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Path coefficient analysis and correlation among grain yield and kernel characters in rice (O*ryza sativa L.*)

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Abstract
An investigation was carried out using 16 rice genotypes including 11 maintainer lines and 5 varieties for grain yield and kernel characters to understand the association among yield components and their direct and indirect influence on the grain yield. Analysis of variance revealed considerable variability among the genotypes for 13 the characters among 15 characters. The correlation analysis indicated that grain yield was significantly associated with plant height, number of productive tillers per plant, panicle length, leaf area index and number of grains per panicle. Results of path-coefficient analysis revealed that kernel length had the highest positive direct effect on grain yield followed by number of grains per panicle, number of productive tillers per plant and test weight. Hence, selection based on these traits could help to bring simultaneous improvement of yield, yield attributes and kernel characters.

Keywords: rice, path coefficient, kernel, yield

1. Introduction
Rice belongs to the genus Oryza, of the family Gramineae, and is a widely cultivated crop. It is the most important food crop for 2.89 billion people in Asia. With increasing population, high yield has become one of targets in rice breeding programmes. As per estimates of UN, the world population will grow from 6.3 billion in 2003 to 8.5 billion in 2030. Out of this five billion people will be rice consumers and there is a need of 38 per cent more rice by 2030. Hence, we must produce 40 per cent more rice by 2025 to satisfy the growing demand without adversely affecting the resource base (Khush, 2006) [5]. The grain yield and grain quality trait of rice is a complex character which is directly (or) indirectly related with each other. Knowledge on the association between grain yield with yield contributing and grain quality traits is important for selection of desirable genotypes in a breeding programme. Correlation coefficient measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for genetic improvement in yield and quality. Path coefficient analysis permits the partitioning of the correlation coefficient into its components. Correlation in combination with path analysis would give a better insight into cause and effect relationship between different pairs of characters.

2. Material and Methods
During kharif, 2017 eleven maintainer lines and 5 varieties as checks (RNR15048, JGL18047, JGL11470, JGL1798, and MTU1010) were raised at Rice Research Center, Agricultural Research Institute, Rajendranagar, Hyderabad. List of maintainer lines and checks in the experiment is given in Table 1. All the lines were grown in three replications in randomized block design and a spacing of 20x15 cm was adopted. All recommended package of practices were followed and the observations were recorded on randomly selected ten plants excluding border plants in each entry in each replication on maintainer lines such as plant height (cm), days to 50% flowering, leaf area index, panicle length (cm), number of productive tillers, number of grains per panicle, spikelet fertility (%), test weight (g), kernel length (mm), kernel width (mm), kernel L/B ratio, hulling percentage, milling percentage, head rice recovery (%) and yield ($q.ac^{-1}$). Days to 50% flowering was recorded on plot basis. For panicle traits like panicle length (cm) and number of filled grains panicle, observations were recorded from ten randomly selected panicles. Required quantities (100 g) of harvested seeds were used to record the hulling percentage, milling percentage and head rice recovery. Observations on grain characteristics *viz.*, kernel length, kernel breadth, kernel L/B ratio were recorded from 10 randomly selected kernels. Correlation coefficient was computed as per the procedure outlined by Karl Pearson (1932) [4] and path coefficient analysis was carried out as suggested by Dewey and Lu (1959) [1].

3. Results and Discussion
The estimates of simple correlation coefficient computed between 15 characters under study are presented in Table-3. Analysis of variance was significant for 13 traits among the entries, indicting the presence of considerable genetic variation in the experimental material (Table 2).
In the present study, the grain yield per plant showed positive and significant association with plant height, number of productive tillers per plant, panicle length, leaf area index and number of filled grains per panicle at phenotypic level (Table 3). These results were in agreement with the earlier findings of Immanuel

Selvaraj *et al.* (2011) [2] for all the traits and Jing *et al.* (2007) [3] for Leaf area index.

A significant negative association was observed between spiklet sterility and grain yield and this was in accordance with the findings of Premkumar *et al.* (2015) [8]. The highest degrees of associations were observed among plant height, panicle length, leaf area index, spiklet sterility % and head rice recovery.

