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RESEARCH PAPER

TITLE:

INTERRELATION OF YIELD AND YIELD CONTRIBUTING TRAITS IN F1 HYBRIDS AND THEIR PARENTS OF RICE (*ORYZA SATIVA*) UNDER SALT STRESS CONDITION

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INTERRELATION OF YIELD AND YIELD CONTRIBUTING TRAITS IN F1 HYBRIDS AND THEIR PARENTS OF RICE (*ORYZA SATIVA*) UNDER SALT STRESS CONDITION

ABSTRACT

Rice exhibits sensitivity to salinity, with varying degrees among different varieties, therefore to improve rice productivity under such conditions, it's necessary to select salt-tolerant genotypes (both parents and hybrids). The purpose of this examination was to explore the interrelationships among 15 vigorous F1 hybrids. The study entailed an assessment of the attributes of the six parent plants and their performance concerning yield and other relevant traits. This evaluation was predicated on the physio-morphological characteristics observed during the Kharif season of 2021. The findings demonstrated significant genotype variations ($P \leq 0.01$) across all the traits examined. Fifteen F1 hybrids and their parental plants underwent assessment for various morpho-physiological traits across distinct salt treatments. In a hydroponic environment, Treatment 1 (control), Treatment 2 (6 dS m^{-1}), and Treatment 3 (8 dS m^{-1}) of sodium chloride were administered. The findings showed a strong and positive relationship between the number of productive tillers per plant, plant height, harvest index, panicle length, number of spikelets per panicle, leaf area, and grain production per plant when it comes to genetic features. Grain yield is a complicated attribute that depends on a number of other yield-related factors. According to our research, there is a strong positive association between harvest index, 1000 grain weight, potassium content, chlorophyll content, and other features and grain production per plant. On the other hand, there is an inverse relationship with sodium content. Therefore, giving priority to these particular features will help identify the best-performing F1 hybrids that produce more seeds per plant.

Keywords: F_1 Hybrids, Correlation, Salinity, Chlorophyll Content, and Leaf Area

1. INTRODUCTION

Salt tolerance is an important constrain for rice, which is generally categorized as a typical glycophyte. Soil salinity is one of the major constraints affecting rice production worldwide, especially in the coastal areas. Susceptibility or tolerance of rice plants to high salinity is a coordinated action of multiple stress responsive genes, which also interacts with other components of stress signal transduction pathways. Salt tolerant varieties can be produced by marker-assisted selection or genetic engineering by introducing salt-tolerance genes. In this review, we have updated on mechanisms and genes which can help in transferring of the salt tolerance into high-yielding rice varieties. We have focused on the need for integrating phenotyping, genomics, metabolic profiling and phenomics into transgenic and breeding approaches to develop high-yielding as well as salt tolerant rice varieties, Qin et al. (2020) Moreover, considering the impact of climate change is essential, and breeding programs should focus on developing rice varieties that not only tolerate current salinity levels but also have the potential to adapt to future changes in climate and salinity conditions, this can involve incorporating traits related to drought tolerance, heat tolerance, and resilience to other environmental stresses. to maximize the productivity of crop plants under adverse conditions, there is an urgent need to look for sources of diverse genetic variation that can be used for developing new cultivars with greater yield potential and stability over seasons. Salinity typically coexists with other environmental stresses, and it is hard to predict what will occur in the future therefore, developing climate-resilient varieties that can withstand different abiotic stress such as salinity, drought and many others will provide a suitable solution rivero et al. (2022).Soil salinity is a serious problem that reduces rice yield because it is more sensitive to salt stress than other cereal crops. Salinity affects many aspects of the rice plant phases like it has a damaging effect on rice plant growth e.g. germination inhibition, difficulties in the crop establishment, development of the leaf area, decrease in the production of the dry matter, delay in the seed setting and even leading to the sterility It is advised that the study be replicated, incorporating a wider array of pivotal traits and spanning diverse irrigated regions across the country, to facilitate a more comprehensive analysis, as suggested by Li et al. (2018). Hence, the objective of this study was to pinpoint plant varieties resilient to salt stress, capable of thriving in environments with high salinity levels, through exposure to 6 and 8 dS m^{-1} salt stress in both hydroponic and field setups. The aim was to identify the most promising genotypes from a pool of plants exhibiting diverse traits.

