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Correlation and Path Analysis Studies in Rice (*Oryza sativa* L.) Hybrids

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ABSTRACT

The experiment was conducted to carryout correlation and path coefficient analysis in rice (*Oryza sativa* L.) hybrids for fifteen characters *viz.,* days to 50% flowering, days to maturity, plant height (cm), number of productive tillers per plant, panicle length (cm), number of total grains per panicle, grain yield per plant (g), hulling percentage, milling percentage, head rice recovery percentage, L/B ratio, water uptake, kernel elongation ratio, volume expansion ratio and amylose content. The results revealed that grain yield per plant was positively and significantly associated with plant height and number of total grains per panicle indicating importance of these traits as selection criteria in yield improvement programmes. Scrutiny in path analysis indicated that maximum direct effect on grain yield was exhibited by number of total grains per panicle. Hence, the trait should be taken in account of breeding programme to develop the maximum of threshold yield obtaining new rice hybrids.

Keywords: *Correlation, Grain yield, path coefficient analysis and rice Hybrids.*

Rice is one of the most important cereal crops in the tropics as well as parts of temperate regions in the world. Among the rice growing countries in the world, India has the largest area under rice cultivation and ranks second in production next to China. In India, rice is grown in 44.0 mha with the production of 108.50 mt and productivity of 2.4 t/ha during 2016-17 (Directorate of Economics & Statistics, 2016-17).

AP contributes to 12% of total rice production in the country. For the estimated population of 1.63 billion people by the year 2050 with a per capita rice consumption of 225 to 275 g/ day, country would require 133 to 162 Mt of rice (Directorate of Rice Research, 2013). To achieve this target, it is necessary to enhance the production and productivity of the existing rice cultivars through pyramiding of high yield alleles into a agronomically desirable genotypes. Therefore, keeping in mind the future demand of rice as a food for human, there is a continuous need to evolve new hybrids, which should exceed the existing hybrids in yield. For this to happen, yield improvement through genetic approaches would become essential.

Correlation coefficient analysis measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for genetic improvement in yield. Grain yield is a complex character and is the end product of various traits. Therefore, knowledge regarding the correlation of grain yield with other component characters is valuable for understanding the correlated response to selection for yield. Path coefficient analysis is helpful to recognize direct and indirect causes of correlation and also enables us to compare the causal factors on the genetic basis of their relative contributions. Hence, the present study of correlation and path analysis would serve path for future breeding programmes.

MATERIALS AND METHODS

The present investigation was carried out during *kharif,* 2017 at Agricultural College Farm, Bapatla. The experimental material consisted of twenty entries (15 Hybrids + 5 Checks) of Rice (*Oryza sativa* L.) obtained from Indian Institute of Rice Research (IIRR), Rajendranagar, Hyderabad, Telangana, which were sown in nursery beds and transplanted into the main field in Randomized Block

Design in three replications with a spacing of 15 x 15 cm.

Observations were recorded on five plants selected at random per genotype per replication for characters *viz*., plant height (cm), number of productive tillers per plant, panicle length (cm), number of total grains per panicle, grain yield per plant (g) and their means were used for statistical analysis. However, observations on days to 50% flowering, days to maturity were recorded on plot basis and all grain quality parameters *viz.,* hulling percentage, milling percentage, head rice recovery percentage, L/B ratio, water uptake, kernel elongation ratio, volume expansion ratio and amylose content were done as per DRR laboratory manual on rice grain quality procedures. The data collected for all the characters studied were subjected to analysis of variance technique on the basis of model proposed by Panse and Sukhatme (1967). The phenotypic and genotypic correlation coefficients were calculated using the method given by Johnson *et al*. (1955). Path analysis was carried out following the method suggested by Dewey and Lu (1959).

RESULTS AND DISCUSSIONS

The analysis of variance (Table 1) revealed the existence of significant differences among the genotypes for all the traits, indicating the existence of sufficient variation in the material studied. Hence, the data was further subjected to correlation analysis to estimate the association existing between yield and yield contributing traits. Estimates of correlation between yield and yield component characters in rice genotypes are presented in Table 2 & 3.