Knowledge on interrelationship between yield attributing characters and grain quality traits revealed the intensity and direction of association with each other. This could facilitate effective selection for simultaneous improvement of one (or) more yield contributing traits and grain quality characters. Plant height exhibited significant and positive inter correlation with panicle length. Immanuel Selvaraj *et al.* (2011) [2] and Nagendra Rao *et al*. (2010) [6] were also reported the same result for plant height with panicle length. Test weight exhibited positive and significant association with kernel length and kernel breadth. The results were supported by the earlier findings of Nandan *et al.* (2010) [7]. Kernel length expressed a positive and significant inter correlation with kernel L/B ratio. This was in agreement with results of Sarika *et al.* (2011) [9].

Path analysis partitions the phenotypic correlation coefficient into direct and indirect effects, indicates the relative significance for each component character to the dependent trait (fig. 1). It forms the best method to evaluate the cause and effect relationship in order to get the developmental relationship between them.

Path coefficient analysis using grain yield as dependent variable and other yield contributing and grain quality traits were considered as independent variable. Two yield contributing characters *viz.*, Number of productive tillers per plant and test weight exhibited high and positive direct effects on grain yield (Table 4). Similar results were also reported by Satish Chandra *et al*. (2009) [10] for number of productive tillers per plant**.**

The grain quality trait *viz.*, kernel length showed high and positive direct effects on grain yield. Panicle length, leaf area index and number of grains per panicle exerted a high positive indirect effect through kernel width. Number of productive tillers showed high indirect positive effects through kernel length. Plant height, panicle length, leaf area index and number of grains per panicle exerted a high showed negative and moderate indirect effect on kernel L/B ratio. From the present study, it can be concluded that the characters *viz.*, Plant height, panicle length, leaf area index, number of grains per panicle, kernel length and kernel L/B ratio could be used as selection indices for the improvement of grain yield in rice.

Table 1: List of CMS lines and maintainer lines used in the experiment

Maintainer Lines	Source	Character
CMS 11B	IRRI, Philippines	LS grain, Very early duration
CMS 14B	IRRI, Philippines	LS grain, Early duration
CMS 23B	IRRI, Philippines	LB grain, Very early duration
CMS 46B	IRRI, Philippines	LS grain, Early duration
CMS 59B	IRRI, Philippines	LS grain, Mid early duration
CMS 64B	IRRI, Philippines	LS grain, Early duration
JMS 11B	RARS, Jagtial, Telangana, India	LS grain, Early duration
JMS 13B	RARS, Jagtial, Telangana, India	MS grain, Medium duration
JMS 14B	RARS, Jagtial, Telangana, India	MS grain, Medium duration
JMS 17B	RARS, Jagtial, Telangana, India	SS grain, Mid early duration
JMS 18B	RARS, Jagtial, Telangana, India	SS grain, Mid early duration
Checks		
RNR 15048	RRC, ARI, Hyderabad, Telangana, India	SS grain, Early duration
JGL 18047	RARS, Jagtial, Telangana, India	LS grain, Early duration
JGL 11470	RARS, Jagtial, Telangana, India	SS grain, Medium duration
JGL 1798	RARS, Jagtial, Telangana, India	MS grain, Early duration
MTU 1010	APRRI, Maruteru, AP, India	LS grain, Early duration

Table 2: Analysis of Variance (ANOVA) for grain yield and kernel characters in rice

Source of variation	df	DFF	PH (cm)	NPT	PL (cm)	LAI	SS (%)	TW	HP	MP	HRR (%)	KL(mm)	KW(mm)	KLBR	NG	GY (q/ac)
Replication	2	0.333	53.492	6.961	0.161	0.1	1.487	0.646	5.893	7.593	13.385	0.149	0.002	0.105	34.623	72.32
Genotypes	15	116.443 **	159.475**	5.892 **	6.678**	1.452 **	87.658 **	60.533**	4.625	13.182	81.809 *	1.224 **	0.039 **	0.220 **	14472.200**	137.934 **
Error	30	0.556	12.499	2.105	2.089	0.041	1.943	1.654	4.53	9.676	39.173	0.043	0.003	0.033	1155.586	35.788