2. MATERIALS AND METHODS

The Tandojam Institute of Nuclear Agriculture (NIA) conducted a study in the Kharif season of 2021. F_1 hybrids along with their parent lines were cultivated under both saline and regular conditions: T_1 = 0.0 dS m^{-1}NaCl, T_2 = 6.0 dS m^{-1}NaCl, and T_3 = 8.0 dS m^{-1}NaCl in the NIA Tandojam Greenhouse. This experiment followed a randomized complete block design with three replicates. The objective was to assess how the superior parental variety or line responds to salt stress and to explore the genetic connections among different traits within the F_2 population. Hence, morph physiological characteristics were deemed unsupportive for their performance in diallel mating designs. The same treatment methodology was employed throughout the study.

F_1 HYBRIDS AND PARENTS

The following are the combinations of different product types: KSK-133 in combination with Kharaganjia, FL-478, GML-498, HHZ-10-SAL-DT1 DT1, and RST-177. Additionally, RST-177 was partnered with Kharagnjia, FL-478, GML-498, and HHZ-10-SAL. Furthermore, HHZ-10-SAL partnered with Kharaganjia, FL-478, and GML-498. Lastly, FL-478 is coupled with Kharaganjia and GML-498.

Six Parents

Kharaganjia, FL-478, GML-498, HHZ-SAL-10-DT1-DT1, RST-177, and KSK-133

CULTIVATED SPECIES OF RICE

The predominant species, Asian rice (Oryza sativa L.), has spread throughout the world's regions. B. Only tropical Africa is home to African rice, or Oryza glaberrima L.

Asian rice can be divided into three different ecological types according to its morphophysiological traits and geographic suitability.

Indica rice is grown in tropical regions, including Malaysia, Taiwan, China, India, Sri Lanka, and Thailand.

Japonica rice is grown mostly in Korea and Japan in regions with moderate temperatures.

Genotypes	Source
Kharaganja	IR2071-625-1-252, NIA
RST-178	Basmati 370 x IR760, KSK
RST-177	Basmati 370 x IR760-A1-40-2-1, RRI, Kala Shaka Ku
FL-478	Pokali x IR29, produced from IRRI, obtained from NIBGE
IR-8	Introduction from IRRI (Peta x DGWG), 1966
IR-6	Introduction from IRRI (Siam 29 x DGWG)
IR-72	Promising lines were evaluated in RYT during 1985-86.
KSK-282	Basmati 370 x IR-95, 1982, Kala Shah Kaku
HHZ-5-SAL-10 DT1DT1	Green super rice (GSR) lines, Zhong 413 donor parent, BC1F8
IR-83	IR833-6-2-1-1/ IR1561-149-1//IR24*4/O. nivara
GML-592	Genetically modified line, NIBGE
DR-83	Parentage: BU1/CR115; Pedigree: CR156-5021-207 RRI, Dokri, 1982
GML-536	Genetically modified line, NIBGE
Shua-92	Fast nuetrons (14 GY), Irradiation, Mutant of IR8, 1993, NIA, Tando Jam
GML-498	Genetically modified line, NIBGE
HHZ SAL-10 DT1 DT1	Pure line selection, RRI, Dokri, 1932
Kangni-27	Three way cross of F_1 (Basmati 320 x 10486) with 50021, 1995-96.
Basmati-515	Through selection of basmati 370, Kala Shak Ku
PS-2	KSK 282/ 4321, line of Kala Shaka Ku
KSK-133	KSK 282/ 4321 (line of Kalashakgu)

Morpho-physiological parameters recorded:

Plant height (in centimeters), number of tillers per plant, length of panicle (in centimeters), number of spikelets per panicle, number of grains per panicle, thousand grain weight (in grams), grain yield per plant, harvest index percentage, chlorophyll content (in RG units), percentage of sodium and potassium content, and leaf area (in square centimeters) are among the parameters being measured.