The perusal of phenotypic and genotypic correlation (Table 2 & 3) analysis revealed that, positive significant correlation of plant height (0.2969* & 0.3311**) and number of total grains per panicle (0.6814** & 0.7630**) at both phenotypic and genotypic level with grain yield per plant. Improvement of grain yield might be possible if the above traits were considered in the selection programme. The results are in agreement with Dhurai *et al.* (2014), Khare *et al.* (2014), Lakshmi *et al.* (2014), Ramanjaneyulu *et al.* (2014), Bhati *et al.* (2015), Ekka *et al.* (2015), Devi *et al.* (2017), Gunasekaran *et al.* (2017), Jan *et al.* (2017) and Priya *et al.* (2017). It was also observed that the association of days to 50% flowering, days to maturity, number of productive tillers per plant, hulling percentage, milling percentage, water uptake, kernel elongation ratio and amylose content showed non-significant positive association at phenotypic and genotypic levels with grain yield per plant.

L/B ratio showed non-significant and significant negative association with grain yield per plant (-0.2771 & -0.3225*) at phenotypic and genotypic levels, respectively, which is similar to results reported by Gunasekaran *et al*. (2017). Panicle length and head rice recovery showed non-significant negative correlation with grain yield per plant. Volume expansion ratio showed non-significant positive and negative association with grain yield per plant at phenotypic and genotypic levels, respectively. However, the simultaneous improvement of these negatively associated traits might be possible through random matings or paired matings in F_2 and subsequent segregating generations.

Grain yield, which is the major economic character in rice depends on several component traits, which are mutually related. Mere change in any one of the component would ultimately disturb the complex. Hence, these related traits have to be analyzed for its action namely direct effect of component character on grain yield and the indirect effects through other component traits on grain yield. The direct and indirect contribution of various characters on yield in rice genotypes are measured and are presented in Table 3 & 4. The path coefficient analysis furnishing the cause and effect of different yield components would provide better index for selection rather than mere correlation coefficients. The results of path coefficient analysis revealed that simple selection based on character with direct positive effect towards grain yield per plant and positive correlation with grain yield per plant *viz.,* number of total grains per panicle, number of productive tillers per plant and days to maturity *i.e.,* profuse tillering plants having more number of grains per panicle and more days to maturity might be resulted in higher yield in rice genotypes studied. Days to 50% flowering, plant height, volume expansion ratio and amylose content are the characters with negative direct effect and positive association with grain yield per plant at genotypic level. The negative direct effects and positive associations explained the indirect effects seem to be the cause of positive correlation and the indirect causal factors are to be considered simultaneously for

selection. Grain quality parameters like milling percentage, head rice recovery percentage, water uptake and kernel elongation ratio of grain might be improved independent of the yield.

High positive direct effect (0.6988 & 0.7689) coupled with positive significant correlation (0.6813** & 0.7629**) with grain yield per plant was observed for number of total grains per panicle at phenotypic and genotypic levels, respectively, which might be resulted in higher yield. These results showed similarity with experimental results of Raju *et al.* (2013).

The residual effect determines how best the causal factors account for the variability of the dependent factor. In present investigation residual effect is high, indicating that some other factors which have not been considered here need to be included in this analysis to account fully for the variation in yield.

Table 1. Analysis of variance for yield and yield components among 20 genotypes of rice (*Oryza sativa* L.)

S. No	Source	Replications	Treatments	Error
	Degree of freedom	2	19	38
	MEAN SUM OF SQUARES			
1	Days to 50% flowering	2.5167	90.5649**	1.3939
2	Days to maturity	0.45	82.2280**	1.6781
3	Plant height (cm)	2.6047	411.9068**	7.8124
4	Number of productive tillers per plant	1.2167	18.8236**	2.3395
5	Panicle length (cm)	0.1499	7.0572**	0.6626
6	Number of total grains/ Panicle	206.8167	9886.7675**	292.641
7	Grain Yield/ Plant (g)	0.4167	317.0131**	10.1711
8	Hulling %	4.5167	28.3122**	3.9728
9	Milling %	10.5167	27.0973**	5.2711
10	Head Rice Recovery %	9.2167	110.2315**	8.2868
11	Volume Expansion Ratio	0.0072	0.0419**	0.0123
12	Water Uptake	117.91	13463.4648**	157.829
13	L/B Ratio	0.0048	0.1850**	0.012
14	Kernel Elongation Ratio	0.0026	0.0227**	0.0022
15	Amylose Content (%)	3.4042	4.0552**	1.2982

*significant at 5% level, **significant at 1% level

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Table 2. Estimates of phenotypic correlation coefficients among yield and yield components in rice (*Oryza sativa* L.).

