



# Correlation and Path Coefficient Analysis for Grain Yield, Head Rice Recovery and Quality Traits in Rice Hybrids (*Oryza sativa* L.)

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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 study's main objectives were to analyze rice path coefficients and look at the associations between different features. 24 hybrids were created by crossing four CMS lines with six elite restorers utilizing a Line x Tester design. During the Rabi 2023–2024, these hybrids, the parental lines, and two checks were assessed using a randomized block design with two replications. Grain yield was found to be negative significantly correlated with the number of productive tillers per plant and the hulling percentage (%) and positive significantly correlated with plant height (cm), panicle

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length (mm), number of grains per panicle, 1000 grain weight (g), and kernel breadth (mm). Height of the plant (mm), length of the panicles (mm), number of grains in each panicle, weight of 1000 grains (g), length of the kernels (mm), percentage of milling (%), and head rice recovery had exhibited direct positive effect on grain yield per plant. Therefore selection based on these traits could facilitate simultaneous improvements in yield and related attributes.

**Keywords:** Correlation; grain yield per plant; path co-efficient analysis; quality; residual effect; rice.

## 1. INTRODUCTION

“Rice (*Oryza sativa* L.  $2n=2x=24$ ) is a crucial food crop that provides a major portion of carbohydrates to the global population. In Asia, rice demand continues to rise, with consumption at around 90%, and it is projected that global demand for rice will reach 650 million tonnes by 2050” [1]. “Rice serves as the main dietary staple for over half of the world’s population. It is cultivated in approximately 165 million hectares globally, producing about 508.9 million tonnes” [2]. “In India, rice is grown on 47.83 million hectares, with a production of 135.75 million tonnes and a productivity of 2838 kg/ha” [2]. “In Telangana, rice is cultivated on 4.66 million hectares, yielding 15.87 million tonnes with a productivity of 3406 kg/ha” [2]. “Enhancing yield and yield related traits in rice is critical to meet the growing global food demand. The interest in food is consistently extending with the increment of populace, making a yearly increment of 3% for each year’s popular rice” [3].

“Correlation is the mutual relationship between two variables” [4]. “Correlation coefficient is a statistical measure of degree (strength) and direction of relationship between two or more variables. Correlation coefficient analysis is useful for understanding the relationships between different plant traits and identifying the key components that can be targeted for selection to achieve genetic improvement in yield. Selections based on the results of correlation coefficient analysis may not produce the expected outcome, it is necessary to include path coefficient analysis for estimation of degree of association” [5] insight into cause and effect relationship between different pairs of character. Path analysis helps to study the direct and indirect effects of the different traits on yield, the dependent variable. “The nature of effect like direct or indirect effect of yield and its characteristics can be explained through path coefficient analysis” [6]. Correlation in combination with path analysis would give a better yield.

## 2. MATERIALS AND METHODS

The current study was conducted during the *Kharif* season of 2023 (for production of  $F_1$  hybrids) and the *Rabi* season of 2023-2024 (for evaluation) at the Regional Agricultural Research Station, PJTSAU, Polasa, Jagtial, Telangana. The experimental materials consisted of four lines (CMS 52A, CMS 64A, JMS 18A and RMS 2A) with proven high head rice recovery and six testers (SN 233, SN 232, SN 223, SN 2397, SN 1326 and BV 166), along with their twenty four hybrids produced through the Line  $\times$  Tester mating design described by Kempthorne in 1957. Two standard hybrid checks Shabnam and KPH 473, were included for comparative purposes. The genotypes were arranged using a randomized block design (RBD) with two replications and spacing of 20  $\times$  15 cm. Information on grain yield, yield contributing factors, and quality characteristics have all been recorded as part of the data gathering process.

This data was gathered from five randomly selected healthy plants per entry within each replication viz., plant height (cm), panicle length (cm), number of productive tillers per plant, number of grains per panicle and grain yield per plant (g). The attribute, days to 50% flowering, was recorded on a plot basis. 1000 grain weight (g) and quality traits were gathered from five randomly selected samples per entry within each replication.

Falconer's [7] proposed equations were used for estimating correlation. Using the method suggested by Wright [8] and further developed by Dewey and Lu [9] the correlation coefficients were partitioned into direct and indirect effects.

