Evaluation of Germplasm for Seedling Stage Salinity Tolerancein Rice (*Oryza Sativa* L.)

Abstract:

Salinity affects rice growth and development. Mostly all growth stages from germination to maturity are affected by the salinity. Among all the stages, seedling and reproductive stages are the most sensitive stages to salinity,which results in considerable yield losses. Development of salt tolerant varieties is most feasible approach for improving the productionof rice in salt affected soils as seedling stage is necessary for better crop improvement. Overall 76 rice germplasm lines were evaluated at RARS, Maruteru, West Godavari, A.P during *Kharif* 2020 for salinity tolerance at seedling stage. The different parameters like root length, shoot length, shoot Na^+ content, shoot K^+ content, Na^+/K^+ content and SIS (salt injury score) at 10th and 16th day were studied under hydroponics subjecting to electrical conductivity of 6 and 12 dSm^{-1}, at a pH of 5.0. Salinity scoring during seedling stage was noted as per the modified standard evaluation score (SES) of IRRI, revealed that four genotypes FL478, MTU1290, MTU1061 and MCM109 as tolerant, 23 genotypes as moderately tolerant, 42 were susceptible and remaining seven genotypes namely BPT2848, BPT3140, Hallabhatta, MTU1271, MTU1121, BPT2846 and Krishnahamsa are highly susceptible. The phenotypic study signified that Na^+/K^+ ratio is the key note for salinity tolerance.

Key words: Abiotic stress, Na^+/K^+ ratio,Salinity tolerance, Seedling stage.

Introduction

Rice (*Oryza sativa*L.) is one of the most valuable staple food crop. Abiotic stresses, are the major causes for severe yield losses on rice. Salinity is one among them,which is responsible for severe reduction in the yield in addition to thecultivated land. Amongst the cereal crops, rice is treated as most saline sensitive cropwith a threshold value of soil salinity about 3 dSm^{-1} for majority of the cultivated varieties. If the soil with electrical conductivity and its saturation extract (ECe) falls above 4 $dSm^{-1}$is considered as saline soils.About 10% of yield loss occurs at ECe at 3.5 dSm^{-1} and even 50% of yield losses werenoticed at ECe 7.2 dSm^{-1}. Salt stress throughout the seedling phase causes significant reduction in germination index and seedling vigor. Salinity has a great influence on growth of rice plant during seedling stage which affectsplant height, tillering ability, root length and shoot length. As salinity toleranceis polygenic,most studies considerit as a single trait and commonly use visual scoring (Gregorio *et al.*, 1997) or the Na^+/K^+ ratio for classification. Combination of both morphological and physiological traits would be more appropriate for screening for salinity tolerance rather than scoring technique.

One of the best strategy to improve rice production in saline effected soils is to develop salinity tolerance varieties. This is a strategic approach, which is cost effective and practical (Sen*et al.*, 2017).Achievement of any plant breeding programme depends on the extent of variation for yield and yield-related components present in the germplasm and the kind of association among these components.The studies oncorrelation among yield and its constituent traits under salinity is very crucial to evaluate the worth of each character that directly or indirectly liable for the salinity. Correlation studies helps in recognition of a character that's responsible for the concurrent improvement of other character. Therefore, the current study was commenced to recognize the rice germplasm lines that exhibit tolerance to salinity along with the component characters that contribute to the salinity tolerance.