Correlation analysis

The correlation coefficient was computed following the method described by Snedecor and Cochran (1980) using the formula. $(r) = \frac{Co-varaince}{Geometric\ mean\ of\ variance}$

$$= \frac{\sum xy}{\sqrt{(\sum x^2)(\sum y^2)}}$$

Where;

$$\sum xy = \sum xy - \frac{(\sum x)(\sum y)}{N}$$

$$\sum x^2 = \sum x^2 - \frac{(\sum x)^2}{N}$$

$$\sum y^2 = \sum y^2 - \frac{(\sum y)^2}{N}$$

3. RESULT

The following characteristics were measured and assessed: plant height (in centimeters), the number of productive tillers per plant, panicle length (in centimeters), spikelet count per panicle, grain count per panicle, 1000-grain weight (in grams), grain yield per plant, harvest index (in percentage terms), chlorophyll content (in RG units), sodium content (in percentage terms), potassium content (in percentage terms), and leaf area (in square centimeters). Plants can be categorized into two main groups depending on their response to salt's impact on their growth: Glycophytes refer to crop species sensitive to soil salinity, whereas halophytes are plants either cultivated in highly saline environments or naturally possessing a higher tolerance to elevated salt levels, and salinity restricts production efficiency during the mature stage. It has been observed that shoot length, root length, and dry matter decrease significantly at stress levels of 5–6 dSm^{-1} NaCl **(**Hasegawa et al., 2000). Examining the initial phases of growth might offer a more accurate forecast of how plants will react to salinity compared to later stages. Salinity poses considerable abiotic stress and remains a focal point for plant breeders and researchers in the fields of plant physiology and biotechnology.

Plant height (cm)

There exists a strong association among rice height and various parameters: the tillers (r = 0.192**), panicle length (r = 0.396**), spikelets per panicle (r = 0.167*), and the number of panicles (r = 0.282**). Additionally, significant correlations are observed with weight per 1000 grains (r = 0.367**), grain yield per plant (r = 0.441**), chlorophyll content (RG) (r = 0.440**), Na+% (r = 0.712**), and K+% (r = 0.461**). However, there is no notable correlation between harvest index (%) (r = 0.041 ns) and leaf area (r = 0.046 ns) under control conditions. Under salt stress conditions (6 dS m-1 salinity pressure), plant height exhibits correlations with spikelets per panicle (r = 0.284**), spikelets per plant (r = 0.494**), and chlorophyll content (r = 0.709**). Additionally, correlations are observed with Na+% (r = 0.253) and K+% (r = 0.306**). However, insignificant associations were found with tiller number per plant (r = 0.039 ns), panicle length (r = 0.069 ns), leaf length (r = 0.154 ns), and harvest index (r = 0.172 ns). This investigation demonstrates that the majority of morphological and physiological traits in both parents and F1 hybrids are linked to plant height (see Table 01).

Productive tillers plant 1

The above-mentioned trait is strongly associated with panicle length (r = 0.451**), spikelets per panicle (r = 0.155*), grains per panicle (r = 0.149*), plant yield per plant (r = 0.121*), thousand grain weight (g) (r = 0.325**), and K+% (r = 0.299**). Conversely, properties such as chlorophyll content (RG) (r = -0.393**), leaf area (cm2) (r = -0.485**), and % Na+ (r = -0.385**) exhibit negative associations with the number of tillers per plant. However, there was no negative correlation observed with harvest (r = -0.069 ns). This indicates that the most significant morphological similarities lie with the number of tillers per plant. Under salinity stress (6 dS m-^{1} salinity pressure), notable correlations were found with grains per panicle (r = 0.473**), grain yield per plant (r = 0.258**), chlorophyll content (r = 0.338**), and K+% (r = 0.245**). However, other parameters did not exhibit significant effects. According to the current research findings, tiller count demonstrated a robust relationship with research quality under both control and salinity conditions (refer to Table 01).

Panicle length (cm)

This trait exhibited a positive and significant correlation with spikelets panicle^{-1} (r = 0.393**), the number of grains panicle-1, and other yield-associated traits, including agronomical and physiological, except the character harvest index (r = 0.101ns), which exhibited a non-significant association with this trait. Under salinity stress, this character showed a positive and significant correlation with the number of spikelet panicles (0.302**) and K+% (0.348**), while other characters showed a non-significant association under stress. This character resembled the fact that yield traits were highly associated with panicle length. It is concluded that panicle length represented highly significant positive correlations with the majority of the yield and morphological traits in both situations, normal and salinity stress, but also non-significant associations with a few of the traits under both conditions (Table 01).

