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RESEARCH ARTICLE

Evaluation of salinity tolerance in Tamil Nadu and Kerala's popular traditional rice varieties during germination and early growth stages

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ABSTRACT

Rice is a key food crop worldwide. Drought, salinity, and flooding stress are the most common abiotic stresses in rice crops, and they result in large production losses each year. The present study aimed to assess the salinity tolerance in the early growth phases of 14 rice varieties, including local varieties from the Indian states of Tamil Nadu and Kerala were investigated at NaCl concentrations of 0 mM (control), 100 mM, 150 mM, 200 mM, and 250 mM. Salt tolerance was examined in selected varieties using the Petri plate method in a controlled environment (24 ± 2 ºC) in a plant growth chamber. At 7 days after sowing (DAS), data were statistically analysed for germination percentage, root length, branch length, and total seedling length. The vigour index is also determined for seven DAS seedlings. Lower magnitude values in germination percentage, root length, shoot length, and total seedling length resulted in shorter shoot and root lengths across all kinds. At 250 mM NaCl, Karunguruvai had the highest germination percentage (85%), followed by TPS-5 (50%). Furthermore, at 150 mM NaCl concentration, the traditional rice variety karunguruvai showed 100% seed germination, followed by mappilai samba and TPS-5 (90%), arupatham kuruvai (85%), and pongar (80%). At a 250 mM NaCl solution, karunguruvai exhibits much better rates of root and shoot growth than other types. As a result, the current study suggests that Karunguruvai could be utilised to further investigate salinity's effect on growth processes and physiological repercussions at an advanced stage of development.

Keywords: germination, rice, salinity screening, salt tolerance. traditional rice varieties.

INTRODUCTION

Rice is a semi-aquatic cereal and is the staple food of over two billion Asians and hundreds of millions of Africans and Latin Americans (IRRI, 1985). Drought, salinity, and flooding cause serious harm beyond economic injury and agricultural losses annually (Akpeji et al., 2021). Abiotic stress has lowered crop yields by almost 50% worldwide. Since salt stress reduces global agricultural productivity, the mechanism of salt tolerance is one of the most critical areas that may be studied in plant science (Lafitte et al., 2004). When seen from the agricultural perspective, stresses such as these are among the most critical elements that can lead to considerable and unpredictably significant losses in crop yield. The progression of salinization of agricultural land is associated with the appearance of harmful consequences during plant development, most noticeably at the seedling stage (Ashokkumar et al., 2013). As a result, the development of rice genotypes that are ideal for places prone to salinity can assist us in maintaining a stable yield in conditions with limited access to water. Saline water incursion and rising sea levels owing to global warming make coastal areas prone to salinity (Ashokkumar et al., 2023).

Richards (1996) asserts that conventional ways of breeding crop plants to improve their tolerance to abiotic stress have had limited success. This is because conventional approaches have been used. The traditional methods need a considerable amount of time due to the difficulty in selecting secondary traits and the complexity of the systems responsible for tolerance. It is possible that biotechnology, and more specifically genetic engineering, could offer significant potential for enhancing rice productivity even under particularly unstable situations. When it comes to the process of developing genetically modified plants by the application of biotechnological methods, the phase that is considered to be the most significant is almost always the phase in which relevant genes are isolated (Kumar et al., 2013).

An understanding of salinity stress tolerance was difficult to achieve because of the multigenic nature of the trait. As a direct consequence of this, there is not a single traditional rice line in the gene pool that possesses both resilience to high salinity and high yield, which is yet another disadvantageous feature. In the course of their investigation into the processes of tolerance, plant scientists have developed hypotheses by analysing the correlational evidence from a variety of species. These hypotheses are founded on the biochemical and biophysical principles that determine the tolerance or resistance to stress (Levitt, 1980). Based on the concept that these principles affect stress tolerance or resistance; various hypotheses have been developed. The presence of an excessive amount of sodium chloride in saline soil inhibits the growth of plants. Rice requires resistant types to be able to overcome the effects of salt stress (Akbar et al., 1972). According to Ashokkumar et al. (2013), for rice to be able to tolerate high levels of salinity, it is necessary to analyze the genetic diversity, screening methods, genetics, and physiological mechanisms. In the current study, the objective was to determine the degree to which fourteen different genotypes of rice, which were gathered from different regions in Kerala and Tamil Nadu, were sensitive to salinity.

