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Assessment of rice genotypes for salinity tolerance at germination and seedling stage

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Abstract: Four rice (*Oryza sativa* L.) genotypes *viz.*, CO 43, Pokkali, ADT 38 and IR 50 with varying levels of tolerance to salinity were used for assessing their response to salt at germination and seedling stage. Differential response of genotypes to salt concentration was observed. Germination was more than 90% in tolerant varieties Co 43 and Pokkali was below 70% in susceptible variety IR 50. Shoot and root length, vigour index and germination per cent decreased with increasing salinity levels. Among the four genotypes, Pokkali showed a higher activity of peroxidase and catalase followed by Co 43, while ADT 38 and IR 50 showed lesser activity of these enzymes.

Key words : Oryza sativa, salinity, catalase, peroxidase, vigour index.

Introduction

Salinity affects plant growth and development in several ways leading to very low productivity. About 10 million hectares of land in India are affected by soil salinity and alkalinity (Bhargava, 1989). This problem could be overcome either by reclaiming the environment through soil amendments or by inherent capacity of the genotype or by genetically changing the plant to improve its tolerance level which is more permanent and environment friendly (Christiansen and Lewis, 1976). To breed a tolerant line, one must be aware of crop genetics and physiology and develop an efficient screening system based on stable selection criteria. Soil salinity increases the catalase and peroxidase activity among tolerant and sensitive varieties of cotton (Gossett *et al.* 1994). The relationship between salinity and antioxidants was studied by Swamy and Reddy (1991) who reported that $O_2^{\cdot}$ radical and H_2O_2 could play an important role in the mechanism of adaptation. The aim of the present study was to assess the response of rice genotypes to salinity by understanding the role of oxidative enzymes, *viz*, peroxidase and catalase.

Materials and Methods

The experiment was conducted in the glass house of Crop Physiology, Tamil Nadu Agricultural University, Coimbatore - 3 during 2000-2001. Mature seeds of four genotypes *viz*, CO 43, Pokkali, ADT 38 and IR 50 were used for the study. Data were recorded on germination percentage, shoot and root length, vigour index, catalase and peroxidase activity. Germination test was carried out as suggested by Maliwal and Paliwal (1971) and Gupta (1993). Seeds were treated with 100, 200 and 300 mM NaCl solution in the petridishes lined with filter paper, each containing 100 seeds. Double distilled water was used as a control. The treatment was replicated thrice and germination count was taken 10 days after sowing and expressed as percentage. The length of root of twenty five seedlings from the seed to the tip of the root was taken as the root length. The height of the twenty five seedlings from the seed to the tip of the leaf blade were recorded and expressed in centimetres. Vigour index was calculated as follows.

Vigour index = (Average shoot length + Average root length) x Germination percentage.

The activity of enzymes catalase and peroxidase was assayed as per Gossett *et al.* (1994). The catalase activity was expressed in μg of H_2O_2/ min/g and peroxidase activity as change in absorbance at 430 nm/min/g, respectively. For catalase activity 0.1 ml of enzyme extract solution and 1 ml of H_2O_2 - free phosphate buffer (0.2 M) and set as blank. To this, add 3 ml of H_2O_2 - phosphate buffer. Mix gently. Note the change in time required for a decrease in OD at 250 nm. Peroxidase was extracted

Table 1. Effect of salt stress on germination percentage and shoot length

Germination percentage

Variety	Control	Salinity levels			
		100mM	200mM	300mM	Mean
CO 43	98.66	94.66	81.66	81.66	89.16
Pokkali	96.33	91.33	90.34	90.33	92.08
ADT 38	92.00	88.66	84.20	69.33	83.54
IR 50	94.33	60.00	58.66	28.33	60.33
Mean	95.33	83.65	79.63	67.41	81.28
	Genotype	Salinity level	Genotype x salinity level		
C.D (5%)	0.9159**	0.4317**	2.2436**		

Shoot length (cm)

Variety	Control	Salinity levels			
		100mM	200mM	300mM	Mean
CO 43	10.28	8.22	7.51	6.81	8.20
Pokkali	10.59	10.46	9.72	9.75	10.15
ADT 38	10.01	9.56	9.46	8.88	9.47
IR 50	10.80	7.92	6.68	6.48	7.97
Mean	10.42	9.04	8.36	7.98	8.95
	Genotype	Salinity level	Genotype x salinity level		
C.D (5%)	0.2188**	0.1031**	0.5361**		

in pre-chilled distilled water, the content was centrifuged at 2000 rpm and 1 ml of extract was used for assay. The assay mixture contains 0.5 ml of 0.05 N H_2O_2, 2 ml of phosphate buffer and 0.5 ml of 1% pyrogallol. The change in OD at 425 nm was recorded. Statistical analysis was carried out as per Panse and Sukhatme (1961).