Number of spikelets panicle ^{1}

The spikelet panicle^{-1} character showed a positive and significant association with the number of grains panicle^{-1}, grain yield, and other yield-contributing traits, whereas a non-significant correlation was found with leaf area as r = 0.084 ns. Under saline stress (6 dS m^{-1} salt stress), this character showed a positive and significant association with grain yield plant^{-1} (0.414**), leaf area (0.379**), chlorophyll content (0.532**), Na+% (0.484**), and K+% (0.286**) under stress conditions. A similar trend of correlations between the number of spikelets spike^{-1} with yield and the morphological traits of their parents and F_1 hybrids was demonstrated under normal and salinity stress conditions (Table 01).

Number of grains panicle^{-1}

The character grains panicle observed to be highly positively and significantly associated with almost the characters as yield plant^{-1} (0.369**), seed index (r = 0.454**), final harvest index (0.339**), and other physiological traits such as chlorophyll and ionic %. This character responded significantly to all the yield characters, showing that they were associated with each other in improving yield (Table 01).

1000-grain weight, (g)

Under control conditions, this character showed a positive and significant association with the number of grains panicle^{-1} (0.4496**), while other characters were non-significant under this environment. However, under a saline stress environment (6 dS m^{-1} salt stress), this character was significant with grain yield plant^{-1} (0.411**) and K+% (0.492**), respectively. While other characters showed a non-significant association (Table 01).

Grain yield plant [1]

This is a polygenic trait, a complex character that is dependent on other important economic characters. Grain yield plant^{-1} depicted a positive and significant association with 1000 grain weight (0.256**), final harvest index (0.253**), chlorophyll (0.011*), and K+% (r = 0.720**). A positive and significant correlation was observed with Na+% (r = -0.603**), and a non-significant correlation was found in leaf area (r = 0.017ns). This showed that yield traits were highly associated with grain yield. Under saline conditions, correlation observed a positive and significant association with harvest index (0.257**), chlorophyll content (0.582**), Na+% (0.406**), and K+% (0.492**), respectively.

Harvest index (%)

Under typical growth conditions, there was a strong and significant association found between the harvest index characteristic and the weight of 1000 grains (g) (0.306**), the number of grains per panicle (0.359**), and the grain yield per plant (0.320**). On the other hand, in saline conditions, the chlorophyll content (0.261**) and leaf area (0.317**) demonstrated substantial positive associations, while other features showed negative correlations (see Table 01).

Leaf area (cm^2)

The leaf area showed significant and positive association with (0.211**), number of spikelets panicle^{-1} (0.489**), 1000 grain weight (g) (0.309**), and grain yield plant^{-1} (0.437**), while others showed non-significant relationship for length of panicle (0.167ns), grains panicle^{-1} (0.081ns), and final harvest index (0.009ns). Under salt stress, leaf area showed a significant association with chlorophyll content (0.394**) and Na ratio (0.473**), respectively, while a non-significant association was found with K^+ content (0.099ns).

Chlorophyll content (RG)

The chlorophyll content showed a negative but significant association with plant height (--0.368**), number of productive tillers (-0.246**), and panicle length (-0.253**), respectively. However, a significant and positive association was observed with the number of spikelets panicle^{-1} (0.466**), the number of grains panicle^{-1} (0.211**), and leaf area (0.347**), while this character observed a non-significant relationship for seed index (0.025ns), yield plant^{-1} (0.046ns), and harvest index (0.072ns). Similarly, under saline stress, significant and positive associations were observed with Na+% (0.286**) and K^+% (0.413**), respectively (Table 01).

Na^+ (%)

Sodium% varied and showed significant association with plant height (0.701**), panicle length (0.397**), number of grains panicle^{-1} (0.325**), 1000 grain weight (0.319**), grain yield plant^{-1} (0.495**), leaf area (0.438**), and chlorophyll content (0.452**). Under saline stress, a significant and positive correlation was found with K+% (0.286**) (Table 01).

4.15.13 K^+(%)

Potassium% exhibited positive and significant correlation with plant height

(0.4843**), panicle length (0.185**), number of spikelets panicle (0.524 **), 1000 grain weight (0.199**), grain yield plant^{-1} (0.595**), leaf area (0.4642**), and Na+% (0.566**), respectively.

