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Research Article

Assessment of genetic variability, character association and path analysis for yield and yield component traits in rice (*Oryza sativa* L.)

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Abstract
The present investigation was undertaken with 107 elite rice genotypes to study the variability, heritability and genetic advance as per cent of mean for yield and yield component traits. In addition, character association between the yield and yield components and their direct and indirect effects on grain yield were also studied. High PCV and GCV were recorded for ear bearing tillers per plant, while high heritability were recorded for all the traits studied. Further, the high genetic advance as per cent of mean was recorded for plant height, the number of ear bearing tillers per plant, the total number of grains per panicle, test weight and grain yield per plant. Among these, ear bearing tillers per plant had recorded a high variability, heritability and genetic advance as per cent of mean in addition to correlation and direct effects with grain yield per plant indicating its effectiveness as important selection criterion for the yield improvement.

Keywords
Character association, Genetic advance, Heritability, Path analysis, Rice and Variability

INTRODUCTION

Rice is one of the world's most important cereal food crops. It is the primary source of food and protein for about half of the mankind with an enormous nutritional and economic impact. It is the crucial dietary and food security source of many Asian countries. The two most populous nations namely China and India are the largest producers and consumers of rice(FAOSTAT 2018). Worldwide rice is grown over an area of 162.76 million hectares with the total production of 495.87 million tonnes with a productivity of 4.55 t/ha. Among rice growing countries, India has largest area under rice cultivation in the world *i.e.* 43.86 million hectares and ranks second in the production with 99.24 million tonnes and the productivity of 2.49 t/ha next to wheat. (Ministry of Agriculture, Government of India, 2018-19). Assessment of variability for grain the yield and yield attributes is essential for the successful yield improvement through breeding. Further, grain yield depends on various component characters and knowledge of correlation with yield and among yield component traits in addition to identification of the direct and indirect effects of the traits on yield would help in effective yield improvement. The present investigation was undertaken in this context to elucidate information on variability, heritability, genetic advance, character associations and path coefficients in promising rice genotypes.

MATERIAL AND METHODS

Experimental material for the present investigation comprised of 107 elite rice genotypes developed at Regional Agricultural Research Station (RARS), Maruteru and Agricultural Research Station (ARS), Bapatla. These genotypes were sown during *Kharif* 2017 at RARS , Maruteru in a randomized block design with two replications. For transplanting, nursery was raised separately and 28 days old seedlings were transplanted in the main field with a spacing of 20×15 cm. Standard agronomic practices were followed to raise good crop. Observations were recorded on five randomly selected plants for grain yield per plant (g) and yield component characters namely days to 50% flowering, plant height (cm), the number of ear bearing tillers per plant, panicle length (cm), the total number of grains per panicle, spikelet fertility (%) and test weight (g). However, days to 50 per cent flowering was recorded on plot basis. In contrast, the observations for test weight were obtained from a

random grain sample drawn from each plot in each genotype and replication. The data collected was subjected to standard statistical procedures given by Panse and Sukhatme (1978). Correlation was worked out using the formulae suggested by Falconer (1964). Partitioning of the correlation coefficients into direct and indirect effects was carried out using the procedure suggested by Wright (1921) and elaborated by Dewey and Lu (1959). The characterization of path coefficients was carried out as suggested by Lenka and Mishra (1973).

RESULTS AND DISCUSSION

The results on analysis of variance (ANOVA) for yield and yield component traits revealed highly significant mean squares due to genotypes for all traits studied, indicating the existence of sufficient variation among the genotypes and therefore an ample scope for effective selection. The results on mean, range, Phenotypic Coefficient of Variation (PCV), Genotypic Coefficient of Variation (GCV), heritability and genetic advance as per cent of mean for the yield and yield component traits are furnished in Table 1. A perusal of these results revealed maximum range of variability for the trait total number of grains per panicle (147.5-371.3) while minimum range (4.3-14.7) was recorded for the number of ear bearing tillers per plant. Higher PCV, compared to GCV were recorded for all the traits studied in the present investigation, indicating the influence of the environment. Similar findings were reported earlier by Tiwari *et al.* (2019). High phenotypic and genotypic coefficients of variation (>20%) was recorded for the number of ear bearing tillers per plant. Similar results were reported earlier by Srilakshmi *et al.* (2018). Further, moderate estimates (10-20%) of PCV and GCV were observed for traits plant height (PCV=12.15 and GCV=11.44), the total number of grains per panicle (PCV=13.64 and GCV=13.30), test weight (PCV=13.47 and GCV=12.53) and grain yield per plant (PCV=17.63 and GCV=13.70). These results are in accordance with the findings of Srilakshmi *et al.* (2018) for the total number of grains per panicle, Sudeepthi *et al.* (2017) for test weight and Ravikanth *et al.* (2018) for plant height and grain yield per plant. In contrast, low (<10%) estimates of genotypic and phenotypic coefficients of variation were observed in the present study for days to 50% flowering, panicle length and spikelet fertility, indicating low variability for these characters in the present experimental material and therefore little scope for the improvement of these traits. Similar findings were reported earlier by Sudeepthi *et al.* (2017).

