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Effect of salinity on the relative water content of selected rice genotypes targeted for Konkan coast

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Abstract

An experiment was conducted in collaboration with the school of water stress management, ICAR-NIASM, Malegaon, Baramati, during 2021-2022 to evaluate the rice (*Oryza sativa* L.) genotypes. 20 rice genotypes were collected from R.A.R.S., Karjat and K.L.R.S., Panvel, including checks. Plants treated with salt had an electrical conductivity of 6 dSm^{-1} and 9 dSm^{-1}, respectively, with control (3 dSm^{-1}) (Coastal saline soil with no additional salts) during the seedling stage. The relative water content of the fully expanded third leaf at the top seedling was measured from three independent biological replicates of both control and stressed plants for three days after the imposition of stress from all treatments was weighed. Among 20 rice genotypes, at 3 dSm^{-1}, FL 478 and CST 7-1 have maximum relative water content, but there was no discernible difference between these two genotypes, where Karjat 6 had the lowest relative water content significantly. At 6 dSm^{-1}, Kala rata had the highest relative water content, followed by CST 7-1 and SR 3-9. However, Karjat 6 had minimum relative water content to check FL 478 and Karjat 4. At 9 dSm^{-1}, Kala rata and CST 7-1 had significantly maximum relative water content followed by SR 3-9 and Damodar; however, Karjat 6 showed minimum relative water content to that of check FL 478 (78.34%) and Karjat 4.

Keywords: Rice, genotypes, salt, salinity, relative water content

Introduction

Oryza sativa L. (2n=24) is a self-pollinated cereal belonging to the family Gramineae or Poaceae, with 22 wild species and just two cultivated varieties (Vaughan *et al*., 2003) [21]. Rice is grown throughout humid tropical and subtropical climates (Blair *et al*., 2002) [6]. In India, rice occupies a 45.76 MH area with an annual production of 124.36 MT and 2.72 tons per hectare productivity (Anonymous, 2021) [4]. Konkan has a rice-dominating area of about 0.387 million ha with an annual production of 1.031 MT, and the average productivity of the Konkan is about 2.66 tons per hectare (Anonymous, 2021) [5]. More than 127000 ha of saline soil have been found in Maharashtra state. Out of these, 70,000-hectare land is classified as coastal salinity and 57000 ha land is classified as inland salinity. The coastal saline soils are fertile, but their productivity is limited due to the inundation of tidal brackish water and submergence during the rainy season (Sawardekar *et al*., 2003) [17].

Natural disasters caused by climate change and biotic and abiotic stresses represent a severe problem for the world's 60 per cent food security and economic development. Singh *et al*. 2004 estimated that the ultimatum for rice in 2025 will be 140 MT; contrarily, the abiotic stress of soil salinity is the subject of this study since it contributes significantly to the decline in global rice output. Nevertheless, many Asian countries, where rice nurseries frequently have to establish in soils already tainted with salt, consider the increase of salt tolerance as a breeding priority.

It may be necessary to test genotypes for salt tolerance when plants are at the seedlings stage because there is significant time saving (Gregorio *et al*., 1997; Ali *et al*., 2014) [8, 1], and it helps to develop salt tolerance with high-yielding cultivars. The present study examined the screening salinity tolerance in selected rice genotypes by measuring the magnitude of relative water content (%).

Materials and Methods

Plant growth environment and plant materials

The experiment included 20 rice genotypes, including checks as well-known salt-tolerant and salt-sensitive varieties undertaken collected from the R.A.R.S., Karjat and K.L.R.S., Panvel of the coastal area, in collaboration with the ICAR-NIASM, Malegaon, Baramati, 413115 during 2021-2022. The soil used in the experiment was coastal saline soil from the Konkan coast (Panvel). Plants were treated by salt stress and had an electrical conductivity of 6 and 9 dS/m, with control (C) (Coastal saline soil with no additional salts) 21 days after emergence. Experimental design set up with saline and without saline conditions in a Factorial Completely Randomized Design (FCRD) in 3 replication.

