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RESEARCH ARTICLE

Assessment of Traditional and Modern Rice Varieties for Salt Tolerance at Early Growth Stages

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ABSTRACT

The germination and early growth stages of eight rice varieties, including popular traditional varieties from Tamil Nadu, were studied at 0 mM, 100 mM, 150 mM, 200 mM, and 250 mM of NaCl concentrations. Data were analyzed statistically for germination percentage, plumule length, root length, shoot length, and total seedling length at 7 DAS (days after sown). Lower magnitude values for the varieties of final germination percentage (FGP) and germination energy (GE) % led to reductions in the shoot and root length in all varieties. The magnitude of the reduction increased with increasing stability stress. Rice varieties TRY 1 (84%), ADT 45 (71%), and Thuyamalli (71%) showed a more significant germination percentage at 250 mM salt concentration. However, in 200 mM salt concentration, Mappilai samba had recorded higher seedling length (3.3 cm) followed by Aathur kitchali samba (2.5 cm), ADT 45 (2.5cm), TRY 1 (2.2 cm), and other varieties were had lower total seedling length. The result revealed that Mappilai samba, Aathur kitchali samba, ADT 45, and TRY 1 might be utilized to research salinity's effects on growth processes and physiological effects at advanced growth stages.

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

INTRODUCTION

Rice is a tropical semi-aquatic cereal. It is the staple meal for almost two billion people in Asia, the world's most densely populated region, and hundreds of millions in Africa and Latin America (IRRI, 1985). However, 42.2 million hectares of the 148 million hectares of arable land produced 2.12 metric tons per hectare of rice in 2009. Abiotic stress reduces key crop yields by around 50% worldwide. 953 million hectares 8% of the land are salinized. Saline water incursion and rising sea levels from global warming make coastal areas prone to salinity.

Abiotic stress like salinity, drought, and flooding caused severe damages beyond economic injury levels and crop losses yearly (Atkinson and Urwin, 2012; Akpeji et al., 2021). Saline soil has an excessive sodium chloride (NaCl) content, which inhibits plant growth. Rice is moderately sensitive to salinity, and the most practical approach to overcome salinity is developing tolerant varieties (Akbar et al., 1972). The basic requirements are genetic variability, screening techniques, and understanding genetics and salt tolerance's physiological mechanism (Ashokkumar et al., 2013).

Rice is susceptible to salt from 0 to 8 dS m^{-1}. Two criteria determine salt tolerance. The salinity threshold is the maximum salinity without yield decline, while the slope is the percent yield reduction per unit increase of salinity above the threshold. Rice (*Oryza sativa* L.) has a 3.0 dS m^{-1} salinity threshold and a 12% yield reduction per unit increase in ECe. Rice is sensitive to salinity at the seedling stage, tolerant at the vegetative stage, and very susceptible at the reproductive stage in regarding grain yield, with a 50% reduction in yield and seedling emergence at 3.6 and 18 dS m^{-1}, respectively. Saline crop production requires early seedling identification of varieties' sensitivity and tolerance (Anbumalarmathil & Preeti Mehta, 2013). This study examined the salt tolerance of selected rice cultivars from diverse Tamil Nadu locations

MATERIALS AND METHODS

A total of eight rice varieties were used for this study. Four of them were Tamil Nadu's famous traditional [Aathur kichali samba, Thuyamalli, Karupu kavuni, Mapillai samba] varieties, and four were modern rice [CO 51, CO 45, TRY 1, and ADT 45] varieties were used for salinity testing. Traditional rice varieties were collected from the CREATE-Nel Jayaraman organic farm and traditional paddy research centre in Thiruvarur, Tamil Nadu, during the year 2022. The experiment was carried out in three replications for each trait or treatment, which were germinated on top of double-layered papers in Petri dishes with 10 ml of NaCl salt solution (0 mM, 100 mM, 150 mM, 200 mM, and 250 mM), (Ashokkumar et al., 2013; Kaliyarasi et al., 2019). Seven days after sowing (DAS), germination percentage (%), root length (cm), shoot length (cm), total seedling length (cm), and vigour index were measured (Abdul-Baki, & Anderson, 1973; Zhang et al., 2021). Statistical analysis was performed using WASP.2.0 software.