MATERIALS AND METHODS

The fourteen traditional and modern rice varieties, White ponni, Mappillai samba, Arupatham kuruvai, Poongar, Karunguruvai, Rakthasali, Joythi matta, Seeraga samba, CO 53, CO 51, TPS 5, IR 20, ADT 36, and TRY 1 were collected from TNAU, CREATE- Nel Jayaraman, organic farming and traditional paddy research centre, Tiruvarur, Tamil Nadu, and traditional rice growers from Kottayam, Kerala during the year 2022-2023. Using Petri dishes, germination tests were conducted with NaCl solutions containing concentrations of 0, 100, 150, 200, and 250 mM. The experiment was carried out at the Crop Improvement Laboratory, School of Agriculture and Animal Sciences, Gandhigram Rural Institute-Deemed to be University, Dindigul, India.

Uniform-sized rice seeds were selected for the experiment. Following a thirty-minute exposure to a solution of 5% sodium hypochlorite, each seed underwent three washing using distilled water. After the washing process, a total of 20 seeds from each rice variety were carefully transferred into a 9-centimetre Petri plate that was lined with two filter papers. Subsequently, these seeds were immersed in either 10 millilitres of distilled water (serving as the control) or an equivalent volume of a non-concentrated saline solution. Subsequently, a Petri dish lid was placed over the petri dish to minimise evaporation. The treatments underwent three replications. The seeds were planted in Petri dishes within a growth chamber maintained at 24 ± 2ºC and a relative humidity of 75% (Zhang et al., 2021).

The evaluation of the germination rate starts on the seventh day following seeding and is quantified as a percentage. The measurements of shoot length and root length were conducted for all of the types. The measurement of the distance between the seed and the tip of the leaf blade was recorded. Ashokkumar et al. (2023) measured and reported the mean height of 20 seedlings in centimetres. The calculation of the vigour index (VI) was performed using the formula VI = Germination x total seedling length, (Abdul-Baki and Anderson,1973).

RESULTS AND DISCUSSION

Effect of *NaCl* on germination (%)

In this investigation, the germination percentage decreased as the level of salt concentration increased. Levitt (1980) found that NaCl has a deleterious effect on reserve foods and enzyme systems during the process of seed germination. As a result, the rate of germination slowed down as the salinity level increased. At 250 mM, Karunguruvai (85%) and TPS-5 (50%) showed the most germination, while Mappilai samba (15%), CO 51 (15%), and Arupatham kuruvai (15%) showed the least. Varieties like CO 53, IR 20, Seeraga samba, ADT 36, and TRY 1 do not respond at a 250 mM concentration. However, at 150 mM NaCl concentration, the traditional rice variety Karunguruvai recorded 100% seed germination, followed by Mappilai samba and TPS-5 (95%), Arupatham kuruvai (85%), and Pongar (80%), and the remaining varieties recorded below 70% germination (Table 1). A similar trend was also observed in previous reports by Krishnamoorthy et al. (1987), Gupta (1993), and Ashokkumar et al. (2023).

Table 1. Effect of *NaCl* on germination percentage at 7 DAS traditional and modern rice varieties (by Petri plate method)

		Germination (%)				
S. No.	Varieties	Control	100 mM	150 mM	200 mM	250 mM
1	White Ponni	95^{b}	75^{e}	75^{e}	30^{g}	20^{e}
2	Mappilai Samba	100^{a}	95^{b}	90^{b}	70^{a}	15^{f}
3	Arupatham Kuruvai	85^{d}	90^{c}	85^{c}	35^{f}	15^{f}
4	Poongar	90^{c}	85^{d}	80^{d}	40^{e}	30^{d}
5	Karunguruvai	100^{a}	100^{a}	100^{a}	65^{b}	85^{a}
6	Jyothi Matta	95^{b}	70^{f}	66^{f}	60^{c}	35^{c}
7	Rakthashali	90^{c}	66^{g}	63^{g}	61^{c}	16^{f}
8	CO 53	90^{c}	60^{h}	30^{k}	5^{h}	0^{g}
9	CO 51	80^{e}	95^{b}	55^{i}	65^{b}	15^{f}
10	TPS- 5	95^{b}	95^{b}	90^{b}	65^{b}	50^{b}
11	IR -20	90^{c}	65^{g}	60^{h}	45^{d}	0^{g}
12	Seeraga Samba	85^{d}	25^{j}	5^{l}	0^{i}	0^{g}
13	ADT 36	75^{f}	45^{i}	40^{j}	0^{i}	0^{g}
14	TRY 1	90^{c}	75^{e}	5^{l}	5^{h}	0^{g}
	CV	0.75	0.88	1.05	1.69	3.56
	CD (0.05)	1.46	1.40	1.34	1.40	1.51

