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Genetic Studies for Determination of Yield Components in Rice (*Oryza sativa* L.) Varieties under Saline Conditions Pooled Over Seasons

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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

The current study was conducted on 50 rice genotypes to evaluate the pooled correlation and path analysis of various biometrical traits viz., fifty percent flowering, plant height, panicle length, number of tillers per panicle, number of productive tillers per plant, number of grains per panicle, 100 seed weight with seed yield per plant of three seasons under salinity. The analysis of variance pooled over seasons revealed that all eight traits were highly significant thus indicating the existence of high genetic variability among the genotypes for all the traits and suggest the possibility of improving yield under saline condition. The pooled correlation analysis indicated that seed yield per

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plant has exhibited significant positive correlation with total number of tillers per plant, number of productive tillers per plant, panicle length and number of seeds per panicle. Thus, selection pressure could be applied for increasing the seed yield per plant under saline situation. From the path analysis studies, it was understood that the characters *viz*., number of productive tillers per plant, panicle length and number of seeds per panicle might be applied with selection pressure directly or indirectly to improve seed yield per plant and the characters studied for seed yield per plant is sufficient and sufficiently control the expression of seed yield in rice under saline situation due to their low residual effect.

Keywords: Correlation; path analysis; pooled ANOVA; rice; salinity.

1. INTRODUCTION

Rice is a staple cereal crop providing 50-80% daily calorie intake to over three billion people, feeding almost half of the world's population and is very rich in genetic diversity [1]. “India is the second largest producer next to China. Tamil Nadu is one of the most prominent rice-growing states in India” [2]. Abiotic stresses like drought, heat, and salinity significantly impact rice yield, with salinity being one of the major soil problems. In India, 8-10 million hectares are affected by salinity, particularly in coastal areas, affecting rice growth and yield [3]. “Salinity impacts rice growth and yield in such a way that with increased salinity, seed number per panicle and other yield attributing traits are affected, leading to minimum yield in rice. Considering the importance of salinity stress in rice, selection of appropriate genotypes for its tolerance to saline soil condition is crucial. When choosing superior genotypes under stress, knowledge of association and the direct and indirect effects between yield and associated traits could be helpful. Crop improvement is based on the selection and identification of tolerant genotypes, along with research on the associations between different characters and yield” [4]. Given this context, the current study was conducted on rice to evaluate the pooled correlation and path analysis of various biometrical traits with yield for three seasons under salinity.

2. MATERIALS AND METHODS

The experiment was conducted at the experimental farm of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Tamil Nadu located at latitude 11°24'N, longitude 79°44'E, and height + 5.79 m for all three seasons during January 2022 - June 2023 (Table 1). The soil sample collected at the beginning of each season was analyzed for pH using the Systronic pH meter. The electrical conductivity (EC) of soil and irrigation water was determined at the beginning of the experiment using the Systronics conductivity meter and the values were expressed in dsm^{-1}. The details of pH and salinity level of the experiment are detailed in the Table 2. The experimental material comprised of 50 genotypes including checks obtained from the University of Agricultural Sciences, Bangalore. Pokkali, TRY3 and CSR27 were employed as tolerant checks while IR36 and ADT46 as susceptible checks. Twenty-five-days-old seedlings were transplanted in the main field, which was set out in a Randomized Block Design (RBD) with three replications. For parameters such as days to fifty percent flowering, plant height, panicle length, number of tillers per panicle, number of productive tillers per plant, number of grains per panicle, hundred seed weight and seed yield per plant, the observations were recorded on five randomly selected plants of each genotype in every replication. Recommended agronomic practices and need based plant production measures were carried out. The pooled analysis of variance (ANOVA) was calculated by taking data from all three environments. The genotypic correlation coefficient was worked out as elaborated by Aljibouri et al. [5]. The direct and indirect effect of yield attributing traits on seed yield were calculated through path coefficient analysis as suggested by Wright [6] and elaborated by Dewey and Lu [7]. The scale for path coefficient analysis suggested by Lenka and Mishra [8] was followed to rate the values of direct and indirect effects. The estimates of pooled ANOVA, genotypic correlation coefficient and path analysis were also calculated by examining the data using TNAUSTAT statistical package.