Table 1. Genetic parameters for yield and yield components in rice

S. No	Character	Mean	Range		PCV (%)	GCV (%)	Heritability (broad sense) (%)	Genetic Advance as per cent of Mean
			Minimum	Maximum				
1.	Days to 50% Flowering	113.05	78.50	132	9.80	9.73	98.00	19.90
2.	Plant Height (cm)	112.8	80.30	158.30	12.15	11.44	88.60	22.20
3.	Number of Ear bearing tillers per plant	7.83	4.3	14.7	27.91	25.35	82.52	47.45
4.	Panicle length (cm)	26.76	19.39	32.37	8.95	7.91	78.00	14.39
5.	Total Number of Grains per panicle	230.26	147.5	371.3	13.64	13.30	95.14	26.74
6.	Spikelet Fertility	86.4	73.74	96.94	6.53	5.74	77.28	10.39
7.	Test weight (g)	20.39	13.9	29.50	13.47	12.53	86.51	24.01
8	Grain yield per plant (g)	20.12	14.54	27.73	17.63	13.70	60.39	21.93

In the present study, heritability estimates for the various traits studied ranged from 60.39 (grain yield per plant) to (98.00) days to 50% flowering. High estimates of heritability (> 60%) were recorded for all the traits studied. Similar results were reported Srilakshmi *et al.* (2018). A perusal of the results on genetic advance as per cent of mean revealed high values (>20%) for plant height, the number of ear bearing tillers per plant, the total number of grains per panicle, test weight and grain yield per plant. The results are in accordance with the reports of Srilakshmi *et al.* (2018). Further, moderate estimates (10-20%) of genetic advance as per cent of mean were observed for days to 50% flowering, panicle length and spikelet fertility. The results are in agreement with findings of Srilakshmi *et al.* (2018) for days to 50% flowering and panicle length and Karande *et al.* (2015) for spikelet fertility.

High heritability coupled with high genetic advance as per cent of mean was recorded for plant height, the number of ear bearing tillers per plant, the total number of grains per panicle, test weight and grain yield per plant indicating that heritability observed was due to additive gene effects and therefore the selection would be effective for these traits. However, days to 50% flowering, panicle length and spikelet fertility had recorded a high heritability coupled with moderate genetic advance as per cent of mean indicating the role of additive and non- additive gene effects for the characters. Further, the information on genetic variation along with heritability and genetic advance estimates has been reported to give a better idea about the efficiency of selection (Burton, 1953). In the present study, high GCV and PCV coupled with a high heritability and high genetic advance as per cent of mean

was observed for the number of ear bearing tillers per plant indicating the pre-ponderance of an additive gene action and therefore the scope for improvement of the trait through selection.

Character associations for yield and yield component traits were studied in the present investigation and the results are presented in **Table 2**. A perusal of these results revealed a positive and significant association of grain yield with days to 50% flowering, plant height, the number of ear bearing tillers per plant, panicle length, the total number of grains per panicle, spikelet fertility and test weight. Similar results were reported by Tiwari *et al.* (2019). Studies on inter-character associations for the yield component traits revealed significant and positive association of days to 50% flowering with plant height (Tejaswini *et al.* 2018), the number of ear bearing tillers per plant (Tejaswini *et al.* 2018), panicle length (Umarani *et al.* 2019) and the total number of grains per panicle (Sreedhar and Reddy, 2019); plant height with the number of ear bearing tillers per plant (Tejaswini *et al.* 2018) and panicle length (Sreedhar and Reddy, 2019); the number of ear bearing tillers per plant with panicle length, the total number of grains per panicle (Patel *et al.* 2014) and spikelet fertility (Seyoum *et al.* 2012); panicle length with the total number of grains per panicle (Patel *et al.* 2014) and spikelet fertility (Sravan *et al.* 2012); the total number of grains per panicle with spikelet fertility (Seyoum *et al.* 2012) in the present investigation, indicating a scope for simultaneous improvement of these traits through selection. In contrast, significant negative association was observed for the traits namely the total number of grains per panicle with test weight and spikelet fertility with test weight probably due to competition for a common possibility such as nutrient supply. Their association with grain yield per plant was however a significant and positive, indicating a need for balanced selection for these traits while effecting improvement for grain yield.

