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Screening of Rice (*Oryza sativa* L.) Genotypes against NaCl Salinity

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ABSTRACT

One hundred ten rice genotypes were tested for their salt tolerance at different salinity levels (0; 50; 100 mol m^{-3}) grown in nutrient solution culture. Three days after transplanting NaCl was added in three increments to salanize the respective medium. Tillering and fresh shoot and root yield of all the genotypes was noted to assess their salinity tolerance. Although reduction in tillering and root and shoot fresh biomass was observed due to NaCl salinity raised to 100 mol m^{-3} but the tolerant genotypes manifested promising results under this salinity. Out of 110 genotypes 34 were found to be highly sensitive including five genotypes that totally failed to survive under stress conditions and 33 rice lines showed moderate performance with respect to their behaviour of salt tolerance while 38 genotypes yielded exceptionally even with the stress of 100 mol m^{-3} NaCl salinity.

Key Words: Rice Genotypes; Salt Stress; Tolerance; Solution Culture; Pakistan

INTRODUCTION

Annual losses due to low yield of rice from salt-affected areas of Pakistan are quite considerable. Since out of 6.3 m ha of salt affected land, over one m ha is under rice cultivation with a total production of 3.4 million tones (Qureshi *et al.,* 1991; Ashraf *et al*., 1993) and most of the rice grown areas are affected by salinity. In Pakistan, reduction in paddy yield is 40–70% because of salinity and sodicity (Muhammad *et al*., 1991; Aslam *et al*., 1995).

Agro-chemical measures to mend the soil environment for plant growth are available but the biological methods can be more economical under specific situations (Verma & Abrol, 1980). Hence, to improve paddy yield from salt-affected lands, development of salt tolerant rice varieties is a basic requirement. Consequently, there is an urgent need to breed and enhance the salt tolerance of crop plants for which potential exists (Wyn Jones & Gorham, 1986). Various physiological characters are related to plant's salt tolerance that certain mechanisms to tolerate salinity (Flowers *et al*., 1977; Yeo & Flowers, 1984; Gorham *et al.,* 1985; Aslam *et al.,* 1993). In this study, the nature of growth responses of several rice lines to different salinity levels were studied to isolate the salt tolerant genotypes capable of high yielding under reluctant situations.

MATERIALS AND METHODS

One hundred and ten rice genotypes (*Oryza sativa* L.) were tested for their salinity tolerance in artificially salinized solution culture. The genotypes were collected from International Rice Research Institute (IRRI). The sensitive (BAS 370 and IR 1561) and tolerant (NIAB 6, KS 282 and IR 6) varieties were used as a check for assessing the relevant salt tolerance of other genotypes. Fourteen day old seedlings of each genotype, raised in gravel culture, were transferred to foam plugged holes in thermopal sheets floated over 100 litres of nutrient solution (Yoshida, *et al*., 1972) during rice growing season, 1994. The experiment was quard replicated following the Completely Randomized Design (CRD). Three days after seedling transplanting, NaCl salt was added in three increments to develop salinity of 50 and 100 mol m^{-3} in the respective tubs. The nutrient solutions were changed weekly. After four weeks of salt stress, plants were harvested and tillering capacity and root and shoot biomass were noted for each genotype.

RESULTS AND DISCUSSION

For screening of a large number of rice lines, tillering capacity and root and shoot biomass is a convenient and fairly reliable criterion for determining differences with respect to salt tolerance. Generally it is stated that the assessment of salt tolerance in rice, based on shoot biomass at the early seedling stage, is related to the paddy yield thus could be used for mass screening purpose to reduce the time requirement as well as the financial losses (Aslam, *et al*., 1993*a*). Therefore, tillering and root and shoot biomass were used as a criterion for assessing the relative salt tolerance. These growth parameters were significantly reduced due to increasing salinity stress with NaCl salt (Tables I, II & III). The tolerant rice lines gave better response maintaining relatively better growth even when exposed to high concentration of NaCl (100 mol m^{-3}) salinity. Nevertheless,

Table I. Tillering and root and shoot biomass of tolerant rice (*Oryza sativa* L.) genotypes as influenced by salt stress in solution culture (average of four repeats)