The approaches used for analysis followed the guidelines provided by Singh and Chaudhary's for correlation coefficient analysis. Characterizing path coefficients was done in accordance with Lenka and Mishra's [10] guidelines.

## 3. RESULTS AND DISCUSSION

Significant differences between the genotypes for all variables under investigation have been

identified through analysis of variance (Table 1), suggesting that the material under study has a significant amount of genetic diversity.

### 3.1 Correlation Coefficient Analysis

Studies on the nature of association of yield and quality traits is crucial for simultaneous improvement of yield and quality. In this context, correlation studies provide valuable information on the nature and extent of relationship between the characters. Analyzing genetic correlation also gives us an idea about the extent to which the characters are under the control of genes and this kind of analysis could help in developing more effective selection strategies for crop improvement. (Table 2) presents the correlations between yield and quality traits, as well as their relationships with grain yield per plant and among each other.

Grain yield per plant was noticed to be positively and significantly associated with plant height, panicle length, number of grains per panicle, 1000 grain weight and kernel breadth at both genotypic and phenotypic levels suggesting a scope for simultaneous improvement of these traits during selection for high yield levels. Singh et al. [11] Buelah et al. [12] and Saketh et al. [13] also reported similar findings for plant height. Choosing plants based on their height can also enhance the grain yield per plant. Sharma and Hemanth, [14] Jangala et al. [15] and Kiruba et al. [16] reported comparable results for number of grains per panicle. The number of grains per panicle is a key factor in yield, particularly in hybrids, which are noted for their larger sink size. The results are in line with the earlier reports of Sharma and Hemanth, [14] Begum et al. [17] Sujitha et al. [18] Devi et al. [19] and Manivelan et al. [20] for 1000 grain weight. These results are in line with the earlier report of Priyanka et al. [21] for kernel breadth.

The highest degrees of associations were observed in accordance with panicle length, plant height, number of grains per panicle, kernel breadth and 1000 grain weight.

A significant negative association was observed for number of productive tillers per plant and hulling percentage with grain yield per plant. These findings align with the results reported by Sujitha et al. [18] Devi et al. [19] and Manivelan et al. [20] for number of productive tillers per plant. Similar reports are reported by Prem

Kumar et al. [22] Devi et al. [23] and Edukondalu et al. [24] for hulling percentage.

“Head rice recovery had a significant association with milling percent at phenotypic and genotypic correlation indicated that milling percent and head rice recovery are important quality attributes for rice. Simultaneous improvement of these two quality traits *viz*, milling percent and head rice recovery can be made with the selection of a single traits is either milling percent or head rice recovery. Head rice recovery showed negative significant association with kernel breadth and positive significant association with Kernel length/breadth ratio. Hulling percent had significant positive association with milling percent. In the present study the positive significant correlation of hulling percent with milling percent and milling percentage with head rice recovery indicated that genotypes with high hulling percent also exhibited higher estimates for milled rice and head rice”. Edukondalu et al. [24] Devi et al. [23] and Adjah et al. [25].

However, non-significant associations of grain yield per plant were observed with days to 50 % flowering, kernel length, L/B ratio, milling percentage, hulling percentage and head rice recovery, showing that selecting for both yield and these quality attributes at the same time is unproductive.

These results were in confirmation with Edukondalu et al. [24] Devi et al. [23] Adjah et al. [25] Hossain et al. [26] Gupta et al. [27] Lakshmi et al. [28] Vennela et al. [29] Manasa et al. [30] and Devi et al. [19] for these traits.

### 3.2 Path Coefficient Analysis

The results of the path coefficient analysis for grain yield and quality traits in rice (Table 3). Grain yield per plant was used as a dependent variable in the path coefficient analysis, while other yield-contributing characteristics and grain quality attributes were taken into account as independent variables.

Analysis revealed a very high (>1) positive direct effect for kernel length (1.7582) and a high (>0.3) positive direct effect for panicle length (0.7081) and milling percentage (0.3868) whereas head rice recovery (0.2335) showed a moderate positive direct on grain yield per plant (Table 3).

