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Studies on Character Association and Path Analysis in Rice (*Oryza sativa* L.)

K Ramya, D P B Jyothula, T Srinivas, D Ramesh and V Roja
Department of Genetics and Plant Breeding, Agricultural College, Bapatla, A. P.

ABSTRACT

Twenty five rice genotypes obtained from Agricultural Research Station, Bapatla, Andhra Pradesh constituted the experimental material for the present investigation. Character association among yield, yield components and quality traits and path effects of the yield component traits and quality characterson yield were studied. The results revealed positive and significant association of plant height, test weight and zinc content with grain yield per plant at genotypic level in addition to high and positive direct effects indicating the effectiveness of direct selection of these traits for improvement of grain yield per plant, Hence, these traits were identified as effective selection criteria for improvement of grain yield per plant in rice.

Keywords: *Correlation, Path analysis, Rice, Quality and Yield.*

Rice is the second most important cereal crop and an important staple food crop for more than two thirds of world population. It is grown in tropical and sub tropical regions of the world. It is referred to as "Global Grain" (Shalini and Tulasi, 2008). Improvement in grain yield continues to be an important objective of rice breeders across the globe. In this context, studies on correlation that gives a measure of association between characters helps in the identification of important characters to be considered during selection for improvement in grain yield. Breeding strategy in rice, therefore, mainly depends upon the degree of associated characters as well as their magnitude and nature of variation (Zahid *et al.*, 2006). Further, path analysis permits the partitioning of the correlation coefficients into direct effect of a independent variable upon its dependent variable and the indirect effect(s) of a independent variable on the response variable through another dependent variable (Dewey and Lu, 1959). Thus, the present investigation was undertaken to study the character association and path effects of yield components and quality traits on grain yield per plant and to identify effective selection criteria for realizing higher grain yield in rice.

MATERIAL AND METHODS

The experimental material comprised of 25 rice genotypes obtained from Agricultural Research Station, Bapatla, Andhra Pradesh. All the 25 rice genotypes were sown during *kharif* 2020 at Agricultural College farm, Bapatla. The experiment was laid out in a randomized block design with three replications. Each genotype was sown in five rows of 5 m length at a spacing of 20 cm between rows and 15 cm between plants within the row. The crop was raised under irrigated condition and all recommended practices were followed to raise a healthy crop.

Observations were recorded on yield and quality traits, viz., days to 50% flowering, plant height, number of productive tillers per plant, panicle length, grains per panicle, test weight (g), grain yield per plant (g), hulling (%), milling (%), head rice recovery (%), protein (%), iron content and zinc content. All observations were recorded from five randomly selected plants of each genotype in each replication except for days to 50% flowering which was recorded on plot basis. The data collected was subjected to standard statistical procedures. Genotypic and phenotypic correlation coefficients were calculated using the method given by Johnson *et al.* (1955). Path coefficient analysis was carried out by the procedure originally proposed by Wright (1921) and subsequently elaborated by Dewey and Lu (1959) to estimate the direct and indirect effects of the individual characters on yield.

RESULTS AND DISCUSSION

Grain yield in rice is a complex quantitative character and is highly influenced by many yield contributing traits. The selection of a desirable type based on yield is misleading. Hence, knowledge about the relationship between yield and its contributing traits is essential for efficient selection. The nature and magnitude of association among grain yield and its component traits were studied in the present investigation and the results are presented in Table 1.

A perusal of these results revealed phenotypic and genotypic correlations to be of similar direction and significant. However, genotypic correlations recorded were in higher magnitude compared to phenotypic correlation, indicating the true relationship among the traits. Positive and significant association of grain yield per plant was noticed with plant height (0.6930**), number of grains per panicle (0.4310**), test weight (0.2330*) and zinc content (0.3470**) at genotypic level. The findings are in agreement with the reports of Bhor *et al.* (2020) and Krishna *et al.* (2008) for plant height; Loitongbam *et al.*(2020) and Singh *et al.* (2020) for number of grains per panicle; Basavaraja *et al.* (2013) for test weight; Singh *et al.* (2020) for zinc content. However, significant and negative associations were noticed for grain yield per plant with days to 50% flowering (-0.4490**), number of productive tillers per plant (-0.3960**), hulling (-0.3230**) and milling (-0.3300**). These findings are in agreement with the reports of Devi *et al*. (2019) for days to 50 % flowering; Kumar *et al.* (2018) for productive tillers per plant.