CV, Co-efficient of Variation, CD, Critical Difference. Values with the same letters in a column are not significantly different ($p < 0.05$)

Effect of NaCl on Root Length (cm)

Significant root length variation was observed all varieties and each NaCl concentration (Table 2). The root growth was recorded highest in Karunguruvai (1.10cm) is much higher than in other varieties at a 250 mM NaCl concentration. A similar trend was observed by Gupta (1993), and Kaliyarasi et al. (2019), Moreover, the minimum root growth was observed in the varieties like IR20, Seeraga samba, TRY1, and CO 53 at 250 mM concentration. However, at 200 mM, Mappilai samba recorded the greatest root length (2.50 cm), followed by Karunguruvai, Ponngar, and Jyothi Matta were on par with 1.23 cm (Table 2).

Table 2. Effect of *NaCl* on root length (cm) at 7 DAS traditional and modern rice varieties (by Petri plate method)

		Root length (cm)				
Sl.No.	Varieties	Control	100 mM	150 mM	200 mM	250 mm
1	White Ponni	4.13^{fg}	1.83^{def}	1.33^{e}	0.43^{cd}	0.10^{cd}
2	Mappilai Samba	7.00^{bcd}	4.23^{abc}	4.87^{a}	2.50^{a}	0.63^{b}
3	Arupatham Kuruvai	6.83^{bcd}	5.53^{a}	4.30^{b}	0.33^{ccd}	0.37^{bcd}
4	Poongar	7.83^{bc}	2.66^{cd}	3.07^{cd}	1.23^{b}	0.17^{cd}
5	Karunguruvai	17.66^{a}	4.30^{adc}	2.73^{d}	1.23^{b}	1.10^{a}
6	Jyothi Matta	8.80^{b}	5.13^{ab}	4.03^{abc}	1.23^{b}	0.10^{cd}
7	Rakthashali	4.66^{efg}	3.00^{cd}	3.37^{bcd}	0.30^{cd}	0.53^{bc}
8	Co 53	2.70^{gh}	1.93^{def}	1.23^{e}	0.37^{cd}	0.07^{d}
9	Co 51	4.23^{fg}	2.50^{cde}	1.20^{e}	0.93^{bc}	0.03^{d}
10	TPS- 5	6.33^{cde}	3.27^{bcd}	2.53^{d}	0.60^{cd}	0.67^{ab}
11	IR -20	5.13^{def}	0.53^{ef}	3.43^{bcd}	1.03^{bc}	0.07^{d}
12	Seeraga Samba	1.33^{h}	1.90^{def}	0.07^{f}	0.07^{e}	0.07^{d}
13	ADT 36	3.03^{gh}	0.40^{f}	1.03^{ef}	0.07^{e}	0.13^{cd}
14	TRY 1	6.26^{cde}	2.10^{def}	0.07^{f}	0.07^{e}	0.06^{d}
	CV	19.58	42.55	27.94	37.57	93.38
	CD (0.05)	2.01	1.99	1.11	0.46	0.45

Values with the same letters in a column are not significantly different ($p < 0.05$)

Effect of NaCl on Shoot length (cm)

The salinity affected the length of the shoots, just as it did on the length of the roots. When compared to the growth of plumules in Karunguruvai and Mappilai samba had a greater plumule growth rate at a concentration of 250 mM. The varieties, TRY1, IR20, White Ponni, TPS 5, CO 53, and ADT36 possess lower shoot length in 250 Mm NaCl concentration. As saline levels rise, the Karunguruvai varieties have been seen to have a longer shoot length (1.13 cm). However, in 100, 150, and 200 mM NaCl concentrations, the Mappilai samba variety had a higher shoot length than the other varieties (Table 3). Similar results were also observed by Gupta (1993), Kaliyarasi et al. (2019) and Ashokkumar et al. (2023).