Table 1. Details of the seasons

Seasons	Date of Transplanting
Season 1	19.01.2022
Season 2	22.06.2022
Season 3	18.01.2023

Table 2. Details of P^H and Salinity level of the experiment

Seasons	P^H of the Soil	EC_e of Soil paste	EC_e of the irrigation water
Season 1	7.70	5.0dsm^{-1}	3.2 dsm^{-1}
Season 2	7.50	4.8dsm^{-1}	3.0 dsm^{-1}
Season 3	7.60	5.0dsm^{-1}	3.3 dsm^{-1}

3. RESULTS AND DISCUSSION

The analysis of variance (ANOVA) for pooled over the environments revealed that all the eight traits *viz*., days to fifty per cent flowering, plant height, number of tillers per plant, number of productive tillers per plant, panicle length, number of seeds per panicle, 100 seed weight and seed yield per plant were highly significant showing differential performance over different environments thus indicating the existence of high genetic variability among the genotypes for all the traits and suggest possibility of improving yield under saline condition (Table 3). The variances due to the environment were also significant for all the eight traits indicating that these characters were influenced by salt stress environments too.

For correlation and causation studies, pooled data for different traits were taken up, to understand the inter relationship and to study the principal components of seed yield. Breeding high yielding varieties in most of the crops needs information on the extent of inter relationship among yield components. The efficiency of selection for yield mainly depends on the direction and magnitude of the association of the component traits with yield.

Correlation studies which provide estimates of degree of association of seed yield with its components aids in planning effectively among the eight traits. The inherent association between two variables is referred to as genotypic correlation. Genotypic correlation is more stable and is of significant importance to the plant breeder to bring about genetic improvement in one character by selecting other character of pair that is genetically correlated. The pooled correlation of three seasons for eight biometric traits are detailed in Table 4. Days to fifty per cent flowering recorded significant positive association with plant height and *vice versa*. Similar results were reported by Srijan et al. [9] and Kiranmayee et al. [10]. Number of tillers per plant exhibited positive association with plant height, number of productive tillers per plant, number of seeds per panicle, 100 seed weight and seed yield per plant which were in line with findings of Kahani and Hittalmani [11] and Swapnil et al. [12]. “Number of productive tillers per plant exhibited positive and significant association with plant height and number of tillers per plant. Analogous observation was documented” by Bhargava et al. [13]. None of the characters exhibited positive and significant association with panicle length. Plant height, number of tillers per plant and number of productive tillers per plant exhibited positive and significant association with grains per panicle which was on par with the results of Priyanka et al. [14] and Seneega et al. [15]. 100 seed weight revealed significant and positive association with plant height [16] and number of tillers per plant. Seed yield per plant exhibited positive and significant association with number of tillers per plant [12], number of productive tillers per plant [17], panicle length [18] and number of grains per panicle [19]. “Positive correlation between desirable traits is favorable to the plant breeder because it helps in simultaneous improvement of both the characters while the negative correlation on the other hand hinders simultaneous expression of both characters with high values. The genetic improvement in dependent trait can be achieved by applying strong selection to those characters which are genetically correlated with the dependent traits called correlated response. Thus, it is understood that traits viz., total number of tillers per plant, number of productive tillers per plant, panicle length and number of grains per panicle could be applied selection pressure for increasing the seed yield per plant under saline situation” [20].

The correlation coefficients alone are insufficient to explain the relationship for effective manipulation of the characters, as path analysis furnishes a method for portioning the correlation coefficient into direct and indirect effect and measures the relative importance of the causal factor involved. The results of path analysis are presented in the Table 5. The straightway effect of an independent character on dependent character is known as direct effect. The characters *viz*., number of productive tillers per plant, panicle length and number of grains per panicle exhibited maximum positive direct effects towards seed yield per plant. Similar results were found by Swapnil et al. [12] and Bhargava et al.

[13]. Number of tillers per plant recorded maximum negative significant direct effects towards seed yield per plant which was comparable with the results of Muthuvijayaragavan and Murugan [21]. The correlation between seed yield per plant and the above traits due to direct effects of such traits revealed true relationship between them and direct selection for this trait would be rewarding for yield improvement. In path analysis, the effect of an independent character on dependent character *via* other independent character is known as indirect effect. None of the characters exhibited positive and negative significant indirect effects towards seed yield per plant through this trait. Plant height demonstrated negative high indirect effects with days to fifty percent flowering and number of tillers per plant towards seed yield per plant. Number of tillers per plant displayed maximum positive significant indirect effects with number of productive tillers per plant towards seed yield per plant. Panicle length recorded positive significant indirect effect towards seed yield through number of productive tillers per plant. Similarly, number of tillers per plant disclosed negative significant indirect effects towards seed yield for this trait. None of the characters exhibited positive and negative significant indirect effects towards yield per plant through this trait. Number of productive tillers per plant recorded positive significant indirect effects towards seed yield per plant through number of grains per panicle. None of the characters exhibited positive and negative significant indirect effect towards seed yield per plant through this trait. Similar results were estimated by Kiran et al. [22]. The correlation mainly due to indirect effects of characters via other component traits, indirect selection, through such traits would lead to yield improvement.

