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CORRELATION AND PATH COEFFICIENT ANALYSIS FOR GRAIN YIELD AND ITS COMPONENT TRAITS IN F_1 FILIAL GENERATION OF RICE (*Oryza sativa* L.)

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ABSTRACT

A correlation and path-coefficient analysis were conducted to identify selection criteria for grain yield in hybrid rice (*Oryza sativa* L.). Thirty F_1 hybrids were developed using a Line x Tester design (10 lines × 3 testers), along with 13 parents and two standard checks and evaluated during rabi 2021-22 at RARS, Polasa, Telangana, in a randomized complete block design with three replications. Data were recorded on 15 agronomic and quality traits. Grain yield per plant showed significant positive associations with days to 50% flowering, plant height, panicle length, number of grains per panicle, spikelet fertility, hulling (%), milling (%) and head rice recovery. Path analysis indicated that plant height, grains per panicle, productive tillers, spikelet fertility, 1000-grain weight, head rice recovery and kernel length exerted strong positive direct effects on grain yield, highlighting their utility as key selection indices. The residual effect showed that most of the variation in grain yield was explained by the studied traits, highlighting the importance of combining correlation and path analysis for effective selection in rice crop improvement.

***Key words*:** Hybrid rice, Line x Tester, Correlation analysis, Path coefficient analysis, Grain yield.

Introduction

Rice (*Oryza sativa* L.) is one of the most important staple food crops, feeding nearly half of the global population and contributing about 21% of the total caloric intake worldwide. In India, rice serves as the staple food for nearly 65% of the population, supporting around 800 million people and its production has increased substantially from 20.60 million tonnes with an average productivity of 0.67 t ha^{-1} in 1950-51 to about 150.18 million tonnes from 51.27 million hectares with an average productivity of 2.92 t ha^{-1} during 2024-25 (MOA&FW). Grain yield, being a complex quantitative trait governed by multiple genes, is highly influenced by environmental factors. Consequently, direct selection for yield alone is often inefficient and may lead to limited progress in crop improvement. Therefore, improvement in yield can be more effectively achieved through indirect selection based on its component traits, which act as independent variables. These traits are interrelated among themselves and also exhibit significant associations with yield. Hence, it is essential for plant breeders to identify the nature and magnitude of relationships between yield and its contributing traits, as well as to assess their direct and indirect effects on yield. The present study was undertaken to evaluate the correlation among yield and its component traits and to analyse the cause-effect relationships of these

independent variables on grain yield.

Materials and methods

The study involved 45 genotypes, including 30 F_1 (hybrids developed through a Line × Tester mating design using 10 lines and 3 testers), 13 parental genotypes and two standard checks were included. The experimental material was evaluated during the *Rabi* season of 2021-22 at the Regional Agricultural Research Station (RARS), Polasa, Telangana, under a randomized complete block design (RCBD) with three replications. Observations were recorded on five randomly selected plants in each replication. The traits studied were days to 50 per cent flowering, plant height (cm), panicle length (cm), number of grains per panicle, number of productive tillers per plant, spikelet fertility (%), 1000-grain weight (g), hulling (%), milling (%), head rice recovery, kernel length (cm), kernel breadth (cm), length-to-breadth ratio, zinc content (ppm) and grain yield per plant (g). Correlation at phenotypic and genotypic level were estimated as per producer outlined by Falconer (1964). The direct and indirect effects at both genotypic and phenotypic levels were estimated by taking seed yield as dependent variable, using path coefficient analysis suggested by Wright (1921) and Dewey and Lu (1959).

Results and Discussion

Days to 50% flowering exhibited a significant positive genotypic correlation with grain yield and its dependent traits, including number of grains per panicle, plant height, panicle length and spikelet fertility (%) while showing a negative association with 1000-grain weight and kernel breadth. However, path analysis revealed a negative direct effect on grain yield, indicating that its positive correlation was due to positive indirect effects through productive tillers, 1000-grain weight, kernel length, zinc content and kernel breadth. Earliness thus contributed indirectly to grain yield, consistent with Meena *et al.*, (2020), Sudeepthi *et al.*, (2020) and Lohiteswararao *et al.*, (2021).