Character	Days to 50% flowering	Days to maturity	Plant height(cm)	Number of productive tillers / plant	Panicle length(cm)	No. of total grains / panicle	Hulling %	Milling %	Head rice recovery (%)	Volume expansion ratio	Water uptake	L/B ratio	Kernel elongation ratio	Amylose content(%)	Grain yield/plant (g)
Days to 50% flowering	**1**	0.9645**	-0.0438	-0.2088	-0.0421	0.0143	0.2588*	0.3171*	0.3803**	-0.0466	-0.148	-0.0225	-0.0439	0.1367	**0.2407**
Days to maturity		**1**	-0.0321	-0.1803	0.0516	0.0076	0.1683	0.2653*	0.3674**	-0.1079	-0.1682	0.0679	-0.0588	0.0845	**0.2344**
Plant height			**1**	0.1496	0.1264	0.4212**	0.1724	0.2033	-0.0469	0.0282	-0.0102	0.0126	-0.027	-0.2137	**0.2969***
Number of productive tillers / plant				**1**	-0.0057	0.4154**	0.095	0.2437	0.0235	0.2356	-0.1316	-0.1718	-0.1147	-0.2204	**0.2104**
Panicle length					**1**	-0.0952	-0.2887*	-0.1949	-0.1415	0.0409	-0.3213*	0.4818**	-0.1371	-0.1799	**-0.2194**
No. of total grains / panicle						**1**	0.2994*	0.3297*	0.0997	0.213	0.2640*	-0.2622*	-0.076	-0.2349	**0.6814****
Hulling %							**1**	0.8044**	0.5748**	0.1793	-0.147	-0.3031	0.0438*	0.0513	**0.0989**
Milling %								**1**	0.6114**	0.0814	-0.1729	-0.3891**	-0.0412	0.0859	**0.2019**
Head rice recovery %									**1**	-0.0678	-0.0504	-0.1431	0.068	0.1175	**-0.0567**
Volume expansion ratio										**1**	-0.0236	-0.2847*	0.084	-0.1875	**0.0017**
Water uptake											**1**	0.0572	-0.0903	-0.1558	**0.1665**
L/B ratio												**1**	0.0027	-0.0608	**-0.2771**
Kernel elongation ratio													**1**	0.0962	**0.1447**
Amylose content														**1**	**0.0126**
Grain yield per plant															**1**

*significant at 5% level, ** significant at 1% level

Table 3. Estimates of genotypic correlation coefficients among yield and yield components in rice (*Oryza sativa* L.).

Character	Days to 50% flowering	Days to maturity	Plant height(cm)	Number of productive tillers/ plant	Panicle length	No. of total grains/ panicle	Hulling %	Milling %	Head rice recovery%	Volume expansion ratio	Water uptake	L/B ratio	Kernal elongation ratio	Amylose content(%)	Grain yield/ plant (g)
Days to 50% flowering	1	0.9920**	-0.0328	-0.2734*	-0.0066	0.0211	0.2900*	0.4378**	0.4322**	-0.1384	-0.149	-0.0059	-0.0226	0.1911	**0.248**
Days to maturity		1	-0.0192	-0.1963	0.0562	0.0245	0.2335	0.3993**	0.3837**	-0.1957	-0.1784	0.0543	-0.0689	0.1721	**0.2532**
Plant height			1	0.1965	0.1409	0.4487**	0.2422	0.2797*	-0.087	0.0977	-0.0074	-0.0022	-0.0008	-0.3831**	**0.3311****
Productive tillers/ plant				1	-0.0006	0.5285	0.1293	0.3609**	0.0808	0.4181**	-0.1631	-0.2151	-0.0617	-0.4886**	**0.2402**
Panicle length					1	-0.1146	-0.2647*	-0.2054	-0.1978	-0.0191	-0.4077**	0.5938**	-0.1539	-0.242	**-0.2054**
No.of total grains/ panicle						1	0.3260*	0.4181**	0.1244	0.2988*	0.3001*	-0.2761*	-0.075	-0.2774*	**0.7630****
Hulling %							1	0.9141**	0.7660**	0.2661*	-0.174	-0.3906**	0.0859	0.0411	**0.1025**
Milling %								1	0.8345**	0.1888	-0.2484	-0.5299**	-0.0009	0.0095	**0.222**
Head rice recovery%									1	-0.1053	-0.0732	-0.2171	0.1391	0.1267	**-0.0448**
Volume expansion ratio										1	-0.0311	-0.3440**	0.0383	-0.4437**	**-0.0126**
Water uptake											1	0.049	-0.0994	-0.2831*	**0.184**
L/B ratio												1	0.0266	-0.0074	**-0.3225***
Kernal elongation ratio													1	0.2702*	**0.1742**
Amylose content														1	**0.0221**
Grain yield/ plant															1