*&** Significant at 5% and 1% level, respectively

Table 3: Phenotypical Correlation coefficients of different traits on grain yield

Characters	DFF	PH (cm)	NPT	PL (cm)	LAI	SS (%)	TW	HP	MP	HRR (%)	KL(mm)	KW(mm)	KLBR	NG	GY (q/ac)
DFF	1	0.4671*	-0.2053	0.3212*	0.2776	-0.2320	-0.3094*	0.0957	0.0037	0.1546	-0.3324*	-0.3035*	-0.1980	0.5589*	0.2808
PH (cm)		1	-0.0189	0.3360*	0.6108*	-0.5192*	0.0432	0.0003	0.1876	0.3012*	0.0672	-0.1675	0.2357	0.2491	0.4990*
NPT			1	-0.2081	0.1642	-0.0185	0.0900	-0.2124	-0.0466	0.0022	0.1609	-0.1802	0.3715*	- 0.3070*	0.3203*
PL (cm)				1	0.4930*	-0.1540	-0.2187	0.1446	0.1827	0.0842	-0.1212	-0.2571	0.0557	0.4406*	0.3819*
LAI					1	-0.5909*	-0.0997	0.1053	0.1391	0.0334	0.0097	-0.2974*	0.2637	0.4306*	0.7959*
SS (%)						1	0.0156	-0.0003	-0.0284	-0.0922	0.0763	0.1156	0.0160	-0.3237*	-0.5678*
TW							1	-0.2253	-0.0453	0.0825	0.9059*	0.8117*	0.5499*	-0.8166*	0.0251
HP								1	0.7563*	0.3625*	- 0.1125	-0.2009	0.0024	0.2837	0.0027

MP									1	0.6299*	0.0397	-0.1920	0.1999	0.1149	0.0816
HRR (%)										1	0.1070	-0.0162	0.1557	-0.0096	0.0198
KL(mm)											1	0.6637*	0.7958*	-0.7493*	0.0801
KW(mm)												1	0.0769	-0.6680*	-0.1182
KLBR													1	-0.4628*	0.2040
NG														1	0.3567*
GY (q/ac)															1

* Significant at 5% level

Table 4: Direct (diagonal) and indirect effects of different traits on grain yield

Characters	DFF	PH (cm)	NPT	PL (cm)	LAI	SS (%)	TW	HP	MP	HRR (%)	KL(mm)	KW(mm)	KLBR	NG	GY (q/ac)
DFF	-0.0885	-0.0414	0.0182	-0.0284	-0.0246	0.0205	0.0274	-0.0085	-0.0003	-0.0137	0.0294	0.0269	0.0175	-0.0495	0.2808
PH (cm)	0.063	0.1349	-0.0025	0.0453	0.0824	-0.07	0.0058	0	0.0253	0.0406	0.0091	-0.0226	0.0318	0.0336	0.499
NPT	-0.1428	-0.0131	0.6956	-0.1448	0.1142	-0.0129	0.0626	-0.1478	-0.0324	0.0016	0.1119	-0.1254	0.2584	-0.2135	0.3203
PL (cm)	0.0356	0.0372	-0.023	0.1107	0.0546	-0.017	-0.0242	0.016	0.0202	0.0093	-0.0134	-0.0285	0.0062	0.0488	0.3819
LAI	0.0646	0.142	0.0382	0.1146	0.2325	-0.1374	-0.0232	0.0245	0.0323	0.0078	0.0023	-0.0691	0.0613	0.1001	0.7959
SS (%)	-0.001	-0.0022	-0.0001	-0.0006	-0.0025	0.0042	0.0001	0	-0.0001	-0.0004	0.0003	0.0005	0.0001	-0.0014	-0.5678
TW	-0.2022	0.0282	0.0588	-0.1429	-0.0652	0.0102	0.6537	-0.1473	-0.0296	0.0539	0.5921	0.5306	0.3595	-0.5338	0.0251
HP	-0.0051	0	0.0114	-0.0078	-0.0057	0	0.0121	-0.0537	-0.0406	-0.0195	0.006	0.0108	-0.0001	-0.0152	0.0027
MP	0.0003	0.0154	-0.0038	0.0151	0.0115	-0.0023	-0.0037	-0.0037	0.0824	0.0519	0.0033	-0.0158	0.0165	0.0095	0.0816
HRR (%)	-0.0148	-0.0288	-0.0002	-0.0081	-0.0032	0.0088	-0.0079	-0.0347	-0.0603	-0.0958	-0.0102	0.0016	-0.0149	0.0009	0.0198
KL(mm)	-0.8462	0.1711	0.4096	-0.3085	0.0247	0.1941	2.3058	-0.2864	0.1012	0.2723	2.5454	1.6893	2.0257	-1.9071	0.0801
KW(mm)	0.3448	0.1902	0.2047	0.292	0.3378	-0.1313	-0.922	0.2282	0.2181	0.0184	-0.7539	-1.1359	-0.0874	0.7588	-0.1182
KLBR	0.3747	-0.446	-0.7028	-0.1055	-0.4988	-0.0302	-1.0405	-0.0045	-0.3781	-0.2946	-1.5057	-0.1455	-1.892	0.8756	0.204
NG	0.6986	0.3114	-0.3837	0.5507	0.5382	-0.4046	-1.0207	0.3546	0.1436	-0.012	-0.9365	-0.835	-0.5785	1.25	0.3567

