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Screening of Rice (*Oryza sativa* L.) Genotypes for salinity at Reproductive Stage

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study highlights the varying degrees of tolerance to salinity among different rice genotypes. It's interesting to note that despite rice being considered moderately sensitive to salinity. The phenotypic response of 20 rice genotypes with salt stress at EC=12dsm^{-1} was assessed under hydroponic condition at reproductive stage through visual scoring. Five genotypes, viz., MCM103,CSR27,MCM151-3-2-1-1 , MCM208-12-1-1, AC39416A demonstrated tolerant and 12 genotypes MCM 100, MCM109, MCM125 , MCM1471-1-2-1 , IR04A115, MCM153-1-1-1-1,

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MCM106-2-10-2-2, MCM258-8-2-1-1-1 , MCM148-2-1-1-1 , IR18T1045, IR100120-B-B-B-11 and MCM159-3-1-1-1 considered as moderately tolerant in the face of salt stress.Conversely,3 genotypes like FL478 ,BPT5204 ,PUSA44 showed susceptibility.

Keywords: Screening; salinity stress; Oryzasativa; hydroponics; reproductive stage.

1. INTRODUCTION

"Rice (*Oryza sativa* L.), which belongs to the family Poaceae is one of the important cereal food crops extensively cultivated throughout the world. In the worldwide food production of agricultural commodity; rice had third place next to maize and wheat" [1]. "Global rice cultivated area is 167.2 million hectares with annual production of 769.6 metric tonns and productivity of 4.6 tonns/ha. In India, Rice is cultivated in an area 44 million hectares and ranks second in production (168 metric tonns) with productivity of 3.84 tonns/ha" [2]. "The estimated saline affected area in India is around (12.94 lakh ha) which Gujarat (5.28 lakh ha), West Bengal (5.08 lakh ha), and Andhra Pradesh (1.06 lakh ha) were identified as the top three-salinity affected coastal states in the country". [3]. Coastal regions are frequently inundated by saline sea water and submerged for a prolonged period. Mangrove vegetation is common in the regions. The arable cropping is limited due to the heavy textured soil, tropical climate and poor-quality groundwater. Rice is the most suitable crop in coastal India [4,5]

"The coastal region of Andhra Pradesh is 1014 km long along the Coromandel coast between the Eastern Ghats and the Bay of Bengal. Coastal saline areas of Andhra Pradesh are confined to 15 districts accounting to 105725 ha" [3] "Several studies indicated that rice is tolerant during germination, becomes very sensitive during early seedling stage [6] (2-3 leaf stage), gains tolerance during vegetative growth stage, again becomes sensitive during reproductive stage" [7] "At reproductive stage, salinity causes an increase in sterile florets by affecting panicle initiation, spikelet formation, fertilization, and germination of pollen. Salinity also reduces panicle length, number of primary branches and spikelets per panicle, fertility and panicle weight, thus reducing grain yield" [8,9,10,11]. "Expression of salinity tolerance at seedling and reproductive stage are independent" [12]. "However, progress in phenotyping has been slow due to time consuming and laborious protocols for the reproductive stage screening as compared with the relatively easy phenotyping protocols for the seedling stage" [13,14]. "Screening for reproductive-stage tolerance in micro-plots filled with soil irrigated with saline water or soil preparations in pots or in natural field conditions have been proposed" (Mishra 1996; Singh and Mishra 2004; [15].

The present investigation was conducted to screen the rice cultures for salt tolerance at reproductive stage.

2. MATERIALS AND METHODS

The method involves sowing pre-germinated seeds in perforated plastic pots filled with fertilized soil (50 N, $25P_2O_5$ and 25 K_2 O mg kg^{-1} soil), which are kept in concrete tanks filled with water. Two plants per plot are allowed to grow initially, thinned later to one plant per pot. A water level of 3 cm below the soil surface of the perforated pots is maintained in the tanks. All plants are grown under control conditions (EC < 2 dSm^{-1}) until the flag leaf appears and salt stress is imposed at this growth stage for all genotypes. In the first appearance of the flag-leaf, individual pots are transferred to saline conditions with 12EC and are maintained under these saline conditions for 15–20 days. Plants that were grown under similar conditions without salinization serve as controls. Clipping of leaf was done at the first appearance of the flag leaf, and that was used to accelerate salt accumulation in the flag leaf. Consequently, only the flag leaf and penultimate leaf were left for salt accumulation and translocation to the reproductive organs. This accelerates, after 2 or 3 days, the effects of stress treatment and its effect on yield components as compared to that of control plants where all leaves are left untrimmed. Subsequently, all plants were transferred back to non-saline conditions. Scoring for salt tolerance (Table 1), Yield and yield components were recorded Singh et al. [12], Chattopadhyay et al. [16] from the individual plants. Twenty genotypes designated and coded as CPST1 to CPST20 (MCM100,MCM 103,MCM 109, MCM 125, PUSA 44,FL478 BPT 5204,CSR27,MCM1471-1-2-1,IR04115,MCM15 3,-1-1-1,MCM100-2,MCM258-8-2-1-1-1,MCM14 8-2-1-1-1,MCM151-3-2-1-1,IR18T1045, MCM20

8-12-1-1,IR100120-B-B B11,MCM159-3-1-1-1 and AC39416A are used for screening for salinity at reproductive stage under pot culture conditions in two replications in Completely randomized design. The genotypes were score for salt tolerance at reproductive stage as per standard evaluation system [17,18,15].

3. RESULTS AND DISCUSSION

There is significant variation for salinity tolerance at reproductive stage (Table 2) among the 20 genotypes studied.

