was imposed at panicle initiation stage by withholding water.

The extent of leaf rolling was determined at mid day using 1 to 7 scale standardized for rice (IRRI 1996), where smaller number indicates full turgidity and bigger number indicates complete rolling. Similarly, leaf drying score was made using 1 to 7 scale standardized for rice (IRRI 1996), where smaller number indicates green leaves and bigger number indicates complete drying of plants. Visual scoring for drought recovery was made based on 1 to 7 scale, where the smaller number indicates completely drought susceptible or no recovery and higher score indicates more drought tolerance or complete recovery (IRRI 1996). At the peak period of stress (10 days after withholding water) observations were recorded on plant height, number of tillers, biomass, Relative Water Content (RWC) (Barrs and Weatherley 1962), SCMR value (Peng *et al.* 1993), soluble protein (Lowry *et al.* 1951), proline (Bates *et al.* 1973), chlorophyll stability index (Murthy and Majumdar 1962), cell membrane stability (Blum and Ebercon 1981) and lipid peroxidation (Omran 1980). The statistical analysis and relationships were performed using SAS programme.

Significant variation were observed among the RIL's and the parents for various physio-morphological and biochemical traits. Nootripathu had lesser leaf rolling, leaf drying and better recovery (Table 1). Leaf rolling was induced by the loss of turgor and poor osmotic adjustment in rice (Hsiao *et al.* 1984) and delayed leaf rolling is an indication of turgor maintenance and dehydration avoidance (Blum 1989). Mackill (1991) reported that delayed leaf rolling was positively related to drought résistance and recovery from drought. However, Maji *et al.* (2001) reported that leaf rolling might not necessarily confirm drought susceptibility of a rice variety, since it could be either a symptom of desiccation or a mechanism for water conservation, *i.e.* dehydration avoidance in moderately drought tolerant variety, particular at high water stress level. Leaf rolling and drying showed negative correlation with biomass but stress recovery related positively. Eighteen days of drought spell remarkably reduced the mean leaf relative water content to 53.1% (Table 1). The reduction was higher in IR20 (48.9%) than Nootripathu (65.2%). The capacity to maintain higher relative water content (RWC) under moisture stress condition has been suggested as a possible drought resistance mechanism in rice (O'Toole and Moya 1978). RWC showed significant and positive correlation with biomass. The average membrane stability index (MSI) across the RIL's was 78.5% and it ranged from 36.3 to 93.7% among the RIL's under stress (Table 1). Nootripathu (92.7%) had higher membrane stability index than IR20 (45.0%) (Table 1). Tyagi *et al.* (1999) reported that the MSI was higher in tolerant genotypes under water stress. Lower membrane stability or higher injury reflects the extent of membrane lipid peroxidation, which in turn is a consequence of higher susceptibility to oxidative stress due to various environmental stresses including drought (Leibler *et al.* 1986). Among the parents, Nootripathu had higher chlorophyll stability index (74.0%) than IR20 (59.3%) and it ranged from 51.1 to 94.1% with an average of 71.3% across the RIL's (Table 1). Green pigments are thermosensitive and their degradation occurs when subjected to higher temperature. Mohan *et al.* (2000) reported that during salt stress condition, chlorophyll content was affected more in susceptible than in tolerant rice varieties. Water stress caused an average reduction of 20.3% in soluble protein content across the RIL's. Among the parents, IR20 (24.5%) showed more reduction in protein content than Nootripathu (18.0%). This was in agreement with the result of Jha and Singh (1997) that drought tolerant rice genotypes had comparatively higher protein content than

Table 1. Variation in physio-morphological traits under water stress among rice RIL's.