R SQUARE 0.9094 RESIDUAL EFFECT 0.301

DFF: Days to 50% flowering PH: Plant height NPT: No. of productive tillers PL: Panicle length LAI: Leaf Area Index SS%: Spikelet Sterility% TW: Test Weight HP: Hulling percentage MP: Milling percentage HRR: Head rice recovery KL: Kernel length KW: Kernel width KLBR: Kernel Length Bredth Ratio NG: Number of grains per panicle

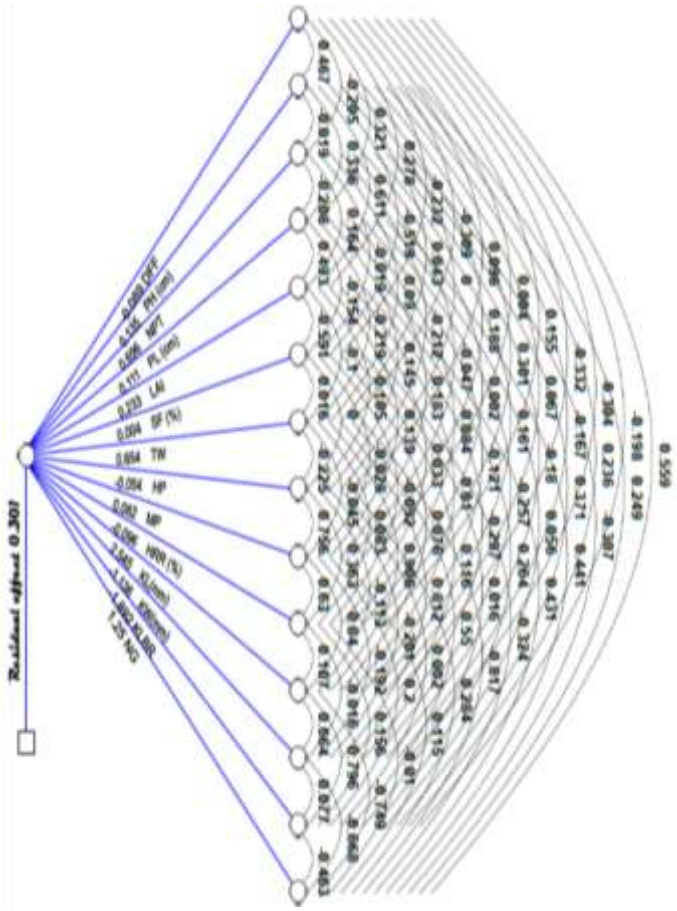

Fig 1: Phenotypical path diagram for grain yield (q/ac)

4. Conclusion

From the present study, it can be concluded that the characters *viz.*, Plant height, panicle length, leaf area index, number of grains per panicle, kernel length and kernel L/B ratio could be used as selection indices for the improvement of grain yield in rice.

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