The standard evaluation score (SES) based on visual salt injury at reproductive stage has given clear indication regarding the tolerance levels of different entries under salinity stress at 12 ds/m t. Four entries vizMCM103, MCM151-3-2-1-1, MCM208-12-1-1 and AC39416Awere considered as tolerant with score of 3 were found to be on par with CSR 27 salt tolerant check at reproductive stage, Another salt tolerant check at seedling stage FL478 a Pokkali derived line showed moderately susceptible score of 7. Susceptible checks BPT5204 and Pusa44 as highly susceptible with score of 9. Tweleve cultures expressed moderate tolerance score of 5 for salinity stress are

Table 1. Standard evaluation score (SES) of reproductive stage salinity

Score	Observation	Tolerance
1	Normal growth, spikelet sterility at ≤ 5%	Highly tolerant
3	Growth slightly stunted, spikelet sterility at > 5% - 20%	Tolerant
5	Growth moderately stunted, ¼ of leaves brown, panicles partially exerted, spikelet sterility at 21% - 40%	Moderately tolerant
7	Growth severely stunted with about ½ of all leaves become brown, panicles poorly exerted, highly sterility 41% - 70%	Sensitive
9	Growth severely stunted with almost all the leaves become brown and affected, panicles not exerted, delayed heads or papery florets/chaffy panicle with very high sterility at > 70%	Highly sensitive

Table. 2 Standard evaluation score (SES) visual salt injury at reproductive stage

Designation	Genotypes	Reproductive score
CPST1	MCM 100	5
CPST2	MCM103	3
CPST3	MCM109	5
CPST4	MCM125	5
CPST5	PUSA44	9
CPST6	FL478	7
CPST7	BPT5204	9
CPST8	CSR27	3
CPST9	MCM147-1-1-2-1	5
CPST10	IR04A115	5
CPST11	MCM153-1-1-1-1	5
CPST12	MCM106-2-10-2-2	5
CPST13	MCM258-8-2-1-1-1	5
CPST14	MCM148-2-1-1-1	5
CPST15	MCM151-3-2-1-1	3
CPST16	IR18T1045	5
CPST17	MCM208-12-1-1	3
CPST18	IR100120-B-B-B-11	5
CPST19	MCM159-3-1-1-1	5
CPST20	AC39416A	3

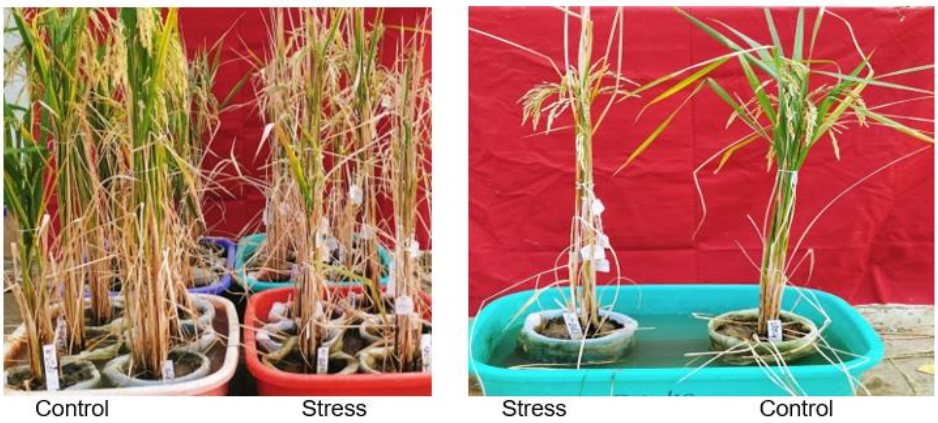

Fig. 1. Symptoms showing 12 dsm-1 salinity level

MCM 100,MCM109, MCM 147-1-1-2-1, IR 04A115, MCM 153-1-1-1-1, MCM 258-8-2-1-1-1, MCM 148-2-1-1-1, MCM 151-3-2-1-1, IR 18T1045, MCM 208-12-1-1-, IR100120-B-B-B-11, MCM159-3-1-1-1. Earlier workers were also reported that FL478 is not tolerant at reproductive stage though it was derived from salt tolerant land race Pokkali [19]. Four salt tolerant cultures viz MCM103, MCM151-3-2-1-1, MCM208-12-1-1 and AC39416A and check CSR 27 at 12ds/m can be used for future breeding for enhancing genetic gains in coastal saline areas. Fine grain rice variety MCM 103 found to be tolerant at EC 12ds/m and the remaining cultures developed by ARS, Machilipatnam expressed moderate salinity score including three elite line of IRRI, Philipines. Our study in agreement with earlier work of salt tolerant rice varieties possessing tolerance at reproductive stage [20]. Interestingly AC 39416 A was found to be salt tolerant as this culture also possess alleles for anaerobic germination, submergence tolerance, stagnant flooding [20, Sandhya et al. (2017) [21,22]. Which can be utilized as genetic source for multiple abiotic stress tolerance [23,24,25].

4. CONCLUSION

The identification of tolerant genotypes like MCM103, CSR27, MCM151-3-2-1-1, MCM208-12-1-1, AC39416A is significant as it opens up opportunities for breeding programs aimed at enhancing salinity tolerance in rice. By using these tolerant varieties as donor parents in backcross breeding or for allele mining, researchers can potentially isolate and incorporate the genes or quantitative trait loci (QTLs) responsible for salinity tolerance into other rice varieties. This could ultimately lead to the development of improved rice varieties that can thrive in saline soils, thus bolstering food security in regions affected by salinity.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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