Salinity had an impact on shoot length, just like it did on root length. The plumule growth was higher in Karunguruvai and Mappilai samba compared to others at 250 mM concentration. The shoot growth, which is low in TRY1, IR20, White Ponni, TPS 5, CO 53, TPS 5, and ADT36, shows no responses. Karunguruvai (1.13cm) has shown higher shoot length as salinity increases.

Table 3. Effect of *Na Cl* on shoot length(cm) at 7 DAS traditional and modern rice varieties (by Petri plate method)

		Shoot length (cm)				
S. No.	Varieties	Control	100 mM	150 mM	200 mM	250 mM
1	White Ponni	4.00^{d}	1.13^{bc}	0.87^{cd}	0.20^{b}	0.07^{bcd}
2	Mappilai Samba	5.50c	2.80^{a}	1.80^{b}	1.50^{a}	1.07^{a}
3	Arupatham Kuruvai	7.33^{b}	2.70^{a}	1.97^{ab}	0.27^{b}	0.10^{b}cd
4	Poongar	5.70^{c}	2.67^{a}	2.10^{ab}	0.27^{b}	0.07^{bcd}
5	Karunguruvai	8.23^{a}	2.73^{a}	2.57^{a}	0.93^{a}	1.13^{a}
6	Jyothi Matta	4.00^{d}	1.00^{bcd}	0.83^{cde}	0.10^{b}	0.17^{bc}
7	Rakthashali	3.20^{ef}	1.30^{bc}	1.10^{c}	0.23^{b}	0.13^{bcd}
8	CO 53	2.77^{fg}	0.73^{cde}	0.17^{fg}	0.03^{b}	0.07^{bcd}
9	CO 51	3.70^{de}	1.00^{bcd}	0.20^{efg}	0.27^{b}	0.13^{bcd}

10	TPS 5	4.13^{d}	1.03^{bcd}	0.73^{cdef}	0.03^{b}	0.03^{cd}
11	IR 20	2.73^{fg}	0.13^{e}	0.40 ^{cdef}	0.93^{a}	0.17^{bc}
12	Seeraga Samba	0.13^{h}	1.43^{b}	0.07^{g}	0.10^{b}	0.20^{b}
13	ADT 36	0.17^{h}	0.43^{de}	0.07^{g}	0.10^{b}	0.00^{d}
14	TRY 1	2.20^{g}	0.77^{cd}	0.13^{fg}	0.07^{b}	0.07^{bcd}
	CV	9.92	25.33	41.80	106.60	40.68
	CD (0.05)	0.63	0.60	0.64	0.64	0.165

Values with the same letters in a column are not significantly different ($p < 0.05$)

Effect of *Na Cl* on Vigor index

The seed lot showing a higher seed vigor index is considered more vigorous. According to Abdul-Baki and Anderson (1973), the seed vigor index was determined by multiplying the germination percentage by the total seedling length. At a concentration of 250 mM NaCl, the traditional rice variety Karunguruvai displayed the highest vigor index (188.63), followed by the varieties TPS-5 (25.80), Poongar (20.67), Jyothi matta (18.63), and Mappilai samba (18.42). Other varieties exhibited lower vigor indexes. Nevertheless, when exposed to 200 mM NaCl, Mappilai Samba exhibited the highest vigor index (277.73), followed by Karunguruvai (139.80) and Jyothi Matta (106.0), as shown in Table 4.

Table 4. Effect of *Na Cl* on Vigour index at 7 DAS traditional and modern rice varieties (by Petri plate method)