Plant height showed a significant positive genotypic association with grain yield and interrelation with its yield attributing and post-harvest quality parameters such as days to 50% flowering, panicle length, number of grains per panicle, spikelet fertility, hulling (%) and milling (%), while exhibiting a negative association with number of productive tillers. Path analysis revealed a positive direct effect of plant height on grain yield, along with positive indirect effects *via* major yield components namely Days to 50% flowering, panicle length, grains per panicle and spikelet fertility which indicate plant height contributes directly and indirectly to yield improvement. Similar results were reported by, Kiranmayee *et al.*, (2018), Chhangte and Devi (2019), Saha *et al.*, (2019) and Vennela *et al.*, (2021).

Panicle length showed a significant positive genotypic correlation with grain yield and related traits such as number of grains per panicle, plant height, spikelet fertility, days to 50% flowering, hulling and milling percentage, while exhibiting a negative association with zinc content. However, path analysis revealed a negative direct effect on grain yield, indicating that its positive correlation was mainly due to positive indirect effects through productive tillers and zinc content. Similar results were reported by Edukondalu *et al.*, (2017), Hemalatha (2018), Devi *et al.*, (2019) and Saha *et al.*, (2019).

Number of productive tillers per plant showed a significant negative genotypic correlation with grain yield and negative interdependence with grains per panicle, plant height, days to 50% flowering and spikelet fertility. However, path analysis revealed a positive direct effect on grain yield, indicating that its negative correlation was due to adverse indirect effects through yield attributing traits. Positive indirect effects were observed through head rice recovery and length-to-breadth ratio. Results suggest that productive tillers have a direct role in yield improvement but should be selected carefully along with other traits. Similar findings were reported by Arulmozhi and Muthuswamy (2019), Priyanka *et al.*, (2020) and Jasmine *et al.*, (2022).

Number of grains per panicle demonstrated a significant positive genotypic correlation with grain yield, alongside positive interrelationships with days to 50% flowering, plant height, panicle length, and spikelet fertility. Conversely, it was negatively associated with 1000-grain weight and kernel dimensions. Path analysis further revealed that this trait exerts a positive direct effect on grain yield, supported by positive indirect effects via days to 50% flowering, plant height, panicle length, and spikelet fertility. Due to its positive association and direct impact, this trait plays a crucial role in yield improvement. These results align closely with the findings reported by Arulmozhi and Muthuswamy (2019) and Sudeepthi *et al.*, (2020).

Spikelet fertility exhibited a significant positive genotypic correlation with grain yield and related traits such as days to 50% flowering, plant height, panicle length, number of grains per panicle, hulling and milling percentage. Path analysis revealed a positive direct effect on grain yield, along with positive indirect effects through days to 50% flowering, plant height, panicle length, grains per panicle and quality traits. These results indicate that

Table 1: Phenotypic (P) and Genotypic (G) correlation coefficients of yield and quality traits in rice (*Oryza sativa* L.).