Rice genotypes	Control (0 mol m^{-3} NaCl Salinity)			50 mol m^{-3} NaCl Salinity			100 mol m^{-3} NaCl Salinity		
	Tillers (p^{-1})	Root Fresh Wt.(g p^{-1})	Shoot Fresh Wt.(g p^{-1})	Tillers (p^{-1})	Root Fresh Wt.(g p^{-1})	Shoot Fresh Wt.(g p^{-1})	Tillers (p^{-1})	Root Fresh Wt.(g p^{-1})	Shoot Fresh Wt.(g p^{-1})
AT 83-1329	6.25	5.85	5.68	5.00	4.12	4.65	3.25	3.07	3.72
BPT 3402	6.75	5.32	7.32	4.00	4.28	5.72	3.00	2.94	4.07
CSR 11	6.00	4.74	7.79	4.75	4.50	6.08	3.25	4.02	4.64
CSR 5	4.75	3.29	6.66	4.00	3.15	4.43	3.00	2.89	3.61
IR 37257-41-3-2-3	4.75	3.20	6.46	4.00	2.60	5.66	3.25	1.12	3.53
IR 39537-4-2-2-3	5.75	3.93	5.42	4.75	3.01	4.75	3.25	2.33	3.94
IR 49635-148-2-1-1-2	6.75	5.36	6.46	3.50	4.65	4.78	3.00	4.00	3.43
IR 49707-1-3-2-3	4.75	5.36	6.83	3.50	4.91	4.89	3.25	2.96	4.09
IR 51337-2B-9-2B-2-2	7.25	5.23	9.92	4.75	4.41	5.96	3.50	2.16	3.89
IR 51471-BB-2-BB-1-1	5.50	4.53	9.26	4.25	4.01	6.99	3.75	2.76	3.72
IR 51499-BB-29-BB-1-1	5.25	5.55	8.46	4.50	4.84	7.36	4.00	3.67	5.81
IR 52713-BB-8-BB-1-2	5.25	4.68	7.57	4.50	4.32	5.05	3.25	2.32	4.02
IR 52718-BB-6-BB-1-1	6.75	5.87	9.25	3.75	4.11	6.81	3.00	3.71	3.76
IR 52724-BB-6-BB-1-1	6.75	4.09	6.37	4.75	3.45	4.73	3.25	2.67	3.65
IR 53649-3B-10-2	6.75	6.44	8.06	5.00	5.69	6.23	4.25	3.82	5.55
IR 54447-BBB-10-2	7.50	8.69	11.77	5.00	7.06	6.56	3.50	3.81	5.00
IR 55177-3B-9-2	6.00	8.11	9.14	3.75	4.85	6.10	3.75	3.65	3.89
IR 55178-BBB-2-1	5.25	8.55	8.22	4.25	6.28	5.64	3.25	3.39	4.97
IR 55178-BBB-9-3	5.25	6.55	7.56	4.25	5.14	4.99	3.00	3.96	3.90
IR 63731-1-1-1-2-2	6.00	6.01	7.64	4.00	5.80	4.89	3.50	4.12	4.00
IR 63731-1-1-3-3-3	5.00	6.45	8.74	3.75	4.83	6.86	3.25	3.39	4.75
IR 63731-1-1-4-2-3	5.25	4.96	7.65	4.00	4.19	5.32	3.00	3.83	3.56
IR 63731-1-1-4-3-2	5.00	4.49	6.88	4.00	3.32	6.03	3.75	3.16	4.00
PNL 1-8-5-17-2	4.50	5.32	9.28	4.00	4.25	7.73	3.00	4.13	4.28
NONA BOKRA	4.00	5.10	9.88	3.75	4.98	8.17	3.00	4.26	6.57
RENDAH PADANG (ACC 43740)	3.50	5.84	6.48	3.25	4.03	5.94	3.00	3.29	3.68
RP 2271-435-326-119	4.75	5.11	5.59	3.75	3.86	4.01	3.25	3.49	3.81
TCCP 266-BBB-10-2-1	4.50	8.28	10.01	3.25	6.36	8.69	2.25	5.60	4.66
TCCP 266-BBB-10-3-1	5.50	5.30	7.06	4.25	4.26	5.64	3.50	4.19	3.89
TCCP 266-BBB-13-1-3	4.50	4.26	8.27	3.75	4.10	6.03	3.25	3.35	4.19
TCCP 6533-8-4-2-AC 204-2	4.75	5.90	8.94	3.75	5.26	6.90	3.50	4.64	4.05
VYTTILA 2	4.75	5.48	8.96	4.00	4.36	6.53	3.25	3.12	4.28
VYTTILA 3	5.00	8.41	11.50	3.50	7.62	9.39	3.00	6.36	6.58
POKALI	4.50	7.27	12.61	3.75	6.01	11.49	3.00	4.83	6.56
IR 53655-3B-7-1	3.50	7.03	7.97	3.25	4.68	6.27	3.00	3.54	3.86
NIAB 6	5.50	3.98	5.69	4.25	2.69	4.67	3.25	2.62	3.74
KS 282	4.75	3..96	6.95	3.75	3.21	4.67	3.50	3.18	3.92
IR 6	6.25	5.38	7.98	4.25	4.93	5.92	3.50	3.00	3.85

some genotypes were remarkably sensitive regarding tillering as well as shoot yield production but maintained well developed root system similar to that of tolerant rice lines even at higher salinity. It seems that these have tried their best to fulfil the growth requirements under stress conditions but failed to sustain growth upto the required level as that of plant under non saline medium. Among all the genotypes, five rice lines totally ceased at higher salinity (100 mol m^{-3} NaCl). The reason might be the excess of toxic ions and nutrient imbalance in the root medium causing depression in growth (see Abrol, 1984). Better shoot and root biomass under NaCl salinity appears to be a characteristic of rice genotypes which shows greater tolerance to salinity hazard. Pearson (1961), Mass and Hoffman (1977), Farah and Anter (1978), Akbar (1986), Yeo *et al*. (1990) and Aslam *et al*. (1993) had discussed similar conclusions.