RESULTS AND DISCUSSION

Variability of morphological traits at 10 DAS seedlings of rice varieties

Morphological traits data were obtained from 10 DAS old seedlings grown in the roll towel method in normal water. Karupu kavuni, Aathurkichali samba, CO 51, and TRY 2 show higher germination percentages than others. Mapillai samba, Aathurkichali samba, and TRY 2 shows significance in shoot length, root length, vigour index. Thuyamalli shows were recorded lower in all morphological traits (Table 1). Mappilai samba had higher total seedling length and vigour index than other rice varieties.

Table. 1. Genetic variability of morphological traits in 10 DAS seedlings of traditional and modern rice varieties (by Roll towel method)

Sl. No.	Varieties	Germination (%)	Root length (cm)	Shoot length (cm)	Total seedling length (cm)	Vigour index
1.	Karupu kavuni	95.0^{a}	13.8^{bc}	7.1^{d}	21.7^{b}	2055.3^{b}
2.	Mapillai samba	91.3^{a}	15.9^{a}	11.2^{a}	26.5^{a}	2460.6^{a}
3.	Thuyamalli	30.0^{c}	11.4^{e}	5.8^{e}	15.3^{c}	508.3^{d}
4.	Aathurkichali samba	95.0^{a}	14.3^{ab}	8.2^{c}	22.4^{b}	2130.3^{ab}
5.	TRY 1	80.0^{b}	11.7^{de}	2.7^{f}	15.4^{c}	1287.3^{c}
6.	TRY 2	95.0^{a}	13.6^{bcd}	9.7^{b}	22.4^{b}	2140.3^{ab}

7.	CO 51	95.0^{a}	11.7^{e}	6.7^{de}	19.9^{b}	1893.3^{b}
8.	ADT 45	90.0^{a}	12.2^{cde}	7.1^{d}	21.6^{b}	2000.6^{b}
9.	CO 45	90.7^{a}	13.8^{bc}	6.5^{de}	20.2^{b}	1858.3^{b}
	CV	5.5	8.4	7.3	7.2	10.1
	CD (0.05)	8.1	1.9	0.9	3.6	333.6

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

Effect of Na Cl on speed of germination (SG) of rice varieties

Salt concentration decreased germination in this study (Table 2). NaCl inhibits enzyme activation and reserves food mobilization during seed germination (Levitt, 1980). When salinity was increased, the germination rate slowed (**Table 2**). At 250 mm, the maximum SG was shown by TRY-1, ADT 45, Thuyamalli, and the minimum in Karupu Kavuni. Krishnamoorthy et al. (1987), and Gupta (1993) recognized the tendency.