Source		DFF	PH	PL	NGP	NPT	SF	1000 GW	HP	MP	HRR	KL	KB	L/B	ZC	GYP
DFF	P	**10000**	0.5165**	0.4266**	0.3690**	-0.0059	0.5971**	-0.3871**	0.3506**	0.2193**	0.2943**	-0.1604	-0.3580**	0.2371**	-0.1286	0.3837**
	G	**1.0000**	0.5555**	0.5010**	0.3812**	-0.0110	0.6206**	-0.3993**	0.6059**	0.3963**	0.3225*	-0.1640	-0.3655*	0.2503	-0.1302	0.3948**
PH	P		**10000**	0.6808**	0.5554**	-0.2665**	0.6604**	-0.1355	0.4355**	0.3540**	0.1468	-0.0088	-0.1599	0.1591	-0.0904	0.6670**
	G		**10000**	0.7819**	0.5983**	-0.4268**	0.7244**	-0.1423	0.8586**	0.6997**	0.1643	0.0024	-0.1668	0.1826	-0.0950	0.7201**
PL	P			**10000**	0.4674**	-0.1670	0.4145**	-0.0003	0.2351**	0.2711**	0.0845	0.0681	-0.0110	0.0642	-0.3515**	0.5116**
	G			**10000**	0.5788**	-0.2040	0.5037**	0.0087	0.5556**	0.5274**	0.1296	0.0900	0.0010	0.0802	-0.4136**	0.6251**
NGP	P				**10000**	-0.0770	0.3222**	-0.5663**	0.2464**	0.3829**	0.4589**	-0.5563**	-0.3672**	-0.1280	-0.2217**	0.6798**
	G				**1.0000**	-0.1397	0.3361*	-0.6028**	0.4815**	0.6331**	0.5059**	-0.5922**	-0.3880**	-0.1407	-0.2316	0.6571**
NPT	P					**10000**	-0.2729**	-0.0990	-0.1602	-0.2405**	0.1521	0.0011	-0.1237	0.1147	-0.0973	-0.2125*
	G					**1.0000**	-0.4540**	-0.1888	-0.6355**	-0.3156*	0.2661	-0.0491	-0.1857	0.1553	-0.1503	-0.3667*
SF	P						**10000**	-0.4366**	0.4755**	0.3462**	0.0555	-0.1547	-0.3757**	0.2776**	0.1862*	0.6511**
	G						**1.0000**	-0.4587**	0.7884**	0.6971**	0.0539	-0.1649	-0.3970**	0.3013	0.1904	0.6858**
1000 GW	P							**10000**	-0.1356	-0.2638**	-0.3541**	0.7497**	0.7490**	-0.1156	-0.1164	-0.3948**
	G							**1.0000**	-0.2454	-0.5173**	-0.3823**	0.7799**	0.7720**	-0.1241	-0.1188	-0.4215**
HP	P								**10000**	0.3508**	0.1374	-0.0647	-0.1972*	0.1512	0.1050	0.2725**
	G								**1.0000**	0.9114**	0.2018	-0.1639	-0.3447*	0.2471	0.1709	0.5167**
MP	P									**10000**	0.1353	-0.2773**	-0.1934*	-0.0360	-0.0338	0.3165**
	G									**1.0000**	0.3019*	-0.5173**	-0.3667*	-0.0967	-0.0728	0.4945**
HRR	P										**10000**	-0.4775**	-0.3009**	-0.1209	-0.0452	0.3673**
	G										**1.0000**	-0.5374**	-0.3420*	-0.1328	-0.0497	0.4043**
KL	P											**10000**	0.4971**	0.3690**	-0.1611	-0.2616**
	G											**1.0000**	0.5161**	0.3684*	-0.1651	-0.2768
KB	P												**10000**	-0.6031**	-0.0766	-0.2809**
	G												**1.0000**	-0.6110**	-0.0783	-0.2964*
L/B	P													**10000**	-0.0448	0.0735
	G													**1.0000**	-0.0463	0.0747
ZC	P														**10000**	-0.0276
	G														**1.0000**	-0.0296

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

spikelet fertility plays a crucial role in enhancing yield both directly and indirectly. Similar findings were reported by Kumar *et al.,* (2017), Sudeepthi *et al.,* (2020) and Vennela *et al.,* (2021).

1000-grain weight showed a significant positive genotypic association with kernel length and kernel breadth, while exhibiting significant negative correlations with grain yield and related traits such as days to 50% flowering, grains per panicle, spikelet fertility, milling percentage, and head rice recovery. Path analysis revealed a positive direct effect on grain yield, indicating its inherent importance despite the negative correlation. Positive indirect effects were observed through panicle length and kernel traits. Similar findings were reported by Lohiteswararao *et al.,* (2021), Vennela *et al.,* (2021) and Jasmine *et al.,* (2022).

Zinc content exhibited a non-significant negative correlation with grain yield and panicle length. Path analysis revealed a negative direct effect on grain yield, along with positive indirect effects through days to 50% flowering, plant height, panicle length, productive tillers and grains per panicle whereas negative indirect effects were observed *via* spikelet fertility and hulling percentage. These findings indicate a complex relationship between yield and zinc content, suggesting challenges in simultaneous improvement. Similar results were reported by Kiranmayee *et al.,* (2018) and Pandey *et al.,* (2018).

Hulling percentage showed a significant positive genotypic correlation with grain yield and related traits such as days to 50% flowering, plant height, panicle length, number of grains per panicle, spikelet fertility and milling percentage, while exhibiting negative associations with kernel breadth and productive tillers. However, path analysis revealed a negative direct effect on grain yield, indicating that its positive association was mainly due to positive indirect effects *via* productive tillers, 1000-grain weight and kernel traits. Similar results were reported by Vennela *et al.,* (2021) and Hemalatha (2018).

Milling percentage showed a significant positive genotypic correlation with grain yield and related traits such as days to 50% flowering, plant height, panicle length, number of grains per panicle, spikelet fertility, hulling percentage and head rice recovery, while exhibiting negative associations with productive tillers and 1000-grain weight whereas path coefficient revealed a negative direct effect on grain yield, indicating that its positive correlation was mainly due to positive indirect effects through productive tillers, 1000-grain weight and kernel traits. Similar results were reported by Rukmini Devi *et al.,* (2017), Hemalatha (2018) and Vennela *et al.,* (2021).