Table 2. Correlation matrix for yield and yield component traits in rice

Character	Plant Height (cm)	Number of Ear Bearing Tillers per Plant	Panicle Length (cm)	Total Number of Grains per Panicle	Spikelet Fertility	Test Weight (g)	Grain Yield per Plant (g)
Days to 50% Flowering	0.2043**	0.4112**	0.2823**	0.3651**	0.172**	0.0363	0.3885**
Plant Height		0.2911**	0.4607**	0.0593	0.0144	0.1048	0.1950**
Number of ear bearing tillers per plant			0.2266**	0.1635*	0.2363**	0.0763	08327**
Panicle length				0.2892**	0.2314**	0.1032	02850**
Total number of grains per panicle					0.3311**	-0.1502*	0.6288**
Spikelet Fertility						-0.2095**	0.1561*
Test Weight							0.5819**

*Significant at 5 % level

**Significant at 1 % level

Path Coefficient Analysis provides an effective means of finding out the direct and indirect causes of association and presents a critical examination of the specific forces acting to produce a given correlation and also measures the relative importance of each causal factor. Hence, the study of direct and indirect effects of traits on the grain yield per plant was undertaken in the present investigation and the results obtained are presented in **Table 3**. A perusal of these results revealed low residual effect (0.3697) indicating that variables studied in the present experiment explained about 63.03 per cent of variability for grain yield per plant and therefore, other attributes besides the characters studied are also contributing for grain yield per plant.

A detailed analysis of the direct and indirect effects also revealed a high (>0.3) positive direct effect for the number of ear bearing tillers per plant (0.4202), the total number of grains per panicle (0.3279) and test weight (0.3699), in addition to significant and positive association with grain yield per plant. High direct effects of the traits therefore appear to be the main factor for their association with grain yield per plant. Hence, the traits should be considered as an important selection criteria in all rice improvement programmes and direct selection for the traits is recommended for yield improvement. The results are in conformity with the findings of Umarani *et al.* (2019). Further, days to 50% flowering, plant height, panicle length and spikelet fertility per cent had recorded low to moderate positive direct effects on grain yield per plant. These findings are in agreement with Tejaswini *et al.* (2018) for days to 50% flowering and Umarani *et al.* (2019) for the total number of grains per panicle. However, association of these traits was noticed to be positive and significant with grain yield per plant indicating indirect effects to be the cause of correlation and hence, the need for consideration of indirect causal factors during selections for yield improvement through these traits.

High PCV, GCV, heritability, genetic advance as per cent of mean was observed for ear bearing tillers per plant in addition to correlation and direct effects of the trait with grain yield indicating its effectiveness as important selection criterion for yield improvement

Table 3. Direct and indirect effects (genotypic path coefficients) of yield and yield components on grain yield in rice

Character	Days to 50% Flowering	Plant Height (cm)	Number of Ear Bearing Tillers per Plant	Panicle Length (cm)	Total Number of Grains per Panicle	Spikelet Fertility	Test Weight (g)	Grain Yield per Plant
Days to 50% Flowering	**0.0397**	0.0127	0.2083	0.0189	0.0832	0.0143	0.0113	0.3885**
Plant Height (cm)	0.0490	**0.0921**	0.0359	0.0009	0.0135	0.0012	0.0025	0.1950**
Number of ear bearing tillers per plant	0.0086	0.0051	**0.4202**	0.0012	0.2112	0.0027	0.1837	0.8327**
Panicle length (cm)	0.0077	0.0086	0.0346	**0.1670**	0.0459	0.0193	0.0020	0.2850**
Total number of grains per panicle	0.0875	0.0037	0.2033	0.0194	**0.3279**	0.0275	-0.0465	0.6228**
Spikelet Fertility (%)	0.0412	0.0009	0.0048	0.0155	0.0755	**0.0832**	-0.0649	0.1561*
Test Weight	0.0087	0.0065	0.0915	0.0069	0.0810	0.0174	**0.3699**	0.5819**

Diagonal values indicate direct effect, Residual effect = 0.3697, *Significant at 5 % level, ** Significant at 1 % level

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