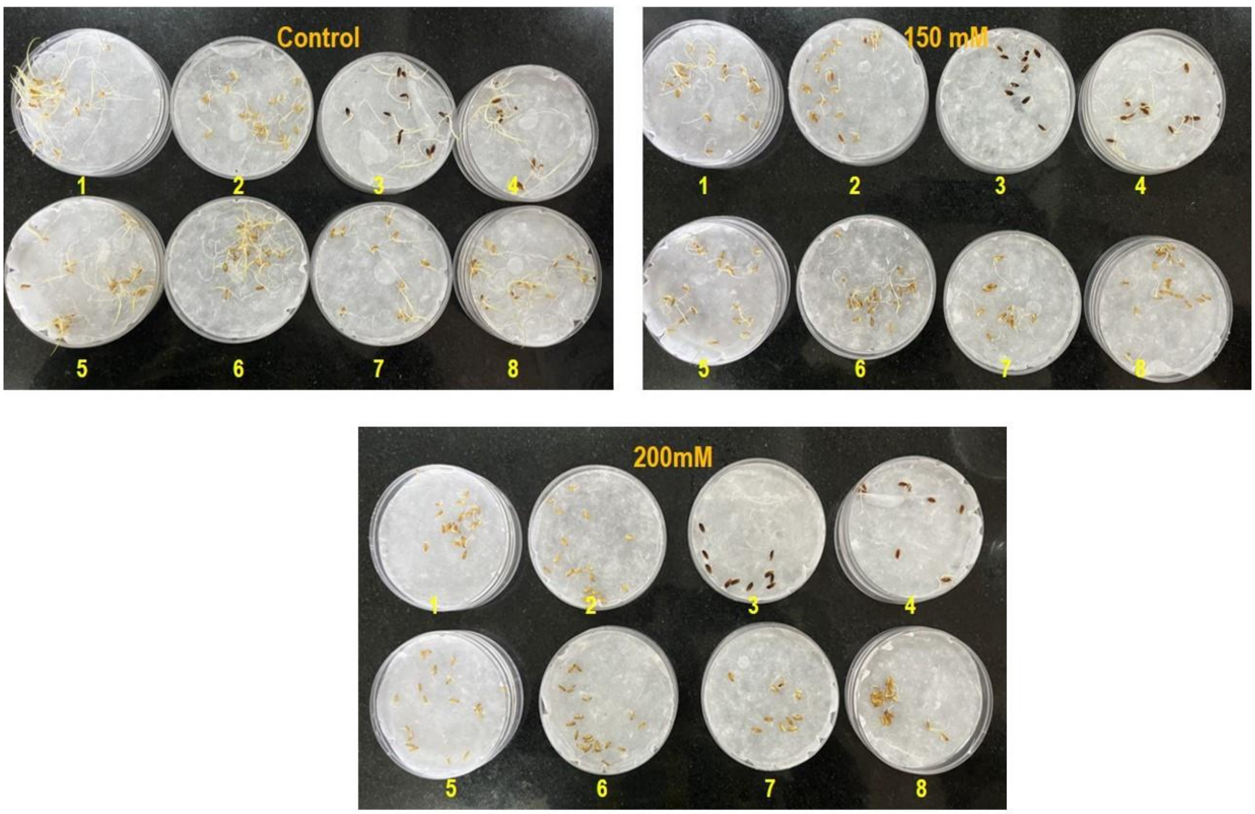

Figure 1. Salinity tolerance screening at various concentrations (0 mM, 150 mM, 200 mM). Note: 1. Aathur kichali samba, 2. Thuyamalli, 3. Karupppu kavuni, 4. Mappillai samba, 5. CO 51, 6. CO 45, 7. TRY 1 and 8. ADT 45.

Table 2. Effect of *Na Cl* on germination percentage at 7DAS traditional and modern rice varieties (by Petri plate method)

Sl. No.	Varieties	Germination (%)				
		Control	100mM	150mM	200mM	250mM
1.	Aathurkichali samba	97.0^{a}	97.7^{a}	97.3^{a}	75.0^{b}	69.0^{bc}
2.	Thuyamalli	85.3^{c}	70.0^{e}	90.0^{b}	76.0^{b}	71.0^{b}
3.	Karupu kavuni	97.7^{a}	90.0^{c}	81.0^{c}	60.0^{d}	39.5^{f}
4.	Mapillai samba	90.0^{bc}	97.0^{ab}	98.0^{a}	60.3^{d}	50.0^{e}
5.	CO 51	98.0^{a}	76.0^{de}	90.0^{b}	73.0^{bc}	60.0^{d}
6.	CO 45	94.0^{ab}	97.7^{a}	90.7^{b}	67.7^{c}	61.0^{cd}

7.	TRY 1	97.0^{a}	97.0^{ab}	97.0^{a}	97.0^{a}	84.5^{a}
8.	ADT 45	90.0^{bc}	81.0^{d}	80.3^{c}	76.3^{b}	71.0^{b}
	CV	3.4	4.2	4.0	4.8	5.5
	CD (0.05)	5.5	6.4	6.1	6.1	7.1

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

The percentage of germination energy also decreased with an increase in salinity levels. It was at its minimum in Karupu kavuni at 250 mM concentration and a maximum of 84.5% in the variety TRY-1, Aathurkichali samba (69%), Thuyamalli (71%), CO 51 (60%), CO 45 (61%), and ADT 45 (71%), showed a maximum response in 250 mM NaCl concentration. The deleterious effects of salts on germination were observed in terms of decreased germination percentage in Karupu kavuni (**Table 2**). The morphological observation of salinity tolerance was showed in **Figure 1.**

Effect of NaCl on root length

Root length is also affected by salinity. The higher root growth recorded in TRY-1 and ADT-45 is much higher than other varieties at 250 mM NaCl concentration (Table 3). Similar trends were observed by Gupta (1993). However, Karupu Kavuni does not show root growth symptoms at 200 mM and 250 mM concentrations. The varieties TRY1 (1.9cm) and ADT 45 (1.5cm) showed increased root length. The results suggested that ADT 45 and TRY 1 might be used to study further the salinity effect on growth processes and its physiological consequences at an advanced stage of growth.