Head rice recovery showed a significant positive genotypic correlation with grain yield and related traits such as milling percentage, number of grains per panicle and days to 50% flowering whereas Path analysis revealed a positive direct effect on grain yield, supported by positive indirect effects *via* days to 50% flowering, plant height, panicle length, grains per panicle, productive tillers and spikelet fertility. These results indicate that head rice recovery contributes both directly and indirectly to yield improvement. Similar findings were reported by Rukmini Devi *et al.,* (2017), Devi *et al.,* (2019) and Singh *et al.,* (2019).

Kernel length showed a significant positive genotypic correlation with kernel breadth, L/B ratio and 1000-grain weight, while exhibiting negative and non-significant association with grain yield. Path analysis revealed a positive direct effect on grain yield through plant height, panicle length and 1000-grain weight. These findings indicate that kernel length has a direct role but its overall influence depends on interaction with other traits. Similar results were reported by Edukondalu *et al.,* (2017) and Singh *et al.,* (2018).

Kernel breadth showed a significant positive genotypic correlation with 1000-grain weight and kernel length, while exhibiting significant negative associations with grain yield, spikelet fertility and days to 50% flowering. Path analysis revealed a negative direct effect on grain yield, along with positive indirect effects through several yield-contributing traits days to 50% flowering, plant height, productive tillers, grains per panicle and quality traits indicating adversely affects grain yield both directly and indirectly. Similar results were reported by Singh *et al.,* (2018) and Radha *et al.,* (2019).

The length-to-breadth (L/B) ratio showed a significant positive genotypic correlation with kernel length and a significant negative association with kernel breadth, while exhibiting a non-significant positive correlation with grain yield. Path analysis revealed a negative direct effect on grain yield, indicating that its positive association was mainly due to positive indirect effects observed through grains per panicle, 1000-grain weight, milling percentage, head rice recovery, zinc content, and kernel breadth. These findings suggest that L/B ratio influences yield indirectly and should be considered along with other traits. Similar results were reported by Shivakumar *et al.,* (2018), Singh *et al.,* (2018) and Barhate *et al.,* (2021).

Grain yield per plant exhibited strong and consistent positive associations with key phenological, yield and quality traits, including days to 50% flowering, plant height, panicle length, number of grains per panicle, spikelet

Table 2: Phenotypic (P) and Genotypic (G) path coefficients of yield and quality traits in rice (*Oryza sativa* L.).