Even though total number of tillers per plant revealed high negative direct effect it portrayed high positive indirect effect towards seed yield through number of productive tillers per plant. Thus, it denotes the importance of spikelet fertility for yield improvement under saline condition. The residual effect was 0.1798 which indicated that the characters studied for seed yield per plant is sufficient and amply controls the expression of seed yield in rice under saline situation.

Table 3. Analysis of variance of 50 genotypes pooled over seasons

Source	Environment	Genotypes	Genotype X Environment	Pooled error
Degrees of freedom	2	49	98	294
DFF	352.40**	43.25**	39.62**	40.88**
PH	616.18**	96.24**	99.74**	35.37**
NTPP	66.21**	10.14**	13.73**	15.68**
NPTP	60.79**	13.03**	13.63**	12.16**
PL	6.03**	7.94**	5.41**	4.99**
GPP	845.43**	338.81**	257.03**	88.19**
HSW	0.69**	4.61**	8.82**	0.42**
SYPP	60.22**	23.29**	17.68**	18.48**

DFF- Days to fifty percent flowering, PH- Plant height (cm), NTPP- No. of tillers per plant, NPTP- No. of productive tillers per plant, PL- Panicle length (cm), GPP- grains per panicle, HSW- Hundred seed weight, SYPP- Seed yield per plant

Table 4. Genotypic correlation coefficient of 50 genotypes pooled over seasons

	DFF	PH	NTPP	NPTP	PL	GPP	HSW
DFF	1.000						
PH	0.342*	1.000					
NTPP	0.068	0.371**	1.000				
NPTP	0.095	0.362**	0.951**	1.000			
PL	0.192	-0.154	0.205	0.254	1.000		
GPP	0.234	0.678**	0.464**	0.467**	-0.009	1.000	
HSW	0.244	0.277*	0.291*	0.226	0.142	0.082	1.000
SYPP	-0.021	-0.386	0.278	0.478	0.571	0.372	0.389

Significant at 5 per cent* * Significant at 1 per cent*

DFF- Days to fifty percent flowering, PH- Plant height (cm), NTPP- No. of tillers per plant, NPTP- No. of productive tillers per plant, PL- Panicle length (cm), GPP- grains per panicle, HSW- Hundred seed weight, SYPP- Seed yield per plant

Table 5. Path Analysis of 50 genotypes pooled over seasons

	DFF	PH	NTPP	NPTP	PL	GPP	HSW	SYPP
DFF	**-0.054**	-0.038	-0.052	0.057	0.009	0.051	0.006	-0.021
PH	-0.339	**-0.111**	-0.328*	0.217	-0.097	0.149	0.007	-0.386**
NTPP	-0.004	-0.041	**-0.772**	0.568**	0.209	0.252	0.083	0.278*
NPTP	-0.005	-0.040	-0.734	**0.598****	0.412	0.203	0.045	0.478*
PL	-0.010	-0.002	-0.158	0.152	**0.296**	0.217	0.077	0.571*
GPP	-0.013	-0.075	-0.358	0.361*	0.120	**0.290**	0.059	0.372*
SGW	-0.013	-0.031	-0.225	0.135	0.007	0.018	**0.026**	-0.083

**Significant at 5 per cent; ** Significant at 1 per cent*
Values on diagonal – direct effects; Residual effect – 0.1798
DFF- Days to fifty percent flowering, PH- Plant height (cm), NTPP- No. of tillers per plant, NPTP- No. of productive tillers per plant, PL- Panicle length (cm), GPP- grains per panicle, HSW- Hundred seed weight, SYPP- Seed yield per plant

4. CONCLUSION

Thus, from this study, it is understood that the characters namely, number of productive tillers per plant, panicle length and number of grains per panicle might be applied with selection pressure directly or indirectly to improve seed yield per plant under saline condition.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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