		Vigor index				
S.No.	Varieties	Control	100 mM	150 mM	200 mM	250 mM
1	White Ponni	766.00^{d}	22.98^{e}	163.85^{def}	17.65^{ef}	12.97^{bcd}
2	Mappilai Samba	1243.83^{b}	664.71^{a}	596.55^{a}	277.73^{a}	18.42^{bc}
3	Arupatham Kuruvai	1195.83^{b}	330.85^{d}	549.43^{a}	52.67^{de}	7.35^{cd}
4	Poongar	1211.30^{b}	343.51^{d}	463.91^{ab}	20.47^{ef}	20.67^{bc}
5	Karunguruvai	2577.17^{a}	419.76^{bc}	527.61^{a}	139.80^{b}	188.63^{a}
6	Jyothi Matta	1169.73^{bc}	365.05^{cd}	338.63^{bc}	106.00^{bc}	18.63^{bc}
7	Rakthashali	282.83^{e}	156.57^{f}	191.89^{de}	8.74^{ef}	10.67^{bcd}
8	CO 53	334.23^{e}	158.47^{f}	45.97^{fg}	2.26^{ef}	0.03^{d}
9	CO 51	630.50^{d}	330.63^{d}	76.36^{efg}	89.47^{bcd}	7.45^{cd}
10	TPS-5	981.50^{c}	427.97^{b}	286.31^{cd}	53.60^{cde}	25.80^{b}
11	IR-20	704.30^{d}	34.68^{g}	247.40^{cd}	87.37^{bcd}	0.02^{d}
12	Seeraga Samba	53.97^{f}	67.07^{g}	11.63^{g}	0.03^{f}	0.01^{d}
13	ADT 36	233.37^{ef}	10.43^{g}	48.83^{fg}	0.05^{f}	0.10^{d}
14	TRY 1	754.62^{d}	240.67^{e}	0.02^{g}	2.82^{ef}	0.09^{d}
	CV	14.49	13.18	12.83	14.18	16.15
	CD (0.05)	210.15	59.38	139.11	52.48	18.25

Values with the same letters in a column are not significantly different ($p < 0.05$)

CONCLUSION

The outcomes of this experiment indicate that when there was a higher concentration of salinity, the percentage of seeds that germinated was lower than it was when there was any other concentration. As a result of the tested rice varieties, the germination rate was highest in Karunguruvai (85%) at a 250 mM NaCl concentration. This indicates that the traditional variety Karunguruvai has a solid capacity to tolerate salt and is an ideal choice for salt-resistant rice. The salinity affected the length of the roots, just as it did on the length of the shoots. Karunguruvai showed a greater capacity for salt tolerance as evidenced by the fact that its shoot length and root length decreased by a lesser percentage than other varieties. It is possible to use it to investigate further the influence that salinity has on growth processes and the physiological effects that it has at a more advanced stage of growth.

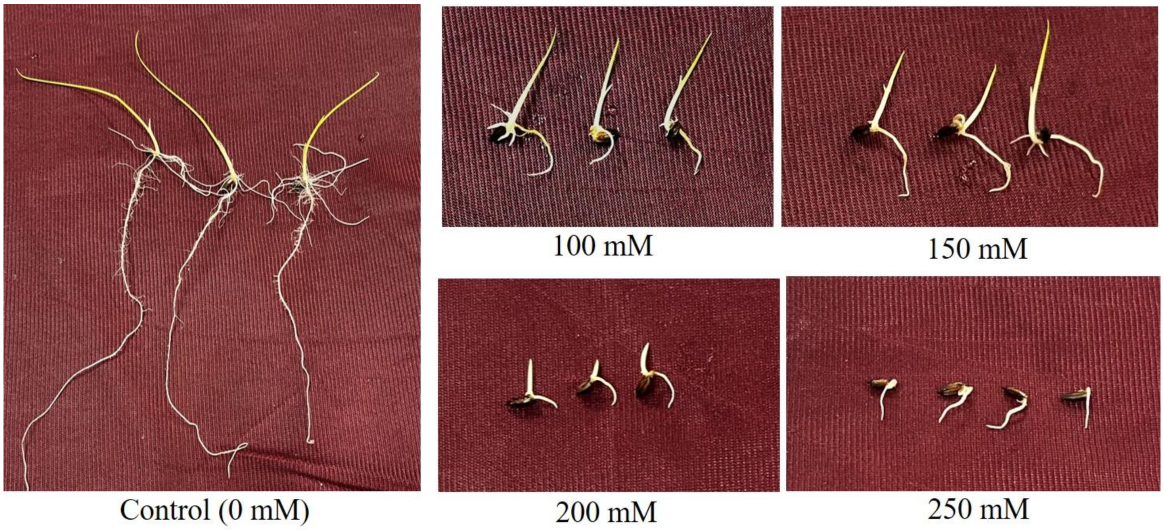
Control (0 mM) 100 mM 150 mM 200 mM 250 mM

Figure 1. Effect of Salinity tolerance potential in the traditional rice variety Karunguruvai at various NaCl concentrations at 7DAS.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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