Methods

Relative Water Content (RWC) was determined by the methods described by Cornic, 1994 [7]. The relative water content of the leaf was measured from three independent biological replicates of both control and stressed plants for three days after imposition of stress; the fully expanded third leaf at the top of each plant from all treatments was weighed as Fresh Weight (FW), then left saturated in distilled water inside a closed petri dish for three hours and their Turgid Weights (TW) was calculated. End of the imbibitions period, leaf samples were kept in a preheated oven at 60 °C for 48 h to know Dry Weight (DW). Finally, the relative water content (RWC) of the leaves was estimated using the equation,

$$RWC\ (\%) = (FW - DW) / (TW - DW) \times 100$$

Where,
FW = Fresh weight of plant (g)
DW= Dry weight of plant (g)
TW= Turgid weight of plant (g)

Results

The relative water content of all the genotypes was measured for three days after the imposition of salt stress. After applying salt stress, a significant difference in relative water content was noted between the treatments and at various day intervals (Fig. 1, Table 1). On average, all the genotypes' relative water content started to decline after the imposition of salt treatments. Among the treatments, 9 EC severely impacted the relative water content of all the genotypes (Fig. 1).

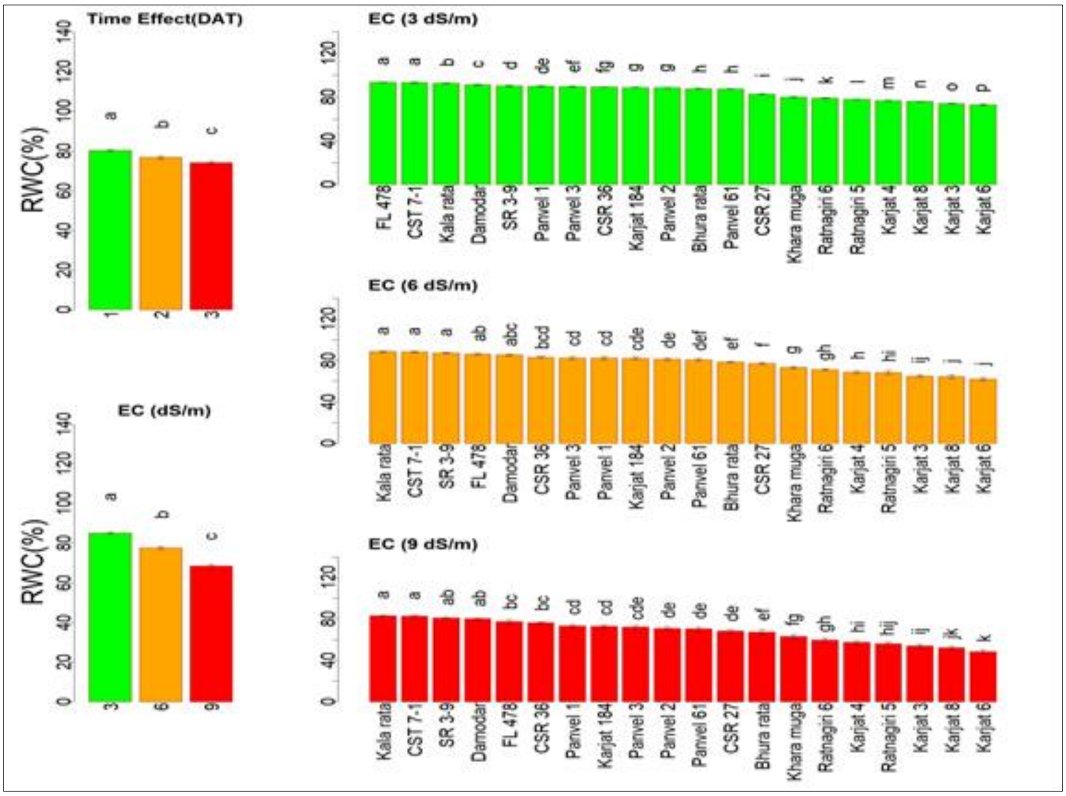

Fig 1: Effect of salt stress on Relative water content (RWC) of rice genotypes

On 1st DAT, all the genotypes significantly differed at 3 dSm^{-1}, 6 dSm^{-1} and 9 dSm^{-1}, which exhibited 85.34%, 81.80% and 74.01% relative water content, respectively (Fig. 1). Among the genotypes, CST 7-1 (89.97%) had significantly the highest relative water content followed by Kala rata (89.64%) and Karjat 6 (65.61%) had the minimum relative water content to that of check FL 478 (89.64%) and Karjat 4 (71.75%). All genotypes showed a significant treatment x genotype interaction for the relative water content. At 3 dSm^{-1}, FL 478 (93.59%) and CST 7-1 (93.45%) had the highest relative water contents, although there was no discernible difference between these two genotypes. Karjat 6 (73.08%), on the other hand, had the relative water content that was considerably the lowest. At 6 dSm^{-1}, the genotype pattern was similar to that at 3 dSm-1, with decreasing relative water content ranging from 68.05% at the least to 90.35% at the maximum. At 9 dSm^{-1}, Kala rata and CST 7-1 had much higher relative water contents than Karjat 6, with respective values of 86.45% and 86.24 and 55.70%, respectively, as compared to check FL 478 (84.97%) and Karjat 4 (64.39%) (Table 1).