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

		Root length				
Sl. No.	Varieties	Control	100mM	150mM	200mM	250mM
1.	Aathurkichali samba	7.7^{ab}	5.1^{a}	3.8^{ab}	1.9^{b}	0.2^{de}
2.	Thuyamalli	6.1^{cd}	4.1^{b}	1.4^{d}	0.4^{cd}	0.6^{cd}
3.	Karupu kavuni	7.0^{abc}	4.2^{b}	2.5^{c}	0.0^{e}	0.0^{e}
4.	Mapillai samba	6.4^{cd}	4.9^{a}	3.4^{b}	2.5^{a}	0.8^{c}
5.	CO 51	5.7^{d}	4.2^{b}	4.3^{a}	0.8^{c}	0.6^{cd}
6.	CO 45	8.1^{a}	5.0^{a}	4.3^{a}	0.3^{de}	0.5^{cd}
7.	TRY 1	6.6^{bcd}	5.1^{a}	3.9^{ab}	1.9^{b}	1.9^{a}
8.	ADT 45	7.9^{a}	4.4^{b}	3.7^{b}	2.1^{b}	1.5^{b}
	CV	9.6	6.5	11.3	11.1	13.1
	CD (0.05)	1.1	0.5	0.7	0.4	0.4

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

Effect of Na Cl on shoot length

Similar to root length, shoot length was also affected by salinity. The plumule growth was observed at higher levels in TRY1 and ADT45 compared to others at 250 mM concentration (**Table 4**). Varieties like Aathurkichali samba, Thooyamalli, Karupu kavuni, and Mapillai samba doesn't show responses. A similar reduction in shoot length was observed in IR20 and IR50 (Hakim et al., 2010). ADT 45 (0.4 cm) and TRY1 (0.6 cm) have shown higher shoot lengths as salinity increases. Similar results were also observed by Krishnamoorthy et al. (1987), Gupta (1993), and Kaliyarasi et al. (2019).

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

		Shoot length (cm)				
Sl. No.	Varieties	Control	100mM	150mM	200mM	250mM
1.	Aathurkichali samba	4.4^{a}	2.4^{bc}	1.2^{c}	0.6^{a}	0.0^{c}
2.	Thuyamalli	4.3^{a}	1.7^{c}	1.5^{bc}	0.1^{bc}	0.0^{c}
3.	Karupu kavuni	4.5^{a}	2.6^{b}	0.6^{d}	0.0^{c}	0.0^{c}
4.	Mapillai samba	4.7^{a}	2.5^{b}	1.4^{bc}	0.7^{a}	0.0^{c}
5.	CO 51	3.1^{b}	3.2^{ab}	2.0^{a}	0.0^{c}	0.3^{abc}

6.	CO 45	3.4^{b}	3.2^{ab}	1.6^{abc}	0.3^{abc}	0.1^{bc}
7.	TRY 1	3.5^{b}	3.1^{ab}	1.8^{ab}	0.4^{ab}	0.6^{a}
8.	ADT 45	4.6^{a}	3.5^{a}	1.9^{a}	0.3^{abc}	0.4^{ab}
	CV	9.7	10.4	11.9	13.3	14.5
	CD (0.05)	0.7	0.8	0.4	0.4	0.3

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

Effect of Na Cl on total seedling length

The total seedling length was calculated by the addition of shoot and root length. The rice varieties TRY1 (2.3 cm) and ADT45 (1 cm) shows higher total seedling length compared to other rice varieties at 250 mM concentration (**Table 5**). The popular traditional rice variety Karupu kavuni does not show a response to 250 mM concentration. Compared to others TRY1 and ADT 45 has higher seedling length and can be used for further salinity studies. A similar result was also observed by Krishnamoorthy et al. (1987), Gupta (1993), Amin et al. (1996), and Kaliyarasi et al. (2019).