A perusal of results on inter-character associations revealed significant and positive association of days to 50% flowering with productive tillers per plant at both phenotypic (0.1474*) and genotypic levels (0.3550**); hulling per cent (0.5280**) and protein content (0.3590**) at genotypic level; plant height with panicle length (0.2771***, 0.7240**), grains per panicle (0.1960**, 0.2800*) and test weight (0.1743**, 0.3190**) at both phenotypic and genotypic levels, respectively. Panicle length with grains per panicle (0.1551*, 0.3450**); hulling per cent with milling per cent (0.2835***, 0.4670**), head rice recovery (0.1441*, 0.3470**) and protein content (0.1640*, 0.5890**); protein with iron (0.2034**, 0.3800**) and zinc content (0.1919**, 0.2860*); and iron with zinc content (0.6890***, 0.7990**) had also recorded significant and positive associations at both phenotic and genotypic levels, respectively. These findings are in agreement with the reports of Sudeepthi *et al.* (2020) for productive tillers per plant with days to 50% flowering and panicle length; and grains per panicle with plant height. Further, Singh *et al.*(2020) had also reported similar associations of hulling per cent with days to 50% flowering; test weight with plant height; and grains per panicle with panicle length. Results of the present study for milling with hulling

Table 1. Phenotypic (r_p) and genotypic (r_g) correlation coefficients for yield, yield components and quality characters in rice

Character	r	PH	PTPP	PL	GPP	TW	HULL	MILL	HRR	PRO	Fe	Zn	GYPP
DFF	r_p	-0.1423 *	0.1448 *	-0.0641	-0.2000	-0.2518	0.0815	0.038	0.1057	0.1125	0.1303	0.0655	-0.072
	r_g	-	0.3550**	-0.1356	-0.2580*	-0.5910**	0.5280**	0.0573	0.1875	0.3590**	0.196	0.1368	-0.4490**
PH	r_p		-0.1474 *	0.2771	0.1960 **	0.1743 **	-0.0724	-0.0148	-0.0595	-0.1484 *	-0.1781	-0.1658 *	0.1257
	r_g		-0.257*	0.7240**	0.2800*	0.3190**	-	-0.1563	-0.1331	-	-0.2420*	-0.2360*	0.6930**
PTPP	r_p			-0.0147	0.0804	-0.1908 **	-0.0158	0.0308	-0.1561 *	0.1156	0.1876 **	0.2880 ***	-0.1239
	r_g			0.004	0.0359	-0.3330**	0.0843	0.2360*	-0.196	0.1897	0.3450**	0.3830**	-0.3960**
PL	r_p				0.1551 *	-0.0463	-0.045	-0.0629	-0.0632	-0.1926	-0.1749	-0.2750	0.1022
	r_g				0.3450**	-0.0942	-0.0408	-0.2206	-0.0872	-	-0.2580*	-0.5000**	0.1386
GPP	r_p					0.0749	-0.0006	0.01	-0.0648	0.0182	0.2541 **	-0.1303	0.0507
	r_g					0.1821	-0.0192	0.1334	-0.0515	-0.0126	-0.3260**	-0.1713	0.4310**
TW	r_p						-0.1490 *	-0.1553 *	-0.0234	-0.1242	-0.1746	-0.1490 *	0.013
	r_g						-	-0.1546	-0.0132	-0.2820*	-0.2860*	-0.1844	0.2330*
HULL	r_p							0.2835	0.1441 *	0.1640 *	-0.0415	-0.1069	-0.1456
	r_g							0.4670**	0.3470**	0.5890**	-0.0952	-0.2570*	-0.3230**
MILL	r_p								0.0604	-0.0541	-0.0098	-0.0147	-0.1969
	r_g								0.2500*	0.0397	0.0651	-0.0307	-0.3300**
HRR	r_p									0.0505	0.0485	-0.0744	-0.0427
	r_g									0.1463	0.0404	-0.103	-0.1228
PRO	r_p										0.2034 **	0.1919 **	0.11
	r_g										0.3800**	0.2860*	0.1136
Fe	r_p											0.6890 ***	0.1759
	r_g											0.7990**	0.2004
Zn	r_p												0.1629
	r_g												0.3470**

*, ** Significant at 5 % and 1 % levels, respectively

DFF= Days to 50 per cent flowering, **PH**= Plant height, **PTPP**= Productive tillers per plant, **PL**= Panicle length, **GPP**= Grains per panicle, **TW**= Test weight,**HULL**= Hulling percentage, **MILL**= Milling percentage, **HRR**= Head rice recovery, **PRO**=Protein content, **Zn**= Zinc content, **Fe**= Iron content, **GYPP**= Grain yield per plant.