Material and methods

1. A total of 76 rice genotypes were studied for salinity tolerance under hydroponic condition during seedling stage as per the protocol of (Gregorio *et al.*, 1997) with certain modifications. Sterilized seeds were kept in petri plates with moistened filter papers and incubated at 30 ^{0}C for 48 hr for germination (Plate i). A total 18 styrofoam sheets were used for screening all the 76 germplasm lines in two replications using Completely Randomized Design. Each Styrofoam sheet had 8 rows and each row had 9 holes, in which two pre-germinated seeds/hole were placed on the styrofoam seedling float (Plate ii). The seedling floats were placed inside the greenhouse under partially controlled environmental conditions. Initially, the seedlings were grown in normal water for two days, the water in the trays was exchanged with salt-amended (Yoshida *et al*., 1976) nutrient solution. The constituents of nutrient solution are represented in the Table i. When the seedlings were at two leaf stage, they were subjected to initial salt stress of EC 6 dsm^{-1} by adding NaCl to the nutrient solution. Later,eight days after initial salinization, the electrical conductivity was increased to 12 dsm^{-1}. Initial scoring and final scoring of the selected individual plants was recorded at 10th dayand 16th dayafter initial salinization, respectivelyaccording tostandard evaluation score (SES) of IRRI (1997) (Plate iii), (Plate iv). The description of the SES of 1 - 9 was presented in Table ii. Daily the pH was observed and retained at 5.0. The score 1 indicates that the line is highly tolerant and a score of 9 indicates high susceptibility. The observations were recorded on shoot length, root length, shoot Na^+concentration, shoot K^+ concentration and Na+/K+ ratio. After screening experiment, the shoots of each germplasmwasoven dried at 60 ^{0}C for 3 days, andthe dry weights arenoted. For measuring the concentrations of Na^+ and K^+ in the shoot, 1g powdered plant sample was taken in 150 mL Erlenmeyer conical flask and digest it, with diacid mixture (nitric acidand perchloric acidin 9:4 ratio)at 50 - 55 ^{0}C heating block for 3 h. The sample digest was filtered through whatman no. 42 filter paper by cleaning the residue with double distilled water till theclear extract was obtained and made up to 100 ml volume. Sodium and potassium in the diacid extract of plant samples was determined using flame photometer and was used for Na^+/K^+ ratio determination.

2. **Statistical Analyses**

   Data regarding seven morpho-physiological characters *viz.,* initial and final salinity scores, shoot length, root length, shoot Na^+ concentration, shoot K^+ion concentration and Na^+/K^+were recordedbesides correlation coefficients were also calculated as per Falconer (1964).

Results and Discussion

Screening for seedling stage salinity tolerance

The analysis of variance for initial (10 days) and final (16 days) salinity scores, shoot length, root length, shoot Na^+ concentration, shoot K^+ion concentration and Na^+/K^+ is furnished in Table iii. The results revealed significant differences among the genotypes for all characters studied.

Screening of 76 germplasm for seedling salinity tolerance was done during *Kharif* 2020 using hydroponics experiment at EC6 and 12dSm^{-1}.The mean performance of 76 genotypes for the characters *viz.*, shoot length, root length, shoot Na^+ concentration, shoot K^+ concentration, Na^+/K^+ ratio, initial salt injury score and final salt injury score, were noted at 16 days after the salinization. The results pertaining to the above characters were presented inTable iv. Salt stress inhibits cell cycle and results in reduction of plant growth which leads to the reduced growth of plumule and radical of a plant.If a genotype that exhibit good shoot growth even beneath saline conditions can be considered as the salt tolerant.Shoot length was recorded maximum by FL 478 (27.12 cm) and minimum shoot length was recorded by MTU 1121 (10.65 cm)with anaverage of 19.09 cm. The root is utmost important organ which is in direct contact with the soil and salt solution,which leads an important role in excluding of Na^+ at root level and maintaining low Na^+ions absorption in the plant.In the current study, root length ranged from 6.9 to 18.75 cm with a mean value of 11.05 cm.The genotype MCM 100 (18.75 cm) recorded highest root length which is significantly superior than the tolerant check FL478 (10.87 cm)and the genotype BPT 2848 recorded lowest root length of 6.90 cm.One of the most harmful effect of salinity stress is the accumulation of Na^+ and Cl^- in tissues of plants whensubjected to the soils possessing high NaCl concentrations. Entry of both Na^+ and Cl^- ions into the cells can cause severe ion imbalance. High Na^+ ions hindersthe uptake of K^+ ions which is an key element for growth and development that ends into lower productivity and may even lead to death.Shoot Na^+ concentration was recorded lowest in FL 478 (42.53 ppm) whereas it recorded highest in Krishnahamsa (287.75 ppm)with anaverage of 133.97 ppm. Potassium (K^+) is a key factor,which leads an important role in resistance to salinity. Superior K^+ retention in salt-stressed roots is positively correlated with salt tolerance in numeral plant species (Wu *et al*., 2018). Throughout salinity stress, due to enhanced concentration of Na^+ in the soil, competes with K^+ for the transporter as they both impart the same transport mechanism, thereby reducing the uptake of K^+. Hence, the genotypes that can extract more K^+ ions from the soil beneath stress condition can exhibit tolerance to salinity.The highest Shoot K^+ concentration was observed in MST 48 (71.11 ppm) which recorded superior than the tolerant check FL 478 (41.72 ppm) while, lowest shoot K^+ concentration was noticed in BPT 2595 (9.24 ppm)with theaverage value of 27.12 ppm. Tolerance to salinity in rice is associated with extrusionof Na^+ and increased absorption of K^+ to maintain good Na^+/K^+ equilibrium in shoot under saline condition. The genotypes that accumulate less Na^+ and relatively more K^+, maintaining a lower Na^+/K^+ ratio in leaves are tolerant genotypes and maintain significantly lower shoot Na^+ concentration, and they effectively limit sodium transport to the shoots.The lowest Na^+/K^+ ratio was exhibited by FL 478 (1.02), MCM 109 (1.86), MTU 1290 (2.15), MTU 1061 (2.23) and MST 21 (2.32) whereas, high Na^+/K^+ ratio was reported by BPT 2615 (9.96), BPT 2595 (9.86), BPT 3140 (9.86) and a hybrid US 301 (9.74). Scoring at 10thand 16th day after salinization treatment revealed that the genotypes FL 478, MTU 1061, MTU 1290 and MCM 109 were recorded as tolerant (3.0) represented in Plate v. The advanced breeding lines *viz.,* MST 21, MST 22, MST 36, MST 38, MST 40, MST 42, MST 44, MST 46, MST 47, MST 48, MST 49, MST 50, MST 51, MST 54 and the genotypes MTU 4870, MCM 100 and MCM 103 recorded as moderately tolerant (5.0). Further, the genotypes BPT 2595, BPT 3141, BPT 3145, US 301, MTU 1253, RP-BIO-226, BPT 2615, BPT 3165, BPT 2841, Apputhokal, Jarava, BPT 3111, Bahadur, DRRDHAN 44, BPT 2776 recorded susceptible reaction to salinity (7.0) while, the genotype Krishnahamsa recorded as highly susceptible to salinity (9.0).