*significant at 5% level, ** significant at 1% level

Table. 4. Direct and indirect effects (phenotypic) of yield components on yield among 20 genotypes of rice (*Oryza sativa* L.)

Character	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of productive tillers/ plant	Panicle length (cm)	Number of total grains/ panicle	Hulling %	Milling %	Head rice recovery (%)	Volume expansion ratio	Water uptake	L/B ratio	Kernel elongation ratio	Amylose content (%)
Days to 50% flowering	**0.0793**	0.0765	-0.0035	-0.0166	-0.0033	0.0011	0.0205	0.0252	0.0302	-0.0037	-0.0117	-0.0018	-0.0035	0.0108
Days to maturity	0.2766	**0.2868**	-0.0092	-0.0517	0.0148	0.0022	0.0483	0.0761	0.1054	-0.0309	-0.0482	0.0195	-0.0169	0.0242
Plant height (cm)	-0.0021	-0.0015	**0.048**	0.0072	0.0061	0.0202	0.0083	0.0098	-0.0023	0.0014	-0.0005	0.0006	-0.0013	-0.0103
Number of productive tillers/ plant	-0.0113	-0.0098	0.0081	**0.0542**	-0.0003	0.0225	0.0052	0.0132	0.0013	0.0128	-0.0071	-0.0093	-0.0062	-0.012
Panicle length (cm)	0.0033	-0.004	-0.0099	0.0004	**-0.0781**	0.0074	0.0226	0.0152	0.0111	-0.0032	0.0251	-0.0376	0.0107	0.0141
Number of total grains/ panicle	0.01	0.0053	0.2944	0.2903	-0.0665	**0.6988**	0.2093	0.2304	0.0697	0.1488	0.1845	-0.1832	-0.0531	-0.1641
Hulling %	-0.0367	-0.0238	-0.0244	-0.0135	0.0409	-0.0424	**-0.1416**	-0.114	-0.0814	-0.0254	0.0208	0.0429	-0.0062	-0.0073
Milling %	0.0315	0.0263	0.0202	0.0242	-0.0193	0.0327	0.0798	**0.0992**	0.0607	0.0081	-0.0172	-0.0386	-0.0041	0.0085
Head rice recovery (%)	-0.1198	-0.1158	0.0148	-0.0074	0.0446	-0.0314	-0.1811	-0.1926	**-0.315**	0.0214	0.0159	0.0451	-0.0214	-0.037
Volume expansion ratio	0.0079	0.0182	-0.0047	-0.0397	-0.0069	-0.0359	-0.0302	-0.0137	0.0114	**-0.1686**	0.004	0.048	-0.0142	0.0316
Water uptake	-0.0078	-0.0089	-0.0005	-0.007	-0.017	0.014	-0.0078	-0.0091	-0.0027	-0.0012	**0.0529**	0.003	-0.0048	-0.0082
L/B ratio	0.0036	-0.0108	-0.002	0.0272	-0.0764	0.0416	0.048	0.0617	0.0227	0.0451	-0.0091	**-0.1585**	-0.0004	0.0096
Kernel elongation ratio	-0.0111	-0.0149	-0.0068	-0.0291	-0.0348	-0.0193	0.0111	-0.0104	0.0172	0.0213	-0.0229	0.0007	**0.2537**	0.0244
Amylose content (%)	0.0175	0.0108	-0.0274	-0.0282	-0.0231	-0.0301	0.0066	0.011	0.0151	-0.024	-0.02	-0.0078	0.0123	**0.1281**
Grain yield/ plant	**0.2407**	**0.2344**	**0.2968***	**0.2104**	**-0.2194**	**0.6813****	**0.0989**	**0.2019**	**-0.0567**	**0.0017**	**0.1665**	**-0.2771***	**0.1447**	**0.0126**

*significant at 5% level, ** significant at 1% level Residual effect = 0.5292 Diagonal bold letters indicate direct effect

Table. 5. Direct and indirect effects (genotypic) of yield components on yield among 20 genotypes of rice (*Oryza sativa* L.).