At 3 dSm^{-1}, 6 dSm^{-1} and 9 dSm^{-1} on the 2nd DAT, all genotypes showed substantially different relative water contents of 85.11%, 77.44%, and 68.21%, respectively (Fig. 1). There was a significant genetic variation was observed between all the genotypes. Kala rata (88.62%) and CST 7-1 (88.22%) had significantly higher relative water content, followed by SR 3-9 (86.91%) and Damodar (85.47%), and the minimum relative water content was observed in Karjat 6 (61.26%) to that of check FL 478 (85.96%) and Karjat 4 (66.95%). All genotypes showed a significant treatment x genotype interaction for the relative water content. The highest relative water content was seen at 3 dSm^{-1} in FL 478 (93.55%) and CST 7-1 (93.43%), but there was no discernible difference between these two genotypes. Among the genotypes, Karjat 6 (73.20%) had the lowest relative water content significantly. At 6 dSm^{-1}, Kala rata (89.14%) had seriously the highest relative water content, followed by CST 7-1 (87.91%) and SR 3-9 (87.88%) to that of check FL 478 (85.99%) and Karjat 4 (68.05%). However, Karjat 6 had a minimum relative water content of 62.53%. At 9 dSm^{-1}, Kala rata and CST 7-1 had significantly maximum relative water content, i.e. 83.98% and 83.32%, followed by SR 3-9 (82.32%) and Damodar (80.34%) however, Karjat 6 (48.04%) showed minimum relative water content to that of check FL 478 (78.34%) and Karjat 4 (55.95%) (Table 1).

On 3rd day after treatment, all the genotypes significantly differed at 3 dSm^{-1}, 6 dSm^{-1} and 9 dSm^{-1}, which exhibited 85.24%, 74.02% and 63.40% relative water content, respectively (Fig. 1). All of the genotypes showed considerable genetic diversity, with CST 7-1 (86.27%) and Kala rata (86.21%) having much greater relative water content than check FL 478 (82.00%) and Karjat 4 (64.59%), which were followed by SR 3-9 (84.82%) and Damodar (84.18%). However, the minimum relative water content was observed in Karjat 6 (56.87%). A significant treatment x genotype interaction for the relative water content was observed across all genotypes. FL 478 (93.98%) and CST 7-1 (93.56%) had the maximum relative water content; however, there was no significant difference observed between these two genotypes, and Karjat 6 (73.24%) had significantly the lowest relative water content at 3 dSm^{-1}. At 6 dSm^{-1}, the relative water content of Kala rata (86.45%) and CST 7-1 (86.24%) was much higher than that of check FL 478 (82.29%) and Karjat 4 (64.39%), which were followed by SR 3-9 (84.97%) and Damodar (82.80%). Karjat 6 (55.70%) exhibited the lowest relative water content among the genotypes. At 9 dSm^{-1}, Kala rata and CST 7-1 had much higher relative water contents than check FL 478 (69.72%) and Karjat 4 (52.43%), with maximum relative water contents of 79.49% and 79.02%, respectively, followed by SR 3-9 (78.82%), Damodar (78.34%), and CSR 36 (76.40%). Among the genotypes, Karjat 6 had a minimum relative water content of 41.66% (Table 1).