Correlation among salinity tolerance traits

The Pearson correlation coefficients indicated that there were significant correlations among different morphological and physiologicaltraits for salinity tolerance (Table v).Salt injury score on 10th day after salinization showed significant and favorable (0.4550**) correlation with$Na^+/K^+$and significant negative correlation with shoot length (-0.3933***), root length (-0.3272**) and shoot K^+ (-0.4204***) concentration. Further Salt injury score on 16th day after salinization also showed positive and significant correlation with Na^+/K^+ (0.5320**), salt initial score on 10th day (0.6091***) and significant negative correlation with shoot length (-0.3955***), root length (-0.4654***) and shoot K^+ (-0.5011***) concentration. Similar results of significant positive correlation between salt injury score and Na^+/K^+, significant negative correlation with shoot K^+ concentration were stated by Leon *et al.* (2015).

Shoot length exhibited positive and significant correlation with shoot K^+ (0.5709***) concentration and negative significant association with Na^+/K^+ (-0.5500**)**.**The favorableassociation of shoot K^+ content with shoot length indicating the importance of K^+ content which is very important for the growth and development of the plant.

Similarly, root length also exhibited significant and negativecorrelation with Na^+/K^+ (-0.2310*). Negative association of Na^+/K^+ratio with root length is mainly because of the accretion of high Na^+ concentration than K^+ ion concentration, which restricts root growth under salinity.

Shoot Na^+ concentration exhibited significant and favorablecorrelation with Na^+/K^+ (0.6090**)**.** These conclusions are in agreement with the results of Ahmadi *et al.* (2011), Ramana Rao *et al.* (2018). Excluding of Na^+ions uptake by the roots maintains low concentrations of Na^+ in the leaves, is one of the mechanisms that plants adopts to tolerate salinity stress. Similarly, shoot K^+ concentration recorded significant positive association with shoot length (0.5709***) and significant negative association with Na^+/K^+ (-0.6130**). The findings are in conformity with Ahmadi *et al.* (2011), Naveed *et al.* (2018), Ramana Rao *et al.*

(2017) and Leon *et al.* (2015).Negative correlation of shoot K^+ concentration with Na^+/K^+ ratio indicating that higher shoot K^+ concentration lower will be the Na^+ concentration in shoots, that enhances the shoot growth under salinity.