Character	Days to 50% flowering	Days to maturity	Plant height (cm)	Numbpr of Productive tillers/ plant	Panicle length (cm)	Number of total grains/ panicle	Hulling %	Milling %	Head rice recovery (%)	Volume expansion ratio	Water uptake	L/B ratio	Kernel elongation ratio	Amylose content (%)
Days to 50% flowering	**-0.5412**	-0.5421	0.0178	0.148	0.0036	-0.0114	-0.157	-0.2369	-0.2339	0.0749	0.0806	0.0032	0.0122	-0.1034
Days to maturity	0.9313	**0.9298**	-0.0178	-0.1825	0.0523	0.0227	0.2171	0.3713	0.3569	-0.1819	-0.1659	0.0505	-0.064	0.16
Plant height (cm)	0.0098	0.0057	**-0.2987**	-0.0587	-0.0421	-0.134	-0.0724	-0.0836	0.026	-0.0292	0.0022	0.0007	0.0002	0.1144
Number of productive tillers/ plant	-0.0039	-0.0028	0.0028	**0.0142**	0.0001	0.0075	0.0018	0.0051	0.0011	0.0059	-0.0023	-0.003	-0.0009	-0.0069
Panicle length (cm)	-0.0014	0.0122	0.0306	-0.0001	**0.2173**	-0.0249	-0.0575	-0.0446	-0.043	-0.0042	-0.0886	0.129	-0.0334	-0.0526
Number of total grains/ panicle	0.0162	0.0188	0.3451	0.4064	-0.0881	**0.7689**	0.2507	0.3215	0.0956	0.2298	0.2308	-0.2123	-0.0576	-0.2134
Hulling %	0.1125	0.0906	0.094	0.0502	-0.1027	0.1265	**0.388**	0.3547	0.2972	0.1033	-0.0675	-0.1516	0.0333	0.0159
Milling %	0.14	0.1277	0.0895	0.1154	-0.0657	0.1337	0.2924	**0.3198**	0.2669	0.0604	-0.0795	-0.1695	-0.0003	0.003
Head rice recovery %	-0.4334	-0.3848	0.0872	-0.081	0.1983	-0.1247	-0.768	-0.8368	**-1.0026**	0.1056	0.0734	0.2177	-0.1395	-0.127
Volume expansion ratio	0.0795	0.1125	-0.0562	-0.2403	0.011	-0.1718	-0.153	-0.1085	0.0605	**-0.5747**	0.0178	0.1978	-0.022	0.255
Water uptake	-0.0336	-0.0402	-0.0017	-0.0368	-0.0919	0.0676	-0.0392	-0.056	-0.0165	-0.007	**0.2253**	0.011	-0.0224	-0.0638
L/B ratio	0.0024	-0.0223	0.0009	0.0882	-0.2435	0.1132	0.1602	0.2173	0.089	0.1411	-0.0201	**-0.41**	-0.0109	0.003
Kernel elongation ratio	-0.0114	-0.0349	-0.0004	-0.0312	-0.0779	-0.038	0.0435	-0.0005	0.0705	0.0194	-0.0503	0.0135	**0.5064**	0.1369
Amylose content (%)	-0.019	-0.0171	0.038	0.0485	0.024	0.0275	-0.0041	-0.0009	-0.0126	0.0441	0.0281	0.0007	-0.0268	**-0.0993**
Grain yield/ plant	**0.248**	**0.2532**	**0.3311****	**0.2402**	**-0.2054**	**0.7629****	**0.1025**	**0.222**	**-0.0448**	**-0.0126**	**0.184**	**-0.3224***	**0.1742**	**0.0221**

*significant at 5% level, ** significant at 1% level Residual Effect = 0.1719 Diagonal bold letters indicate direct effects

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