Similar results were reported by Arulmozhi et al. [31] Gupta et al. [27] and Kujur et al. [32] for number of grains per panicle. "Plant height show positive direct effect on grain yield per plant these results are in accordance with" Nath and kole [33] Begum et al. [17] and Vennela et al. [29]. Similar findings by Paramanik et al. [34] for panicle length and plant height have been reported. Similar reports by Singh et al. [35] for panicle length and 1000 grain weight. Similar results for 1000 grain weight reported by Parimala et al. [36] Vennela et al. [29] Nath and kole [33] and Jasmine et al. [37]. Thus it reveals that these traits were significant in relation to grain yield.

The grain quality traits viz., kernel length, milling percentage and head rice recovery showed positive direct effects on grain yield per plant. Similar results were reported by Prem kumar et al. [22] and Panika et al. [38] for kernel length. Similar findings reported by Prem kumar et al. [22] Devi et al. [19] for milling percentage. Similar results were reported by Edukondalu et al. [24] for head rice recovery. These results implying that selection for these quality traits is likely to result in a direct increase in grain yield per plant. A significant and positive correlation was found between these attributes and grain yield per plant except head rice recovery exhibiting indicating the effectiveness of direct selection for these quality traits in improvement of grain yield per plant.

"Days to 50% flowering, number of productive tillers per plant, kernel breadth, kernel L/B ratio and hulling percentage recorded direct and negative genotypic effect on grain yield per plant. Similar findings are reported" by Kumar et al. [39] Hemalatha et al. [40] and Yadav et al. [41]. The negative direct effects shown that improving through selection with these attributes would be ineffective for grain yield per plant. grain yield per plant. But when the yield is influenced by some component traits as a consequence of their indirect effect via some other traits, selection of the trait through which the indirect effect has been exerted is beneficial for the improvement of yield [42-44].

### 3.3 Residual Effect

In plant breeding, it is quite challenging to have a whole understanding of all component traits related to yield. This residual effect allows for a precise description of the pattern of interaction of other potential yield components that were left out of the study. The residual effect was 0.4580 for genotypic and 0.6645 for phenotypic path coefficient. This indicates that 33.55% and 45.80% of the component traits studied on yield per hectare came from phenotypic and genotypic levels, respectively, while the remaining 66.45% and 54.2% came from other characters that were not studied on the dependent variable.

**Table 1. Analysis of variance for grain yield and quality traits in rice**

S.No	Character	Mean sum of squares		
	Source of variation	Replications	Genotypes	Error
	d.f.	1	35	35
1	Days to 50 % flowering	0.12	119.66 **	1.41
2	Plant height (cm)	0.40	103.34 **	2.84
3	Panicle length (cm)	4.01	4.52 **	1.07
4	Number of productive tillers per plant	0.93	1.47**	0.31
5	Number of filled grains per panicle	1842.24	7064.65 **	499.48
6	1000 grain weight (g)	0.15	30.64 **	0.49
7	Grain yield per plant (g)	23.12	49.87 **	8.21
8	Kernel length (mm)	0.22	0.71 **	0.05
9	Kernel breadth (mm)	0.02	0.04 **	0.006
10	Kernel L/ B Ratio.	0.001	0.23 **	0.005
11	Hulling (%)	10.88	8.00 *	3.83
12	Milling (%)	10.88	20.27 **	4.40
13	Head rice recovery (%)	6.12	380.98 **	3.41