Na^+/K^+ ratiorevealed favorable and significant correlationbetween shoot Na^+ (0.6090**), salt injury score on 10th day (0.4550**), salt injury score on 16th day (0.5320**). The conclusions are in agreement with the reports of Ramana Rao *et al*. (2018) who studied 112 ILs of Nona Bokra / Cheniere under salt stress (EC @ 12 dSm^{-1}) at seedling stage. The above said results can be attributed for direct selection of germplasm lines with lower Na^+/K^+ would be useful for breeding of salt tolerant lines.

Association studies for seven morpho-physiological traits shown that Na^+/K^+ ratio revealed negative and significant association with shoot length, root length and shoot K+ concentration, favorable and significant correlation with salt injury score on 10th and 16th day and shoot Na^+ content, indicating that increasing in the salinity levels resulted in the lesser root and shoot growth during seedling stage. Similarly, shoot K^+ content is reduced due to accumulation of shoot Na^+ content, which causes severe imbalance between Na^+ concentration and K^+ ions. The shoot K^+ concentration showed significant positive correlation with shoot length, which is very important criterion under salt stress. The K^+ ion concentration is very essential for growth and development of the plant as superior K^+ retention in salt-stressed roots is positively correlated with salt tolerance. Further salt injury score on 10th and 16thexposed significant and negative correlation with the shoot and root length indicating that salt stress could significantly reduce the root and shoot growth in the current study.

Conclusion

Salinity tolerance is a complicatedtrait and has strong association with visual symptoms (as indicated by the SIS score) and other traits such as shoot Na^+ concentration, shoot K^+ion concentration and Na^+/K^+ ratio and the overall phenotypic performance of the genotypes is reflected by SIS. The negative association between Na^+ ions and root&shoot growth resulted in reduction of the plant growth. The significant negative correlation between SIS and shoot K^+ concentration specified that the salt tolerance is mainly due to buildup of more K^+ ions. The germplasm lines FL 478, MTU 1290, MTU 1061, MST 48 and MCM 109 that exhibited superiority in all traits.The germplasm FL 478, MTU 1290, MTU 1061 and MCM 109 were recognizedas salt tolerant and can be used as promising resources for breeding salt-tolerant high-yielding rice varieties in future.

List of Abbreviations:

Na^+ : Sodium ions concentration
K^+ : Potassium ions concentration

Na^+/K^+	: Na^+/K^+ratio
NaCl	: Sodium chloride
SIS	: Salt injury score
SES	: Standard Evaluation Score
IRRI	: International Rice Research Institute
ECe	: Electrical conductivity
pH	: Sorensen Value

Declarations

Availability of data and materials

The authors confirm that the data supporting the findings of this study are available within the article.

Competing interests

Salinity tolerance is a complextrait and has strong association with visual symptoms (as indicated by the SIS score) and other traits as above mentioned which would help in recognizing the salt tolerant genotypes and can be used as promising resources for breeding high-yieldingsalt-tolerant rice varieties in future.

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Ethics approval and consent to participate

Not applicable.

Consent for publication

We, the authors are consent for publishing the article in this journal on special request

Author's contributions

- Conception or design of the work was done by Dr. Veeraghattapu Roja, Dr. Puram Venkata Ramana Rao, Dr. Merugumala Girija Rani and Dr. Dasyam Ramesh.
- Data collection was done by Jallu Pranaya.
- Data analysis and interpretation was done by Jallu Pranaya and Dr. Dasyam Ramesh.
- Drafting of the article was done by Jallu Pranaya.
- Critical revision of the article was done by Jallu Pranaya, Dr. Veeraghattapu Roja, Dr. Puram Venkata Ramana Rao, Dr. Merugumala Girija Rani and Dr. Dasyam Ramesh.

- Final approval of the version to be published was done by Jallu Pranaya, Dr. Veeraghattapu Roja, Dr. Puram Venkata Ramana Rao, Dr. Merugumala Girija Rani and Dr. Dasyam Ramesh.