4. DISCUSSION

Numerous studies have investigated wheat's tolerance to salinity, identifying genotypes that can survive in environments with salt levels up to 10 dS m-1 NaCl (Al-Wasinee et al., 2023). In rice breeding strategies, a diverse range of genotypes and crosses are systematically segregated to produce novel and distinct genotypes. These are subsequently assessed and compared to identify genotypes and commercial cultivars with characteristics such as high yield and tolerance to abiotic stresses. Plant height exhibits a close correlation with several other yield-contributing factors, including tiller count per plant, panicle length, spikelet count per panicle, Na+ percentage (r = 0.712**), and K+ percentage. However, there was no significant correlation observed between harvest percentage and leaf area under control conditions. In the presence of salt stress (6 dS m-1 salinity stress), plant height showed similarity with spikelet count, rice yield, chlorophyll content, Na+ percentage, and K+ percentage. Noteworthy correlations were observed with tiller count per plant (r = 0.039 ns), panicle length (r = 0.069 ns), leaf length (r = 0.154 ns), and harvest index (r = 0.172 ns). This research reveals that the majority of morphological and physiological traits of both parents and F1 hybrids are associated with plant height (Table 1). A similar study was reported by Zho et al., 2023. Conversely, plant height exhibits a negative correlation with panicle length, grain count per cluster, days to maturity, and yield. This implies that increasing plant height may lead to a decrease in yield. The study revealed that the tiller count per plant was positively correlated with characteristics such as panicle length, spikelet count per panicle, grain count per panicle, plant yield, thousand grain weight (g), and spikelet count per plant. Additionally, the K+ percentage showed a positive correlation. However, certain traits, such as chlorophyll content (RG), leaf area (cm2), and Na+ percentage, were found to have negative associations and correlations with tiller count per plant. Nevertheless, there were no detrimental effects observed on the harvest. This indicates that the greatest morphological similarities lie in the tiller count per plant. Under salinity stress (6 dS m-1 salinity stress), positive correlations were observed with grain count per cluster, plant yield, chlorophyll content, and percentage of K+. However, other traits did not exhibit significant effects. According to the findings of the present research project, tillering capacity exhibited a strong association with research quality under both control and salinity conditions (Table 01), chlorophyll content (RG), leaf area (cm2), Na+%, and K+%, except the character harvest index, which exhibited a non-significant association with this trait. Under salinity stress, this character showed a positive and significant correlation with the number of spikelets, panicles, and K+%, while other characters showed a non-significant association under stress. This character resembled the fact that yield traits were highly associated with panicle length.