Tolerant genotypes. Ranking of 38 rice lines according to their salt tolerance at 100 mol m^{-3} NaCl salinity in the experiment is summarized in Table I. These lines produced similar and or slightly above yield to that of tested tolerant varieties (NIAB 6, KS 282 and IR 6) included in this study as check. It is obviously specious that although there was slight deflection in the rank orders of lines with intermediate tolerance, particularly when the different criteria (tillering, root and shoot biomass) were used, the most tolerant and the most sensitive lines occupied the top and the bottom position, respectively, in all the cases. The results indicate that, in spite of some variations, the overall pattern of behaviour of the tolerant lines remained fairly constant under different situations, particularly with respect to the most salt tolerant and appeared promising at higher salinity of 100 mol

Table II. Tillering and root and shoot biomass of medium tolerant rice (*Oryza sativa* L.) genotypes as influenced by salt stress in solution culture (average of

Rice genotypes

B 6992D-MR-9
B 71060-KA-3B
GANJEH ROOZ
IR 41427-34-23-
IR 46280-PMI-5
IR 4630-22-5-1-
940
IR 48120-49-5-3
IR 48788-4-3-4-
IR 51164-17-1-2
IR 51194-CN-9
IR 52709-2B-5-
IR5931-110-1
IR 54455-3B-4-
IR 55178-BBB-
IR 63731-1-1-1-
IR 63731-1-1-1-
IR 63731-1-1-4-
IR 63731-3-5-14
IR 63731-3-5-14
PNL 20-16-10-1
PNL 35-23-15-2
PNL 7-22-48
RP 2271-433-32
RP 2274-444-40
RP 2597-14-250
WAR 29-24-2-1
WAR 72-M6-3-
80-H5-76-64
IR 43522-37-3-3
IR 53655-3B-15
KHAO-TAH-H
LEMO BESAR
(ACC 19999)
S 818B-10-2

Table III. Tillering and root and shoot biomass of sensitive rice (*Oryza sativa* L.) genotypes as influenced by salt stress in solution culture average of four repeats)