Table 5. Effect of *Na Cl* on total seedling length(cm) at 7DAS traditional and modern rice varieties (by Petri plate method)

Sl.No.	Varieties	Total seedling length (cm)				
		Control	100mM	150mM	200mM	250mM
1.	Aathurkichali samba	11.7^{a}	9.2^{b}	5.1^{bc}	2.5^{b}	0.2^{de}
2.	Thuyamalli	6.8^{e}	5.2^{d}	4.6^{c}	0.6^{c}	0.5^{cd}
3.	Karupu kavuni	9.1^{d}	7.0^{c}	2.7^{d}	0.0^{d}	0.0^{e}
4.	Mapillai samba	11.4^{ab}	7.6^{c}	5.2^{b}	3.3^{a}	0.5^{cd}
5.	CO 51	9.1^{d}	11.3^{a}	6.6^{a}	0.7^{c}	0.6^{c}
6.	CO 45	9.8^{cd}	9.0^{b}	5.6^{b}	0.6^{c}	0.6^{c}
7.	TRY 1	10.4^{bc}	7.7^{c}	5.5^{b}	2.2^{b}	2.3^{a}
8.	ADT 45	11.6^{a}	$11.^{3a}$	5.7^{b}	2.5^{b}	1.0^{b}
	CV	5.8	6.8	6.6	8.2	7.8
	CD (0.05)	1.0	1.0	0.6	0.3	0.4

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

Effect of *Na Cl* on vigour index

Seed vigour index is calculated by multiplying germination (%) and seedling length (Zhang et al., 2021). Seed lots with higher seed vigour indexes are more vigorous. The rice varieties TRY 1 and ADT 45 shows higher vigour index when compared to other varieties (**Table 6**). However, Karupu kavuni does not show any response at 250 mM concentration.

Table 6. Effect of *Na Cl* on Vigour index at 7 DAS traditional and modern rice varieties (by Petri plate method)

Sl. No.	Varieties	Vigour Index				
		Control	100mM	150mM	200mM	250mM
1.	Aathur kichadi samba	1108.5^{a}	849.5^{ab}	475.2^{b}	181.4^{b}	21.5^{cd}
2.	Thuyamalli	523.8^{c}	392.1^{d}	378.3^{c}	43.2^{cd}	60.1^{bc}
3.	Karupu kavuni	998.7^{a}	586.6^{c}	224.0^{d}	0.0^{d}	0.0^{d}
4.	Mapillai samba	1071.5^{a}	728.0^{b}	487.5^{b}	234.5^{a}	52.7^{c}
5.	CO 51	801.3^{b}	842.0^{ab}	610.1^{a}	55.7^{c}	45.9^{c}
6.	CO 45	994.8^{a}	896.5^{a}	514.6^{b}	40.2^{cd}	43.3^{c}
7.	TRY 1	988.1^{a}	716.5^{bc}	506.3^{b}	61.1^{c}	159.5^{a}
8.	ADT 45	1103.8^{a}	954.7^{a}	490.9^{b}	157.4^{b}	102.8^{b}
	CV	11.0	10.3	11.1	14.0	14.2
	CD (0.05)	181.3	133.8	88.9	50.0	43.2

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

CONCLUSION

According to the findings of this investigation, the proportion of seeds that germinated was reduced whenever there was an increase in salt content. The germination rate slowed down whenever there was an increase in the salinity stress concentration. TRY1 showed a higher final germination percentage at 250 mM concentration, the minimum in Karupu kavuni at 250 mM concentration. Others, like Aathurkichali samba (69%), Thuyamalli (71%), CO 51 (60%), CO 45 (61%), and ADT 45 (71%), showed a maximum response in 250 mM NaCl concentration. The findings suggested that ADT 45, Aathur kichali samba, and Thuyamalli might be employed for further research into the effects of salinity on growth processes and their physiological impacts at an advanced stage of growth.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by authors.

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