RI lines	Plant height (cm)	Tiller number	Biomass (g plant^{-1})	Leaf rolling score	Leaf drying score	Proline (mg g^{-1})	Soluble protein (mg g^{-1})	MSI (%)	CSI (%)	Stress recovery	Lipid peroxidation (µmol g^{-1})	SCMR value	RWC (%)
IR 20	44.73	5.33	25.0	5.7	4.3	0.51	8.89	45.0	59.3	4.3	25.35	23.6	48.9
Nootripathu	58.63	4.67	35.0	3.7	2.3	1.02	10.91	92.7	74.0	6.3	16.20	32.5	65.2
Tolerant RILs 65	42.70	3.00	26.7	5.7	5.7	0.69	9.44	92.7	63.2	6.3	18.67	35.5	40.4
113	86.37	5.00	31.7	1.0	1.0	0.97	0.36	91.7	87.7	5.7	17.27	35.0	69.3
143	54.30	5.00	33.0	2.3	2.3	0.99	10.16	93.0	82.4	5.7	14.48	35.1	62.6
149	47.13	4.67	26.3	2.3	2.3	1.05	10.91	91.7	74.3	7.0	14.64	35.2	69.8
178	54.57	3.33	28.0	2.3	1.7	0.91	10.31	85.4	82.6	2.3	18.70	35.5	44.5
198	67.37	4.33	30.0	1.0	2.3	0.83	10.03	79.6	82.8	4.7	15.41	29.1	62.9
258	84.80	5.67	31.7	5.0	3.0	0.84	11.03	88.3	84.5	5.7	22.61	33.2	50.8
299	60.63	4.67	28.0	4.3	3.7	0.69	8.80	94.0	80.4	3.7	16.58	31.5	63.1
310	68.57	4.33	32.3	4.3	1.7	0.91	11.00	83.3	79.1	6.7	21.27	30.1	60.5
384	67.73	5.33	38.0	3.0	2.3	0.91	10.92	93.7	94.1	7.0	21.98	32.0	68.1
Susceptible RILs 121	51.40	4.67	27.0	4.3	4.3	0.47	19.84	88.3	73.4	1.7	22.23	32.4	35.4
157	51.67	3.33	26.7	3.7	4.3	0.82	7.21	60.3	60.1	3.7	22.14	27.5	48.1
175	53.93	5.33	31.0	3.0	3.0	0.88	10.00	85.3	45.4	2.3	22.77	31.8	39.2
193	63.37	5.00	29.7	5.0	5.0	0.60	8.05	853	59.7	1.0	27.70	29.4	24.1
195	68.60	3.67	30.3	4.3	3.0	0.82	7.97	77.7	62.7	4.3	19.51	32.9	54.8
200	45.93	3.33	30.0	4.3	6.3	0.85	9.83	93.3	51.1	2.3	26.30	30.8	57.3
234	55.20	4.33	25.3	6.3	6.3	0.74	8.38	46.0	64.7	2.3	25.54	27.7	40.9
248	60.27	3.33	26.0	3.7	3.7	0.87	8.84	36.3	70.1	5.3	27.01	32.2	47.9
343	84.73	5.67	32.0	5.0	5.0	0.87	7.60	65.7	60.6	4.3	21.50	31.5	52.7
362	85.57	4.33	31.3	3.7	4.3	0.90	10.27	58.3	79.9	4.3	19.47	29.5	62.8
Mean	61.73	4.46	30.1	3.8	3.5	0.82	9.57	78.5	71.3	4.4	20.70	31.5	53.1
Range	42.70-86.37	3.00-56.70	25.3-38.0	1.0-6.3	1.0-6.3	0.47-1.05	7.21-11.03	36.3-93.7	51.1-94.1	1.0-7.0	14.48-27.01	27.5-35.5	24.1-69.8
SEd	2.30	0.87	0.49	0.07	0.06	0.01	0.15	1.31	1.18	0.07	0.34	0.51	0.88
CD (0.01)	6.21	2.34	1.34	0.17	0.16	0.03	0.42	3.53	3.18	0.20	0.93	1.39	2.39

susceptible lines under water stress. Membrane stability and chlorophyll stability indices were also significantly and positively related to biomass. Lipid peroxidation indicates the presence of malonyldialdehyde (MDA), which are produced as a result of different environmental stresses. In the present study, water stress caused an average increase of 63.5% in MDA across the RIL's. Among the parents, IR20 (76.4%) showed higher increase than Nootripathu (65.7%). Reduction in soluble protein and increase in MDA levels under water stress conditions suggest that lipid peroxidation products hydrolyze protein mRNAs (Jiang *et al.* 1991). Water stress caused reduction in SCMR value (11.9%), plant height (10.4%), total number of tillers (25.7%), biomass (29.7%) and increase in proline (89.6%) across the RIL's as compared to control. Maibangasa (1998) also reported the similar kind of results for plant height, number of tillers and proline content under water stress conditions in rice. Considering the physio-morphological and biochemical characters it is concluded that Nootripathu exhibited some degree of resistance to water deficit. So, these traits can be used as indirect selection criteria to improve the grain yield stability of rice under drought.

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