It is concluded that panicle length represented highly significant positive correlations with the majority of the yield and morphological traits in both situations, normal and salinity stress, but also non-significant associations with a few of the traits under both conditions (Table 01). Only at the phenotypic level did Azad et al. (2022) find a substantial positive association between the number of panicles per panicle and the grain yield per panicle. A positive and substantial correlation was observed between the spikelet panicle-1 character and the following parameters: number of grains panicle-1, grain yield plant-1, 1000 grain weight, harvest index, chlorophyll content, Na+%, and K+%. On the other hand, r = 0.084 ns indicated a non-significant association with leaf area. This characteristic displayed a positive and substantial correlation with leaf area, chlorophyll content, Na+%, K+%, and grain yield plant-1 under saline stress (6 dS m-1 salt stress). Similar trends of correlation were seen between the yield and physical characteristics of the parents and F1 hybrids, as well as the number of spikelets spike-1. These results were similar to those of Huang et al. (2023. The character grains panicle observed to be highly positively and significantly associated with almost the characters as grain yield plant-1, 1000 grain weight, harvest index (%), chlorophyll content, leaf area, Na+%, and K+%, respectively. Salinity stress observed (6 dS m-1 salt stress) depicted a positive and significant association with harvest index and chlorophyll content. This character responded significantly to all the yield characters, showing that they were associated with each other in improving yield (Table 01). Phenotyping for salt tolerance studies has been previously reported in rice, and the number of grains per panicle for most of the lines depicted a positive relationship with yield characters Sadak and Dawood 2023. Under control conditions, this character showed a positive and significant association with the number of grains panicle-1, while other characters were non-significant in this environment. However, under a saline stress environment (6 dS m-1 salt stress), this character was significant with grain yield plant-1 and K+%, respectively. While other characters showed a non-significant association (Table 01), grain yield is a complex character that is dependent on other yield characters. Grain yield plant-1 depicted a positive and significant association with 1000 grain weight, harvest index, and chlorophyll content. This showed that yield traits were highly associated with grain yield. Under saline conditions, correlation observed a positive and significant association with harvest index, chlorophyll content, Na+%, and K+%, respectively. According to Qin et al., 2020, there’s a documented correlation between the thousand grain weight and the grain yield per plant, indicating a positive relationship. The control group yielded excellent results in terms of ear yield, thousand grain weight (g), and yield per plant. However, under saline conditions, leaf area and chlorophyll content displayed comparable effects, while other factors were adversely impacted (see Table 01). Leaf area demonstrated a significant and positive correlation with the number of spikelets per panicle, thousand grain weight (g), and grain yield per plant, while other factors exhibited non-significant associations with panicle length, number of grains per panicle, and harvest index. When subjected to salt stress, leaf area exhibited a significant correlation with chlorophyll content and Na%, respectively, with a non-significant association observed with K+ content. The chlorophyll content exhibited a significant negative correlation with plant height, the number of productive tillers, and panicle length. Conversely, a significant positive correlation was noted with panicle number per plant, grain number per plant, and leaf area, while no significant association was observed with thousand-grain weight, plant yield per plant, or harvest index. Likewise, a significant positive correlation with Na+ and K+ was observed under saline stress conditions (see Table 01). Chlorophyll content showed a positive correlation with various yield traits, as suggested by Azad et al. (2022). Under saline stress, a significant and positive link was found with K+%, despite the fact that salt% fluctuated and showed significant relationships with plant height, panicle length, number of grains panicle-1, 1000 grain weight, grain yield plant-1, leaf area, and chlorophyll content (Table 01). Several scientists reported a positive and significant association between the sodium percentage and physiological aspects and yield (Shereen et al., 2022). The following variables exhibited a positive and significant correlation with potassium%: plant height, panicle length (0.185**), number of spikelets in the panicle, 1000 grain weight, grain yield plant-1, leaf area, and Na+%. Shereen et al. (2022) found a positive link between yield attributes and potassium and advocated stronger accusations with yield traits.

CONCLUSIONS

It is concluded that rice germplasm possess different genetic bases for salinity stress and the ability to survive better under harsh conditions, their tolerance capability can be enhanced by selecting suitable parent combinations for breeding programs. The hybrids KSK-133 x GML-498, KSK-133 × RST-177, KSK-133 x FL478, RST-177 x Kharagnjia, GML-498 x Kharaganjia, HHZ-10-SAL x Kharaganjia, FL-478 x GML-498 x Kharaganjia were selected among hybrids as good combiners exhibiting high heterosis and SCA effects grown under saline stress, while, some parents and hybrids were salt sensitive as they were affected by salt stress.

REFRENCES

Ahmad, I.; Zhu, G.; Zhou, G.; Song, X.; Hussein, I.M.E.; Ibrahim, S.E.G.2022, Effect of N on growth, antioxidant capacity, and chlorophyll content of sorghum. Agronomy 12, 501.

Al-Ashkar, I., Alderfasi, A., El-Hendawy, S., Al-Suhaibani, N., El-Kafafi, S., & Seleiman, M. F. (2019). Detecting salt tolerance in doubled haploid wheat lines. Agronomy, 9(4), 211-225.

Al-Ashkar, I., Ibrahim, A., Ghazy, A., Attia, K., Al-Ghamdi, A. A., & Al-Dosary, M. A. (2021). Assessing the correlations and selection criteria between different traits in wheat salt-tolerant genotypes. Saudi Journal of

Biological Sciences, 28(9): 5414-5427.

Azad, A. K., Sarker, U., Ercisli, S., Assouguem, A., Ullah, R., Almeer, R., & Peluso, I. (2022). Evaluation of Combining Ability and Heterosis of Popular Restorer and Male Sterile Lines for the Development of Superior Rice Hybrids. Agronomy, 12(4), 965-987.

Chen, Y.L.; Li, R.K.; Ge, J.F.; Liu, J.G.; Wang, W.B.; Xu, M.F.; Hussain, S.; Wei, H.H.; Dai, Q.G .2021 Exogenous melatonin confers enhanced salinity tolerance in rice by blocking the ROS burst and improving Na+/K+ homeostasis. Environ. Exp. Bot., 189, 104530.