**Table 2. Phenotypic (P) and Genotypic (G) correlation coefficients for grain yield and quality traits in rice. [45]**

Source		DFF	PH	PL	NPT	NGP	1000 GW	KL	KB	L/B	HP	MP	HRR	GYP
DFF	G	1.0000	0.5092**	0.4087**	-0.2287*	0.4166**	-0.1670	-0.1594	-0.1496	-0.0105	-0.1716	-0.0523	0.3970**	-0.0552
	P	1.0000	0.4832**	0.2970*	-0.1559	0.3747**	-1.665	-0.1560	-0.1502	-0.0049	-0.0950	-0.0301	0.3892**	-0.0505
PH	G		1.0000	0.6152**	-0.2316*	0.5958**	0.1061	0.0118	0.3561**	-0.3116**	-0.3526**	-0.1602	0.0653	0.4727**
	P		1.0000	0.5355**	-0.1940	0.5470**	0.1013	0.0147	0.3450**	-0.2972*	-0.2514*	-0.1371	0.0619	0.4487**
PL	G			1.0000	-0.2315*	0.6286**	0.2218*	0.1715	0.1217	0.0744	-0.1150	-0.0863	-0.1190	0.6330**
	P			1.0000	-0.1941	0.5447**	0.1756	0.1436	0.0884	0.0761	-0.0469	-0.0584	-0.1008	0.5363**
NPT	G				1.0000	-0.4738**	0.2136*	0.4166**	0.0580	0.3825**	0.1443	0.5449**	0.2880*	-0.2141*
	P				1.0000	-0.3282**	0.1616	0.3385**	0.0556	0.2979*	0.1514	0.4517**	0.2455*	-0.1673
NGP	G					1.0000	-0.3533**	-0.3089**	-0.1385	-0.1924	-0.0386	-0.0419	0.1162	0.4350**
	P					1.0000	-0.3341**	-0.2805*	-0.1222	-0.1730	-0.0015	0.0050	0.1120	0.3931**
1000 GW	G						1.0000	0.8058**	0.6997**	0.1996	-0.1651	-0.1712	-0.3990**	0.2560*
	P						1.0000	0.7865**	0.6735**	0.1930	-0.1172	-0.1439	-0.3858**	0.2426*
KL	G							1.0000	0.4849**	0.5923**	-0.1078	-0.0323	-0.1321	0.1705
	P							1.0000	0.4769**	0.5868**	0.0628	-0.0200	-0.1298	0.1664
KB	G								1.0000	-0.4152**	-0.3810**	-0.1953	-0.4232**	0.3678**
	P								1.0000	-0.4290**	-0.2616*	-0.1686	-0.4137**	0.3552**
L/B	G									1.0000	0.2505*	0.1611	0.2466*	-0.1722
	P									1.0000	0.1847	0.1473	0.2411*	-0.1639
HP	G										1.0000	0.4179**	0.0246	-0.3796**
	P										1.0000	0.5031**	0.0346	-0.2509*
MP	G											1.0000	0.2647*	-0.0386
	P											1.0000	0.2488*	-0.0293
HRR	G												1.0000	-0.1817
	P												1.0000	-0.1622

\*: Significant at 5 per cent level; \*\*: Significant at 1 per cent level

DFF: Days to 50 % flowering, PH: Plant height (cm), PL: Panicle length (cm), NPT: Number of productive tillers per plant, NGP: Number of filled grains per panicle, 1000 GW: 1000 grain weight(g), KL: Kernel length (mm), KB: Kernel breadth (mm), L/B: Length/Breadth Ratio, HP: Hulling percentage, MP: Milling percentage, HRR: Head rice recovery (%), GYP: Grain yield per plant (g)