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Table i. Components of the nutrient solution

Element	**Reagent (AR grade)**	**Preparation(g/250 ml solution)**
	MACRO NUTRIENT	
N	Ammonium nitrate (NH_4NO_3)	22.85 g
P	Sodium phosphate, monobasic monohydrate ($NaH_2PO_4.H_2O$)	8.9 g
K	Potassium sulphate (K_2SO_4)	17.85 g
Ca	Calcium chloride, dehydrate ($CaCl_2.2H_2O$)	29.33 g
Mg	Magnesium sulphate, 7-hydrate ($MgSO_4.7H_2O$)	81 g
	MICRO NUTRIENT	
Mn	Manganous chloride, 4-hydrate ($MnCl_3.4H_20$)	0.375 g
Mo	Ammonium molybdate, 4-hydrate [$(NH_4)_6Mo7O_2.4H_20$]	0.0185 g
Zn	Zinc sulphate,7-hydrate ($ZnSO_4.7H_2O$)	0.00875 g

B	Boric acid (H_3BO_3)	0.233 g
Cu	Cupric sulphate, 5-hydrate ($CuS0_4.5H_2O$)	0.00770 g
Fe	Ferric chloride,6-hydrate ($FeCl_3.6H_2O$)	1.975 g
	Citric acid, monohydrate ($C_6H_8O_7.H_2O$)	

Table ii. Standard evaluation score (SES) of visual salt injury at seedling stage

Score	Observation	Tolerance
1	Normal growth, no leaf symptoms	Highly tolerant
3	Nearly normal growth, but leaf tips or few leaves whitish and rolled	Tolerant
5	Growth severely retarded, most leaves rolled; only a few are elongating	Moderately Tolerant
7	Complete cessation of growth; most leaves dry; some plants drying	Susceptible
9	Almost all plants dead or dying	Highly susceptible

Table iii. Analysis of variance of characters for seedling stage salinity tolerance in rice

Source of variance	Degrees of freedom	Shoot length (cm)	Root length (cm)	Shoot Na^+ (ppm)	Shoot K^+ (ppm)	Na^+/K^+	10^{th} day SIS	16^{th} day SIS

Treatments	75	623.75*	376.84*	155.58*	62.92*	24.91*	225.79*	265.75*
Error	76	6.25	4.15	1.15	2.15	1.64	1.25	1.02

Table iv. Screening of 76 rice (*Oryza sativa* L.) germplasm for seedling stage salinity tolerance

S. No.	**Genotype**	**Shoot length (cm)**	**Root length (cm)**	**Shoot Na^+ (ppm)**	**Shoot K^+ (ppm)**	**Na^+/K^+**	**10th day SIS**	**16th day SIS**
1.	27 P 63	21.36	10.03	86.98	24.47	3.59	5	7
2.	ADT 49	25.34	10.71	84.95	25.66	3.31	5	7
3.	Akshaydhan	22.96	11.39	185.85	34.17	5.43	5	7
4.	Apputhokal	22.04	8.24	185.95	22.93	8.10	7	7
5.	Asandi	16.83	12.55	113.78	28.63	3.97	5	7
6.	Bahadur	16.97	10.34	165.65	21.00	7.88	7	7
7.	BPT 1235	16.73	10.92	142.37	20.25	7.02	5	7
8.	BPT 2231	17.46	10.47	114.59	26.19	4.37	5	7
9.	BPT 2411	18.96	10.56	130.38	29.83	4.36	5	7
10.	BPT 2595	13.85	9.31	91.05	9.24	9.86	7	7
11.	BPT 2615	15.73	10.71	161.55	16.20	9.96	7	7
12.	BPT 2660	18.26	11.77	123.59	26.34	4.69	5	7
13.	BPT 2766	14.84	10.65	152.62	21.34	7.15	7	7
14.	BPT 2776	18.32	12.42	93.18	33.49	2.78	5	7