Chinnusamy, V., Jagendorf, A., & Zhu, J. K. (2005). Understanding and improving salt tolerance in plants. Crop Science, 45(2): 437-448.

Dixit, S., Singh, U. M., Singh, A. K., Alam, S., Venkateshwarlu, C., Nachimuthu, V. V., & Kumar, A. (2020). Marker assisted forward breeding to combine multiple biotic-abiotic stress resistance/tolerance in rice. Rice, 13(1), 1-15.

El-Hendawy, S. E., Hu, Y., Yakout, G. M., Awad, A. M., Hafiz, S. E., & Schmidhalter, U. (2005).Evaluating salt tolerance of wheat genotypes using multiple parameters. European Journal of Agronomy, 22(3), 243-253.

Hasegawa, P. M., Bressan, R. A., & Pardo, J. M. 2000. The putative plasma membrane Na+/H+antiporter SOS1 controls long-distance Na+transport in plants. Trend S Plant Science.7(5): 317–319.

Huang, C.C.; Lee, Y.T.; Ly, T.T.; Wang, C.Y.; Chang, Y.T.; Hou, P.F. Volatile cinnamaldehyde induces systemic salt tolerance in the roots of rice (Oryza sativa). Physiol. Plant. 2023, 175.

Hussain, S., Zhang, J. H., Zhong, C., Zhu, L. F., Cao, x. C., Yu, S. M., & JIN, Q. Y. (2017). Effects of salt stress on rice growth, development characteristics, and the regulating ways: A review. Journal of integrative agriculture, 16(11), 2357-2374.

Karim, D., Siddique, M. N. A., Sarkar, U., Hasnat, Z., & Sultana, J. (2014).Phenotypic and genotypic correlation co-efficient of quantitative characters and character association of aromatic rice. Journal of Bioscience and Agriculture Research, 1(1), 34-46.

Li, N., Chen, S., Zhou, x., Li, C., Shao, J., Wang, R., &Polle, A. (2008).Effect of NaCl on photosynthesis, salt accumulation and ion compartmentation in two mangrove species, Kandeliacandel and

Bruguieragymnorhiza. Aquatic Botany, 88(4): 303-310.

Qin, H., Li, Y., & Huang, R. (2020). Advances and challenges in the breeding of salt-tolerant rice. International Journal of Molecular Sciences, 21(21): 8385.

Rivero, R. M., Mittler, R., Blumwald, E., & Zandalinas, S. I. (2022). Developing climate-resilient crops: improvingplant tolerance to stress combination. The PlantJournal: For Cell and Molecular Biology, 109(2): 373–389.

Reddy, I. N. B. L., Kim, S. M., Kim, B. K., Yoon, I. S., & Kwon, T. R. (2017). Identification of rice accessions associated with K+/Na+ ratio and salt tolerance based on physiological and molecular responses. Rice Science, 24(6): 360-364.

Reddy, I. N. B. L., Kim, S. M., Kim, B. K., Yoon, I. S., & Kwon, T. R. (2017). Identification of rice accessions associated with K+/Na+ ratio and salt tolerance based on physiological and molecular responses. Rice Science, 24(6): 360-364.

Sadak, M.S.; Dawood, M.G. 2023. Biofertilizer Role in alleviating the deleterious effects of salinity on wheat growth and productivity.GesundePflanzen, 75, 1207–1219.

Sakina, A., Ahmed, I., Shahzad, A., Iqbal, M., &Asif, M. (2016). Genetic variation for salinity tolerance in Pakistani rice (Oryza sativa L.) germplasm. Journal of Agronomy and Crop Science, 202(1): 25-36.

Shereen, A., Asma, M. U. S., Khan, M. A., Ali, M., &Arif, M. (2022). physio-biochemical analysis of salinity tolerance in sodium contrasting rice (oryza sativa L.) genotype. Pakistan Journal Botany 54(3): 787-794.

Tuteja, N., Gill, S. S., & Tuteja, R. (2011). Plant responses to abiotic stresses: shedding light on salt, drought, cold and heavy metal stress. Omics and Plant Abiotic Stress Tolerance, 3(1): 39-64.