**Table 3. Phenotypic (P) and Genotypic (G) path coefficients for grain yield and quality traits in rice [45]**

Source		DFF	PH	PL	NPT	NGP	1000 GW	KL	KB	L/B	HP	MP	HRR	GYP	
DFF	G	-0.5342	0.0196	0.2894	0.0862	0.0160	-0.0190	-0.2802	0.2111	0.0182	0.0653	-0.0202	0.0927	-0.0552	
	P	-0.3000	0.0574	0.1160	0.0236	0.0899	-0.0283	-0.2849	0.2241	0.0090	0.0247	-0.0078	0.0257	-0.0505	
PH	G	-0.2720	0.0384	0.4355	0.0873	0.0228	0.0121	0.0207	-0.5023	0.5426	0.1342	-0.0619	0.0153	0.4727**	
	P	-0.1450	0.1188	0.2091	0.0293	0.1313	0.0172	0.0268	-0.5148	0.5421	0.0654	-0.0357	0.0041	0.4487**	
PL	G	-0.2183	0.0236	0.7081	0.0873	0.0241	0.0253	0.3016	-0.1717	-0.1296	0.0438	-0.0333	-0.0278	0.6330**	
	P	-0.0891	0.0636	0.3906	0.0289	0.1307	0.0298	0.2622	-0.1319	-0.1389	0.0122	-0.0152	-0.0067	0.5363**	
NPT	G	0.1222	-0.0089	-0.1639	-0.3769	-0.0182	0.0244	0.7324	-0.0818	-0.6661	-0.0549	0.2105	0.0672	-0.2141*	
	P	0.0468	-0.0230	-0.0747	-0.1512	-0.0788	0.0275	0.6182	-0.0829	-0.5433	-0.0394	0.1175	0.0162	-0.1673	
NGP	G	-0.2225	0.0229	0.4451	0.1786	0.0383	-0.0403	-0.5432	0.1954	0.3350	0.0147	-0.0162	0.0271	0.4350**	
	P	-0.1124	0.0650	0.2128	0.0496	0.2400	-0.0568	-0.5122	0.1824	0.3155	0.0004	0.0013	0.0074	0.3931**	
1000 GW	G	0.0892	0.0041	0.1571	-0.0805	-0.0135	0.1141	1.4168	-0.9870	-0.3476	0.0628	-0.0661	-0.0932	0.2560*	
	P	0.0500	0.0120	0.0686	-0.0244	-0.0802	0.1699	1.4362	-1.0049	-0.3521	0.0305	-0.0374	-0.0255	0.2426*	
KL	G	0.0851	0.0005	0.1215	-0.1570	-0.0118	0.0919	1.7582	-0.6840	-1.0315	0.0410	-0.0125	-0.0308	0.1705	
	P	0.0468	0.0017	0.0561	-0.0512	-0.0673	0.1336	1.8260	-0.7116	-1.0703	0.0163	-0.0052	-0.0086	0.1664	
KB	G	0.0799	0.0137	0.0862	-0.0219	-0.0053	0.0798	0.8525	-1.4107	0.7229	0.1450	-0.0754	-0.0988	0.3678**	
	P	0.0451	0.0410	0.0345	-0.0084	-0.0293	0.1144	0.8708	-1.4921	0.7824	0.0680	-0.0439	-0.0273	0.3552**	
L/B	G	0.0056	-0.0120	0.0527	-0.1442	-0.0074	0.0228	1.0414	0.5857	-1.7413	-0.0953	0.0622	0.0576	-0.1722	
	P	0.0015	-0.0353	0.0297	-0.0450	-0.0415	0.0328	1.0716	0.6401	-1.8239	-0.0480	0.0383	0.0159	-0.1639	
HP	G	0.0917	-0.0136	-0.0814	-0.0544	-0.0015	-0.0188	-0.1895	0.5375	-0.4363	-3.805	0.1614	0.0058	-0.3796**	
	P	0.0285	-0.0299	-0.0183	-0.0229	-0.0004	-0.0199	-0.1147	0.3903	-0.3368	-0.2600	0.1309	0.0023	-0.2509*	
MP	G	0.0279	-0.0062	-0.0611	-0.2054	-0.0016	-0.0195	-0.0567	0.2755	-0.2806	-0.1590	0.3868	0.0618	-0.0386	
	P	0.0090	-0.0163	-0.0228	-0.0683	0.0012	-0.0245	-0.0364	0.2516	-0.2687	-0.1308	0.2601	0.0164	-0.0293	
HRR	G	-0.2121	0.0025	-0.0843	-0.1086	0.0045	-0.0455	-0.2322	0.5970	-0.4295	-0.0094	0.1022	0.2335	-0.1817	
	P	-0.1167	0.0073	-0.0394	-0.0371	0.0269	-0.0655	-0.2369	0.6172	-0.4397	-0.0090	0.0647	0.0661	-0.1622	
		Genotypic Residual effect = 0.4580					Phenotypic Residual effect = 0.6645					Bold values are direct effects			

\*: Significant at 5 per cent level; \*\*: Significant at 1 per cent level

DFF: Days to 50 % flowering, PH: Plant height (cm), PL: Panicle length (cm), NPT: Number of productive tillers per plant, NGP: Number of filled grains per panicle, 1000 GW: 1000 grain weight, KL: Kernel length (mm), KB: Kernel breadth (mm), L/B: Length/Breadth Ratio, HP: Hulling percentage, MP: Milling percentage, HRR: Head rice recovery (%), GYP: Grain yield per plant (g).

#### 4. CONCLUSION

Analysis on path coefficient analysis and correlation revealed the importance of selection with regard to panicle length plant height, number of grains per panicle, kernel breadth and 1000-grain weight exhibited significant positive genotypic correlation and would enhance yield. The path analysis studies showed panicle length, 1000-grain weight, plant height and number of grains per panicle expressing positive direct effect and significant association with grain yield per plant, whereas kernel length, milling percentage and head rice recovery recorded positive direct effect on grain yield per plant.

#### DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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