Table 3 contd…

S. No.	Genotype	Shoot length (cm)	Root length (cm)	Shoot Na^+ (ppm)	Shoot K^+ (ppm)	Na^+/K^+	10th day SIS	16th day SIS
15.	BPT 2782	12.83	9.53	92.08	15.59	4.17	5	7
16.	BPT 2841	11.17	7.28	101.65	12.22	8.31	7	7
17.	BPT 2846	11.59	9.45	165.29	17.20	9.60	7	9
18.	BPT 2848	12.85	6.90	175.60	21.94	8.00	7	9
19.	BPT 3111	12.38	8.81	168.20	19.21	8.76	7	7
20.	BPT 3136	18.49	12.34	96.64	26.24	3.68	5	7
21.	BPT 3139	19.66	11.37	65.91	28.23	2.34	5	7
22.	BPT 3140	11.08	9.67	123.09	12.48	9.86	7	9
23.	BPT 3141	15.73	9.51	126.71	20.21	6.27	7	7
24.	BPT 3145	16.04	9.97	189.19	21.83	8.67	7	7
25.	BPT 3165	15.25	10.02	163.61	16.68	9.80	7	7
26.	BPT 3173	17.85	12.09	94.75	30.48	3.11	5	7
27.	BPT 3178	18.18	10.97	100.20	20.79	3.96	5	7
28.	BPT 5204	17.16	11.87	139.3	20.47	6.81	5	7
29.	CO 51	21.67	12.65	86.56	23.76	3.64	5	5
30.	CSR 27	22.86	9.80	82.33	24.81	3.31	5	5
31.	DRRDHAN 42	25.09	11.27	84.89	30.62	2.77	5	7
32.	DRRDHAN 43	26.09	11.53	109.39	46.77	2.33	5	7

S. No.	Genotype	Shoot length (cm)	Root length (cm)	Shoot Na^+ (ppm)	Shoot K^+ (ppm)	Na^+/K^+	10th day SIS	16th day SIS
33.	DRRDHAN 44	20.84	12.12	230.90	28.52	8.09	7	7
34.	FL 478	27.12	10.87	42.53	41.72	1.02	3	3
35.	Hallabhatta	22.77	11.93	201.3	21.34	9.43	7	9
36.	IR 64	23.59	10.49	70.55	24.49	2.88	5	7
37.	Jarava	21.05	9.57	175.06	19.81	8.83	7	7
38.	JKRH 3333	20.58	9.90	139.04	27.65	5.03	5	7
39.	Kakirekalu	23.93	10.88	79.46	29.38	2.71	5	5
40.	Karma mashuri	16.42	13.03	181.05	23.88	7.58	5	7
41.	Krishnahamsa	17.25	9.25	287.75	31.79	9.05	9	9
42.	Mandyavijaya	20.89	12.03	82.87	28.41	2.91	5	5
43.	MCM 100	17.49	18.75	146.11	31.35	4.65	5	5
44.	MCM 103	17.24	17.73	153.55	30.84	4.97	5	5
45.	MCM 109	15.78	17.51	74.34	40.18	1.86	3	3
46.	MST 21	23.11	11.62	69.50	29.92	2.32	5	5
47.	MST 22	25.33	12.17	149.45	31.04	4.82	5	5
48.	MST 36	21.92	11.55	219.30	31.90	6.87	5	5
49.	MST 38	22.13	12.59	115.26	23.69	4.87	5	5
50.	MST 40	25.72	11.95	97.89	34.35	2.85	5	5

S. No.	Genotype	Shoot length (cm)	Root length (cm)	Shoot Na^+ (ppm)	Shoot K^+ (ppm)	Na^+/K^+	10th day SIS	16th day SIS
51.	MST 42	20.36	10.21	200.20	35.93	5.57	5	5
52.	MST 44	22.33	11.91	101.27	35.63	2.84	5	5
53.	MST 46	18.88	9.53	80.25	24.65	3.26	5	5
54.	MST 47	23.81	11.06	159.30	45.35	3.51	5	5
55.	MST 48	22.84	11.15	208.63	71.11	2.94	3	5
56.	MST 49	21.83	10.50	214.70	35.74	6.01	5	5
57.	MST 50	24.26	11.71	123.99	30.81	4.03	5	5
58.	MST 51	22.86	12.06	224.30	43.08	5.21	5	5
59.	MST 54	23.34	9.63	143.61	47.48	3.03	5	5
60.	MTU 1061	22.66	11.13	100.61	45.06	2.23	3	3
61.	MTU 1121	10.65	10.04	221.15	30.73	7.19	7	9
62.	MTU 1238	17.38	9.15	158.90	24.62	6.46	5	7
63.	MTU 1253	19.88	10.56	181.20	18.87	9.60	7	7
64.	MTU 1271	15.59	8.13	149.14	18.53	8.05	5	9
65.	MTU 1282	22.26	9.97	79.75	18.14	4.39	5	7
66.	MTU 1290	20.38	10.13	80.47	37.49	2.15	3	3
67.	MTU 1315	17.17	11.23	128.11	35.29	3.63	5	7
68.	MTU 1318	17.85	11.49	105.14	26.20	6.30	5	7