Table 2. Phenotypic and genotypic path analysis of yield components and quality traits on grain yield in rice

Character	p	DFF	PH	PTPP	PL	GPP	TW	HULL	MILL	HRR	PRO	Fe	Zn	GYPP
DFF	P_p	-0.039	-0.0147	-0.0285	-0.0083	-0.0147	0.0067	-0.0073	-0.0056	-0.0034	0.0139	0.0191	0.0093	-0.072
	P_g	0.005	-0.08	-0.285	-0.1098	-0.0229	-0.091	-0.2068	0.0189	-0.0151	0.2725	-0.1105	0.1756	-0.4490**
PH	P_p	0.0055	0.1032	0.029	0.0357	0.0144	-0.0046	0.0064	0.0022	0.0019	-0.0184	-0.0261	-0.0234	0.126
	P_g	-0.0021	0.1948	0.2062	0.5862	0.0249	0.0491	0.1387	-0.0514	0.0107	-0.2973	0.1364	-0.3031	0.6930**
PTPP	P_p	-0.0056	-0.0152	-0.1965	-0.0019	0.0059	0.0051	0.0014	-0.0045	0.005	0.0143	0.0275	0.0407	-0.124
	P_g	0.0018	-0.05	-0.8039	0.0032	0.0032	-0.0512	-0.033	0.0775	0.0158	0.144	-0.1944	0.4911	-0.3960**
PL	P_p	0.0025	0.0286	0.0029	0.1287	0.0114	0.0012	0.004	0.0093	0.002	-0.0239	-0.0256	-0.039	0.102
	P_g	-0.0007	0.141	-0.0032	0.8095	0.0307	-0.0145	0.016	-0.0726	0.007	-0.2785	0.1455	-0.6415	0.139
GPP	P_p	0.0077	0.0202	-0.0158	0.02	0.0733	-0.002	0.0001	-0.0015	0.0021	0.0023	-0.0372	-0.0184	0.051
	P_g	-0.0013	0.0546	-0.0289	0.2795	0.0888	0.028	0.0075	0.0439	0.0041	-0.0096	0.184	-0.2198	0.4310**
TW	P_p	0.0098	0.018	0.0375	-0.006	0.0055	-0.0266	0.0133	0.0229	0.0007	-0.0154	-0.0256	-0.0211	0.013
	P_g	-0.003	0.0621	0.2673	-0.0763	0.0162	0.154	0.1518	-0.0229	0.0011	-0.214	0.1612	-0.2366	0.2330*
HULL	P_p	-0.0032	-0.0075	0.0031	-0.0058	0	0.004	-0.089	-0.0417	-0.0046	0.0203	-0.0061	-0.0151	-0.146
	P_g	0.0027	-0.0689	-0.0678	-0.0331	-0.0017	-0.0597	-0.3919	0.1536	-0.028	0.4472	0.0537	-0.3295	-0.3230**
MILL	P_p	-0.0015	-0.0015	-0.0061	-0.0081	0.0007	0.0041	-0.0252	-0.1472	-0.0019	-0.0067	-0.0014	-0.0021	-0.197
	P_g	0.0003	-0.0304	-0.1893	-0.1786	0.0118	-0.0238	-0.1829	0.329	-0.0201	0.0301	-0.0367	-0.0394	-0.3300**
HRR	P_p	-0.0041	-0.0061	0.0307	-0.0081	-0.0048	0.0006	-0.0128	-0.0089	-0.032	0.0063	0.0071	-0.0105	-0.043
	P_g	0.001	-0.0259	0.1576	-0.0706	-0.0046	-0.002	-0.136	0.0822	-0.0806	0.1111	-0.0228	-0.1321	-0.123
PRO	P_p	-0.0044	-0.0153	-0.0227	-0.0248	0.0013	0.0033	-0.0146	0.008	-0.0016	0.1239	0.0298	0.0271	0.11
	P_g	0.0018	-0.0763	-0.1525	-0.297	-0.0011	-0.0434	-0.2309	0.0131	-0.0118	0.7591	-0.2143	0.3668	0.114
Fe	P_p	-0.005	-0.0184	-0.0369	-0.0225	-0.0186	0.0046	0.0037	0.0014	-0.0016	0.0252	0.1465	0.0974	0.176
	P_g	0.001	-0.0471	-0.2772	-0.2088	-0.029	-0.044	0.0373	0.0214	-0.0033	0.2885	-0.564	1.0254	0.2
Zn	P_p	-0.0025	-0.0171	-0.0566	-0.0354	-0.095	0.004	0.0095	0.0022	0.0024	0.0238	0.1009	0.1413	0.163
	P_g	0.0007	-0.046	-0.3077	-0.4048	-0.0152	-0.0284	0.1006	-0.0101	0.0083	0.217	-0.4507	1.2831	0.3470**