Results and Discussion

Germination percentage

Germination of seeds involve the activation of enzyme systems as well as mobilization of reserve foods and these process are adversely affected by NaCl (Levitt, 1980). The germination percentage decreased with increasing salt concentration (Table 1). Among the salinity levels, the highest germination was observed in 100 mM (83.65) and the lowest in 300 mM (67.41). Below 70 per cent germination was recorded in IR 50 showing the susceptible nature. Pokkali is a highly tolerant variety (above 90 per cent germination). It is clear from the study that there is a significant difference in germination percentage among the genotypes and interaction of genotypes and NaCl concentration was also significant. A similar trend was also reported by Maliwal and Paliwal (1971), Varsheney and Balija (1985) and Singh and Rana (1989).

Shoot length (cm)

Among the genotypes, Pokkali recorded the maximum shoot length, while IR 50 recorded the minimum shoot length (Table 1). Salt concentration of 100 mM recorded the significantly higher shoot length and shoot length also decreased with increase in salt concentration (Tabel 1). The interaction between genotypes and salt

concentration was significant. The retardation of shoot growth was more in susceptible genotype like IR 50 which was 60 per cent of control. Similar result was observed by Gill and Singh (1989).

Root length (cm)

The highest root length was observed in Co 43 followed by Pokkali, while the lowest root length of 7.73 cm followed by 200 mM (7.44 cm). Like shoot length, root length also decreased with increasing salt level. The interaction between gentoypes and salt levels was highly significant (Table 2). The percentage of reduction in root length at 300 mM over control was higher in IR 50 (42.10), whereas the reduction was less in the tolerant variety, Pokkali. Similar results were reporetd by Datta and Bal (1993). Percentage of decrease of shoot and root length was less for tolerant varieties than susceptible genotypes. Whereas intermediate growth response was noticed resulted moderately tolerant (ADT 38). This confirm the findings with Balakrishna and Iyengar (1980).

Vigour Index

There is a decreasing trend in vigour index as the salt concentration increased. The interaction between varieties and salt concentration was significant. A similar trend was noticed in shoot length, root length and germination percentage. The resistant genotypes showed less reduction of vigour index over its control at different salt levels.

Table 2. Effect of salt stress on root length (cm) and vigour index in rice genotypes

Root length (cm)

Variety	Control	Salinity levels			
		100mM	200mM	300mM	Mean
CO 43	9.64	8.26	8.22	8.08	8.55
Pokkali	8.66	8.48	8.36	8.35	8.46
ADT 38	8.97	7.85	7.33	7.08	7.80
IR 50	9.50	6.33	5.61	5.50	6.73
Mean	9.19	7.73	7.44	7.25	7.87
	Genotype	Salinity level	Genotype x salinity level		
C.D (5%)	0.0640**	0.0302**	0.1570**		

Vigour index

Variety	Control	Salinity levels			
		100mM	200mM	300mM	Mean
CO 43	1965.30	1559.99	1373.70	1215.91	1528.72
Pokkali	1851.46	1720.65	1648.19	1634.97	1713.81
ADT 38	1743.40	1508.10	1372.33	1012.91	1409.18
IR 50	1914.89	782.16	715.245	692.18	1026.11
Mean	1438.76	1392.72	1277.36	1138.99	1311.95
	Genotype	Salinity level	Genotype x salinity level		
C.D (5%)	57.487**	20.099**	140.81**		

Table 3. Catalase and peroxidase activity in rice genotypes at different levels of NaCl

Catalase (μg H_2O_2/min/g)

Variety	Control	Salinity levels			
		100mM	200mM	300mM	Mean
CO 43	198.7	208.8	261.4	340.8	254.42
Pokkali	234.1	248.1	291.2	361.2	283.65
ADT 38	172.4	184.2	198.6	240.6	198.95
IR 50	187.2	190.1	210.4	280.1	216.95
Mean	198.1	207.8	240.4	305.6	238.49
	Genotype	Salinity level	Genotype x salinity level		
C.D (5%)	3.2	4.8	10.3		

Peroxidase (ΔA_{430}/min/g)

Variety	Control	Salinity levels			
		100mM	200mM	300mM	Mean
CO 43	3.92	6.01	7.84	11.17	7.23
Pokkali	5.80	8.62	10.12	13.63	9.54
ADT 38	3.08	4.01	5.39	7.08	4.89
IR 50	3.41	4.36	6.84	8.16	5.69
Mean	4.05	5.75	7.54	10.01	6.83
	Genotype	Salinity level	Genotype x salinity level		
C.D (5%)	0.86	0.98	1.73		

Catalase and Peroxidase activity

Salinity caused a significant increase in the catalase and peroxidase activity. Pokkali showed a maximum catalase activity at 300 mM followed by CO 43 (Table 3).

Salinity also resulted in increased activity of peroxidase. The increase was more in Pokkali followed by CO 43 (Table 3). The higher incerase in enzyme activity may be one of the reason for the successful establishment of tolerant rice varieties under salt condition. The observed increase in catalase activity over control was in accordance with Badiani *et al.* (1990) in wheat. The increase in activity was due to increase in salt concentration. The percentage increase was more in tolerant cultivars showing that it has the inherent capacity to withstand the stressful condition. This was on par with the results of Zhang and Kirkham (1991). The increase in the activity of antioxidant enzymes may be due to the higher levels of O_2 produced under stress. This shows that an efficient defence mechanism might be involved in the increase of the antioxidant levels.

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