S. No.	Genotype	Shoot length (cm)	Root length (cm)	Shoot Na^+ (ppm)	Shoot K^+ (ppm)	Na^+/K^+	10th day SIS	16th day SIS
69.	MTU 4870	17.57	11.88	193.43	31.85	6.07	5	5
70.	PHI 17108	15.21	11.32	58.77	11.28	5.21	5	7
71.	RP-Bio-226	16.41	12.92	134.63	16.31	8.25	7	7
72.	Sampada	22.37	11.59	136.27	17.74	7.68	5	7
73.	Sugandhamati	18.38	11.88	85.08	19.39	4.39	5	5
74.	Swarna Sub 1	16.58	10.35	143.49	21.95	6.54	5	7
75.	US 301	12.23	8.97	129.80	13.32	9.74	7	7
76.	WGL 14	18.64	11.89	126.00	25.25	4.99	5	7
	Maximum	**27.12**	**18.75**	**287.75**	**71.11**	**9.96**	**9**	**9**
	Minimum	**10.65**	**6.90**	**42.53**	**9.24**	**1.02**	**3**	**3**
	Mean	**19.09**	**11.05**	**133.97**	**27.12**	**5.53**	**5.47**	**6.39**
	CD 5%	**7.81**	**6.01**	**7.54**	**5.20**	**2.98**	**0.25**	**0.23**
	CV 5%	**4.67**	**3.25**	**2.17**	**3.20**	**5.31**	**7.34**	**6.67**

Table v. Correlation matrix of morpho-physiological traits of rice germplasm under salt stress at seedling stage

	Shoot length	**Root length**	**Shoot Na^+**	**Shoot K^+**	**Na^+/K^+**	**10th day SIS**	**16th day SIS**
Shoot length	1						

Root length	0.2047	1					
Shoot Na^+	-0.1692	0.0191	1				
Shoot K^+	0.5709 ***	0.2242	0.1335	1			
Na^+/K^+	-0.5500**	-0.2310*	0.6090**	-0.6130**	1		
10th day SIS	-0.3933 ***	-0.3272 **	0.0972	-0.4204 ***	0.4550**	1	
16th day SIS	-0.3955 ***	-0.4654 ***	0.1455	-0.5011 ***	0.5320**	0.6091 ***	1

Plate i. Seeds kept in petriplates for germination

Plate ii. Germinated seeds placed in the tray before imposing stress

Plate iii. Scoring at 10th day after salinization

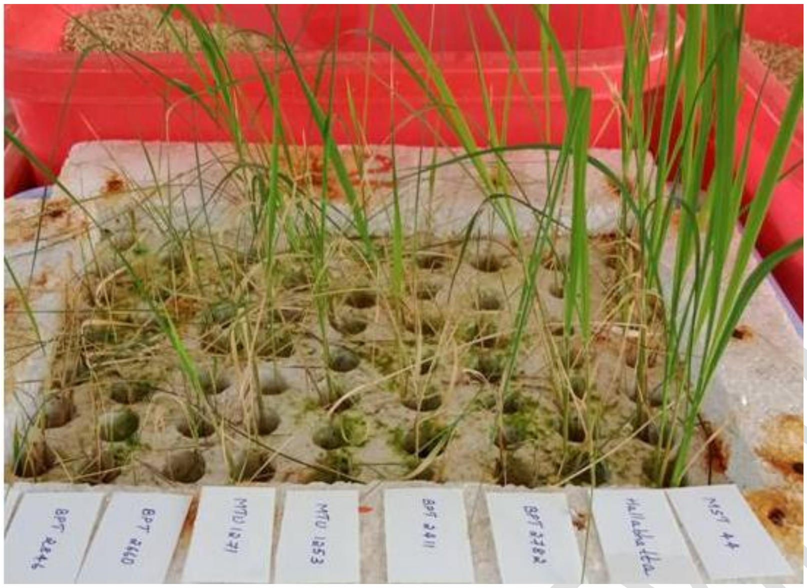

Plate iv. Scoring at 16th day after salinization

FL 478	MST 47	MTU 1121	Krishnahamsa
Score 3	Score 5	Score 7	Score 9

Plate v. Scoring of rice germplasm at seedling stage as per SES, IRRI

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