Table 1: Effect of salt stress on RWC (%) of rice genotypes

Relative Water Content (%)												
Genotypes	**01 Day After Treatment**				**2 Day After Treatment**				**3 Day After Treatment**			
	3 EC	**6 EC**	**9 EC**	**Mean (Gen)**	**3 EC**	**6 EC**	**9 EC**	**Mean (Gen)**	**3 EC**	**6 EC**	**9 EC**	**Mean (Gen)**
Bhura rata	88.21	80.61	76.87	81.89	87.61	78.34	67.65	77.87	87.69	76.44	57.92	74.02
CSR 27	83.38	80.86	74.04	79.43	82.77	76.40	67.65	75.60	82.59	74.04	63.79	73.47
CSR 36	89.16	85.99	79.49	84.88	89.28	83.80	74.04	82.37	89.65	79.49	76.40	81.85
CST 7-1	93.45	90.24	86.24	89.97	93.43	87.91	83.32	88.22	93.56	86.24	79.02	86.27
Damodar	91.78	88.81	82.32	87.63	91.45	84.63	80.34	85.47	91.39	82.80	78.34	84.18
FL 478	93.59	90.35	84.97	89.64	93.55	85.99	78.34	85.96	93.98	82.29	69.72	82.00
Kala rata	92.65	89.82	86.45	89.64	92.74	89.14	83.98	88.62	92.69	86.45	79.49	86.21
Karjat 184	88.98	85.63	78.34	84.31	88.85	82.08	72.69	81.21	89.05	78.34	68.05	78.48
Karjat 3	73.92	69.88	60.58	68.13	74.21	64.39	54.59	64.40	73.92	60.58	47.32	60.61
Karjat 4	76.95	73.92	64.39	71.75	76.87	68.05	55.95	66.95	76.95	64.39	52.43	64.59
Karjat 6	73.08	68.05	55.70	65.61	73.20	62.53	48.04	61.26	73.24	55.70	41.66	56.87
Karjat 8	75.89	70.80	57.92	68.20	76.26	64.39	52.73	64.46	75.93	57.92	46.46	60.10
Khara muga	80.85	76.87	69.72	75.81	79.49	72.52	64.39	72.13	79.98	69.72	55.95	68.55
Panvel 1	89.93	87.45	78.34	85.24	89.95	81.28	72.69	81.31	90.46	78.34	69.07	79.29
Panvel 2	88.62	85.63	76.87	83.70	88.45	80.61	70.80	79.95	89.04	77.07	65.50	77.20
Panvel 3	89.62	87.98	78.34	85.31	89.62	80.86	72.69	81.06	90.07	78.34	66.55	78.32
Panvel 61	87.61	85.48	76.65	83.24	87.80	79.49	70.17	79.16	87.49	77.07	64.85	76.47
Ratnagiri 5	78.67	74.37	62.53	71.86	77.59	67.65	54.59	66.61	77.79	62.53	52.06	64.13
Ratnagiri 6	80.03	75.07	67.65	74.25	78.62	70.80	57.19	68.87	78.62	67.65	54.59	66.95
SR 3-9	90.47	88.33	82.77	87.19	90.53	87.88	82.32	86.91	90.66	84.97	78.82	84.82
Mean (Sal)	85.34	81.80	74.01		85.11	77.44	68.21		85.24	74.02	63.40	
	S.E (m)±	C.D at 5%	C.D at 1%		S.E (m)±	C.D at 5%	C.D at 1%		S.E (m)±	C.D at 5%	C.D at 1%	
Factor A: Salinity levels	0.109	0.306	0.405		0.108	0.302	0.399		0.102	0.287	0.379	
Factor B : Genotypes	0.282	0.790	1.045		0.278	0.779	1.030		0.264	0.740	0.979	
Interaction effect (A×B)	0.489	1.369	1.810		0.482	1.349	1.783		0.458	1.282	1.695	

Discussion

Soil salinity reduces the plants ability to take up water, which quickly causes reductions in the speed of cell growth in developing tissues. Water status is the main factor affecting the plants' growth and development. In a recent study, salinity reduces the relative water content because the high salt concentration in the root zone makes it harder for the root to uptake water (Munns & Tester 2008) [11]. Water is essential for all metabolic processes; lack of water may collapse all the metabolic processes of salt-treated seedlings and influence seedling survivability. When plants are subjected to salinity, firstly, they face an osmotic challenge that reduces water uptake by roots. Similar trends observed in the results of other researchers viz; Suriya-arunroj *et al*. (2004) [20]; Singh *et al.* (2007) [19]; Pattanagul and Thitisaksakul (2008) [13]; Murshed *et al*. (2008) [12]; Amirjani (2010; 2012) [2-3]; Pushpalatha *et al.* (2017) [15]; Ma *et al*. and Polash *et al*. (2018) [14] in rice; Rivelli *et al*. (2002) [16]; Mandhania *et al*., Farooq and Azam (2006) [10] in wheat.

Conclusion

This study suggests that salinity exhibits the relative water content in the selected rice genotypes with different salinity levels of 3 dSm^{-1} (Control), 6 dSm^{-1} and 9 dSm^{-1} at the seedling stage under controlled environmental conditions.

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