Rice genotypes	Control (0 mol m^{-3} NaCl Salinity)			50 mol m^{-3} NaCl Salinity			100 mol m^{-3} NaCl Salinity		
	Tillers (p^{-1})	Root Fresh Wt. (g p^{-1})	Shoot Fresh Wt. (g p^{-1})	Tillers (p^{-1})	Root Fresh Wt. (g p^{-1})	Shoot Fresh Wt. (g p^{-1})	Tillers (p^{-1})	Root Fresh Wt. (g p^{-1})	Shoot Fresh Wt. (g p^{-1})
B 5565-13G-SM-87-3	4.00	6.22	9.00	3.00	5.45	6.64	1.25	3.05	1.26
B 6992D-MR-13-1	2.25	1.96	4.02	1.75	1.59	2.11	0.00	0.00	0.00
B 7003D-MR-3-1-3	4.25	4.36	5.87	3.50	3.51	4.57	0.75	1.00	0.76
B 70960-KN-1-1-3	4.75	3.47	6.04	2.75	2.62	3.65	1.25	2.00	1.08
GIZA 171	2.25	3.64	5.26	1.75	3.41	3.13	1.25	2.97	1.26
GIZA 172	2.25	3.24	5.63	2.00	2.47	2.86	1.25	1.79	0.67
IR 26916-ES	3.50	3.80	4.38	2.00	3.00	2.88	0.00	0.13	0.00
IR 37096-56-1	2.50	2.60	3.96	2.00	2.06	2.72	0.00	0.08	0.00
IR 37255-21-3-3-2	3.75	4.06	5.53	2.00	3.57	3.68	1.00	2.00	1.08
IR 40931-33-1-3-2	4.00	4.68	6.82	2.25	3.30	5.19	1.25	2.84	1.29
IR 28	4.75	5.73	5.81	2.00	5.04	4.42	1.50	3.16	1.07
OR 131-5-8	2.50	4.48	4.90	2.00	3.00	2.91	0.50	0.62	0.47
RP 1603-308-246-87	3.00	2.91	6.46	2.00	2.10	4.06	1.00	1.45	1.12
RP 2269-424-298-18	2.50	3.93	5.78	2.00	3.70	4.20	1.25	2.97	1.02
RP 2270-2-332	2.00	3.13	4.61	1.75	2.76	3.12	1.25	2.58	1.16
RP 2271-434-323-113	2.25	2.51	3.89	1.75	1.89	2.59	1.50	1.67	1.08
RP 2597-3-10-338	2.50	6.46	5.64	2.25	6.03	4.63	1.25	3.48	1.11
RP 2597-444-171	2.75	5.81	5.48	2.25	4.83	4.16	0.50	1.97	0.66
WAR 29-24-2-1-1	3.50	5.21	7.73	2.25	3.83	3.85	1.50	2.86	2.05
BW 311-2	3.00	3.99	6.39	2.00	3.01	3.28	1.00	1.72	0.91
BW 311-7	3.25	4.04	7.27	2.75	3.78	5.18	1.25	1.86	0.94
IR 43526-523-1-1	3.50	3.65	5.85	2.25	3.51	4.29	0.75	1.57	0.75
IR 46292-24-2-2-1-2	2.75	4.24	6.69	2.25	2.99	3.23	0.75	1.57	0.70
R 47554-3B-4-2B-1-2	2.75	3.35	4.86	2.00	2.56	3.35	0.50	0.54	0.36
IR 48120-49-5-3-2	2.25	3.52	4.94	2.00	3.49	3.53	1.75	2.96	0.98
IR 49223-B-142-1-2-1	2.75	4.02	5.39	1.50	2.02	2.85	0.00	0.00	0.00
IR 52280-117-1-1-3	3.50	5.69	5.14	2.00	3.30	2.39	1.25	2.32	0.83
IR 53643-3B-1-3	5.25	6.41	5.56	3.25	4.35	3.98	1.75	2.10	0.98
IR 53647-3B-10-2	3.00	5.89	3.93	2.75	4.02	2.08	2.00	3.14	1.04
IR 53653-3B-10-3	4.00	7.66	6.29	3.00	4.29	4.36	1.75	2.24	1.25
IR 55185-4B-5	2.25	5.12	7.84	1.50	3.84	4.21	1.25	1.89	1.02
IR 57111-3B-7-B-9-1-8	2.25	3.27	4.68	1.25	1.68	1.49	1.00	1.33	0.83
VIJYA (CR 10-5437) (ACC 12892)	2.75	3.52	3.93	1.75	2.25	2.02	0.00	0.00	0.00
IR 26	2.25	2.77	3.54	2.00	1.88	1.94	1.50	1.78	1.28
IR 29	2.50	2.93	3.88	2.00	2.13	2.54	1.25	1.43	1.24
IR 36	3.25	4.45	4.23	2.50	3.02	3.21	2.25	1.93	1.31
IR 42	3.25	4.04	3.28	2.00	3.40	2.41	1.00	1.30	0.76
BAS 370	4.00	6.97	5.77	2.50	4.15	2.18	0.50	1.09	0.45
IR 1561	3.75	9.62	7.93	2.00	5.49	3.67	0.75	1.07	1.33

m^{-3} NaCl.

Salt tolerance of these rice lines may be attributed to the effective exclusion of toxic ions and participation of different genes responsible for salt tolerance in plants. Similar conclusions had been discussed by Akbar (1986), and Yeo and Flowers (1986).

Moderately tolerant genotypes. Thirty three rice lines were found to be moderately tolerant when exposed to NaCl salinity. At 50 mol m^{-3} NaCl salt concentration, a limited reduction was observed otherwise producing approximately the same yield as that of obtained from control (non salinized) medium (Table II). However, further increase in salt stress caused more reduction in growth parameters but less than sensitive rice lines (Table III). These genotypes could be grown successfully under moderately salt-affected environments, nevertheless, excessive salt stress may cause a massive reduction in growth and so yield.

Sensitive genotypes. Among 110 rice lines, 34 genotypes produced much less tillers and root and shoot biomass when exposed to higher salinity (100 mol m^{-3} NaCl) so ranked as sensitive (Table III). These rice lines were compared with tested sensitive varieties (Bas 370 and IR 1561). On the basis of percent mortality at salinity of 100 mol m^{-3} NaCl, five rice lines, i.e., B 6992D-MR-13-1, IR 26916-ES, IR 37096-56-1, IR 49223-B-142-1-2-1 and VUYA (CR-10-5437) (ACC 12892) were classified as highly sensitive rice lines. All the lines exhibited greater sensitivity to salt in the root medium during tillering and at the other stages of plant growth. The cause of sensitivity to stress may be the inefficiency of genes capable of salt tolerance in plants. Resembling interpretations have already been quoted by Akbar (1986).

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