Vijaya, K, P.V. R. Rao, PV Satyanarayana, V Satyanarayana Rao, K Jayalalitha and T Kasturi. 2020. Correlation studies in seedling and reproductive stage salinity tolerance in rice (Oryza sativa L.) under salinity. International Journal of Chemical Studies, 9(21):71-75

Wasinee, P.; Chakkree, L.; Sarunyaporn, M. 2023, Evaluation and clustering of rice cultivars tolerance to salt and drought stresses using morpho-physiological and biochemical indices. J. Crop Sci. Biotechnol. 26, 573–584.

Xu, Y. Bu, W. Xu, Y. Fei, H. Zhu, Y. Ahmad, I. Nimir, N.E.A. Zhou, G.; Zhu, G.2024. Effects of Salt

Stress on Physiological and Agronomic Traits of Rice Genotypes with Contrasting Salt Tolerance. Plants, 13, 1157.1-18.

Zhao, D.Y.; Zhang, Z.W.; Liu, G.L.; Zhao, S.P.; Zhang, X.L.; Zhao,W.F.; Siddique, K.H.M.2023. Effects of phosphorus supply and salt stress on plant growth, organic acid concentration, and sodium, potassium, calcium, magnesium, and phosphorus utilization in wheat. Cereal Res. Commun., 51, 905–915.

Table 01 Correlation coefficient among F_1 hybrids and their parents for various morpho-physiological traits in rice under salinity stress (hydroponic condition; T_1= control and T_2= 6 dS m^{-1}NaCl)

Characters	Plant height (cm)	Number productive tillers plant^{-1}	Panicle length (cm)	Number of spikelets panicle^{-1}	Number of grains panicle^{-1}	1000 grain weight (g)	Grain yield plant^{-1}	Harvest index (%)	Leaf area (cm^2)	Chlorophyll content (RG)	Na^+ %	K^+ %
Plant height (cm)	1	0.039 ns	0.069ns	-0.284**	-0.004ns	0.016 ns	-0.494 **	0.1726	0.154 ns	0.709**	0.253**	0.306**
Number of productive tillers plant^{-1}	0.006ns	1	0.077ns	-0.064ns	0.473**	0.082 ns	-0.238 **	0.113 ns	0.155 ns	0.338**	0.018ns	0.245**
Panicle length (cm)	0.261**	0.223 **	1	0.302**	0.042ns	0.057 ns	-0.141 ns	0.062 ns	0.126 ns	0.169ns	0.189ns	0.348**
Number of spikelets panicle^{-1}	-0.016ns	-0.2083**	0.138ns	1	0.002ns	0.179 ns	0.414 **	0.178 ns	0.379 **	0.532**	0.484**	0.286**
Number of grains panicle^{-1}	0.122**	0.097 ns	0.268**	0.292**	1	0.098 ns	0.203 ns	0.328 **	0.129 ns	0.247**	0.008ns	0.003ns
1000 grain weight (g)	0.104ns	-0.083 ns	0.102ns	-0.171ns	0.4496 **	1	0.191 ns	0.0839ns	0.184 ns	0.030ns	0.090ns	0.492**
Grain yield plant^{-1}	0.386**	-0.210 **	0.111ns	0.556**	0.144ns	0.012 ns	1	0.257 **	0.129 ns	0.582**	0.406**	0.492**
Harvest index(%)	-0.015ns	-0.115 ns	0.0923 ns	0.276ns	0.359**	0.306 **	0.320 **	1	0.317 **	0.261**	0.005ns	0.173ns
Leaf area (cm^2)	0.211**	-0.153	0.167ns	0.489**	0.081ns	0.309 **	0.437 **	0.009 ns	1	0.394**	0.473**	0.099ns

		ns										
Chloropl content % (RG)	-0.368**	-0.246**	-0.253**	0.466**	0.211**	0.025 ns	0.046 ns	0.072 ns	0.347**	1	0.286**	0.413**
Na^+ %	0.701**	0.044 ns	0.397**	0.032ns	0.325**	0.319**	0.495**	0.057 ns	0.438**	0.452**	1	0.286**
K^+ %	0.4843**	0.163 ns	0.185**	0.524**	0.047ns	0.199**	0.595**	0.143 ns	0.4642**	0.081ns	0.566**	1