* ,** Significant at 5 % and 1 % levels, respectively; Diagonal bold values indicate direct effects, Residual effect (Genotypic) – 0.2130; Residual effect (Phenotypic) – 0.3150

DFF=Days to 50 per cent flowering,**PH**= Plant height, **PTPP**= Productive tillers per plant, **PL**= Panicle length, **GPP**= Grains per panicle, **TW**= Test weight,**HULL**= Hulling percentage, **MILL**= Milling percentage, **HRR**= Head rice recovery, **PRO**=Protein content, **Fe**=Iron content, **Zn**=Zinc content, **GYPP**= Grain yield per plant.

per cent are in agreement with the reports of Devi *et al*. (2019) and with those of Joshi (2017) for head rice recovery with milling. The results observed in the present study for iron and zinc content with protein are in conformity with the reports of Sridevi (2018); and Kumar *et al.* (2019) for iron with zinc content.

In contrast, significant and negative associations were recorded in the present study for days to 50% flowering with plant height (-0.1423*, -0.4110**), number of grains per panicle (-0.2000**, -0.2580*) and test weight (-0.2518***, -0.5910**); plant height with productive tillers per plant (-0.1474*, -0.2570*), protein content (-0.1484*,-0.3920**), iron content (-0.1781**,-0.2420*) and zinc content (-0.1658*, -0.2360*); number of productive tillers with test weight (-0.1908**, -0.3330**); panicle length with protein content (-0.1926**, -0.370**), iron content (-0.1749**, -0.2580*) and zinc content (-0.2750***,-0.5000**); test weight with hulling per cent (-0.1490*,-0.3870**) and iron content (-0.1746**,-0.2860*) at both phenotypic and genotypic levels, respectively. These results are in agreement with the reports of Kumar *et al.* (2018) for plant height with days to 50% flowering; Saikumar *et al.* (2014) for grains per panicle and test weight with days to 50% flowering; Devi *et al*. (2019) for productive tillers with plant height; Shivani *et al.* (2018) for iron and zinc content with plant height; Singh *et al.* (2020) for test weight with number of productive tillers; Singh *et al.* (2020) for hulling per cent with test weight. The occurrence of negative associations between the traits could be due to competition for a common possibility such as nutrient supply, indicating the need for balanced selection while effecting simultaneous improvement of these traits. (Kishore *et al.*, 2015)

Path coefficient analysis helps in partitioning of correlation coefficients into direct and indirect effects of various characters on the grain yield. It 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 (Wright, 1921). The results on path co-efficient analysis of yield components and quality traits on grain yield are presented in Table 2. The results revealed residual effect of 0.315 for phenotypic and 0.213 for genotypic path co-efficients, respectively, indicating that the variables studied in the present investigation explained only about 68.5 (phenotypic) and 78.7 (genotypic) per cent of the variability in grain yield and therefore, other attributes, besides the characters studied in the present investigation are contributing for grain yield per plant.

A perusal of the results on genotypic path coefficients revealed positive direct effects of plant height, panicle length, test weight, protein and zinc content on grain yield per plant. The results are in conformity with the findings of Singh *et al.* (2020). Among these, plant height, test weight and zinc content had also recorded significant and positive association with grain yield per plant. The high direct effects observed for these traits, therefore, appeared to be the main factor for their strong association with grain yield, indicating their importance as selection criteria for grain yield improvement. In contrast, negligible and negative direct effects coupled with positive correlation coefficient were noticed for number of grains per panicle and iron content, indicating the role of indirect effects for the correlation and hence, the need for consideration of indirect causal factors simultaneously for selection. The results are in conformity with the reports of Sameera *et al.* (2016). However, milling per cent had recorded negative and significant correlation with grain yield per plant coupled with high and positive direct effect, indicating the need for adoption of restricted simultaneous selection model to nullify the undesirable indirect effects in order to make use of the direct effect.

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