Source		DFF	PH	PL	NGP	NPT	SF	1000 GW	HP	MP	HRR	KL	KB	L/B	ZC	GYP
DFF	**G**	**-0.2666**	-0.1481	-0.1335	-0.1016	0.0029	-0.1654	0.1064	-0.1615	-0.1056	-0.0860	0.0437	0.0974	-0.0667	0.0347	0.3837**
	P	**-0.2282**	-0.1179	-0.0974	-0.0842	0.0013	-0.1363	0.0884	-0.0800	-0.0501	-0.0672	0.0366	0.0817	-0.0541	0.0294	0.3948**
PH	**G**	0.0455	**0.0820**	0.0641	0.0490	-0.0350	0.0594	-0.0117	0.0704	0.0573	0.0135	0.0002	-0.0137	0.0150	-0.0078	0.6670**
	P	0.0100	**0.0193**	0.0132	0.0107	-0.0052	0.0128	-0.0026	0.0084	0.0068	0.0028	-0.0002	-0.0031	0.0031	-0.0017	0.7201**
PL	**G**	-0.1391	-0.2171	**-0.2776**	-0.1607	0.0566	-0.1399	-0.0024	-0.1543	-0.1464	-0.0360	-0.0250	-0.0003	-0.0223	0.1148	0.5116**
	P	0.0259	0.0413	**0.0607**	0.0284	-0.0101	0.0251	0.0000	0.0143	0.0164	0.0051	0.0041	-0.0007	0.0039	-0.0213	0.6251**
NGP	**G**	0.3938	0.6180	0.5979	**1.0329**	-0.1443	0.3471	-0.6226	0.4974	0.6539	0.5225	-0.6117	-0.4007	-0.1453	-0.2392	0.6798**
	P	0.2176	0.3275	0.2756	**0.5897**	-0.0454	0.1900	-0.3340	0.1453	0.2258	0.2706	-0.3281	-0.2165	-0.0755	-0.1308	0.6571**
NPT	**G**	-0.0007	-0.0253	-0.0121	-0.0083	**0.0592**	-0.0269	-0.0112	-0.0376	-0.0187	0.0158	-0.0029	-0.0110	0.0092	-0.0089	-0.2125*
	P	0.0002	0.0083	0.0052	0.0024	**-0.0310**	0.0085	0.0031	0.0050	0.0075	-0.0047	0.0000	0.0038	-0.0036	0.0030	-0.3667*
SF	**G**	1.0000	1.1673	0.8117	0.5416	-0.7315	**1.6113**	-0.7391	1.2704	1.1232	0.0869	-0.2657	-0.6397	0.4855	0.3069	0.6511**
	P	0.3948	0.4367	0.2740	0.2130	-0.1805	**0.6612**	-0.2887	0.3144	0.2289	0.0367	-0.1023	-0.2484	0.1835	0.1231	0.6858**
1000 GW	**G**	-0.3446	-0.1228	0.0075	-0.5201	-0.1629	-0.3957	**0.8628**	-0.2117	-0.4463	-0.3298	0.6729	0.6660	-0.1071	-0.1025	-0.3948**
	P	-0.0187	-0.0065	0.0000	-0.0274	-0.0048	-0.0211	**0.0483**	-0.0066	-0.0128	-0.0171	0.0362	0.0362	-0.0056	-0.0056	-0.4215**
HP	**G**	-0.3406	-0.4827	-0.3124	-0.2707	0.3573	-0.4432	0.1379	**-0.5622**	-0.5124	-0.1135	0.0922	0.1938	-0.1389	-0.0961	0.2725**
	P	-0.0492	-0.0611	-0.0330	-0.0346	0.0225	-0.0667	0.0190	**-0.1403**	-0.0492	-0.0193	0.0091	0.0277	-0.0212	-0.0147	0.5167**
MP	**G**	-0.1320	-0.2331	-0.1757	-0.2110	0.1052	-0.2323	0.1723	-0.3037	**-0.3332**	-0.1006	0.1723	0.1222	0.0322	0.0243	0.3165**
	P	-0.0080	-0.0130	-0.0099	-0.0141	0.0088	-0.0127	0.0097	-0.0129	**-0.0367**	-0.0050	0.0102	0.0071	0.0013	0.0012	0.4945**
HRR	**G**	0.1002	0.0511	0.0403	0.1573	0.0827	0.0168	-0.1188	0.0627	0.0938	**0.3108**	-0.1671	-0.1063	-0.0413	-0.0154	0.3673**
	P	0.0792	0.0395	0.0228	0.1236	0.0409	0.0149	-0.0953	0.0370	0.0364	**0.2693**	-0.1286	-0.0810	-0.0326	-0.0122	0.4043**
KL	**G**	-0.0674	0.0010	0.0370	-0.2433	-0.0202	-0.0677	0.3204	-0.0673	-0.2125	-0.2208	**0.4108**	0.2120	0.1513	-0.0678	-0.2616**
	P	0.0093	0.0005	-0.0040	0.0323	-0.0001	0.0090	-0.0436	0.0038	0.0161	0.0278	**-0.0581**	-0.0289	-0.0215	0.0094	-0.2768
KB	**G**	0.2810	0.1282	-0.0007	0.2982	0.1428	0.3052	-0.5934	0.2650	0.2819	0.2629	-0.3967	**-0.7687**	0.4697	0.0602	-0.2809**
	P	-0.1137	-0.0508	-0.0035	-0.1166	-0.0393	-0.1193	0.2378	-0.0626	-0.0614	-0.0955	0.1578	**0.3175**	-0.1914	-0.0243	-0.2964*
L/B	**G**	-0.1425	-0.1040	-0.0457	0.0801	-0.0884	-0.1715	0.0707	-0.1407	0.0551	0.0756	-0.2097	0.3479	**-0.5694**	0.0264	0.0735
	P	0.0684	0.0459	0.0185	-0.0369	0.0331	0.0801	-0.0333	0.0436	-0.0104	-0.0349	0.1064	-0.1740	**0.2885**	-0.0129	0.0747
ZC	**G**	0.0007	0.0056	0.0245	0.0137	0.0089	-0.0113	0.0070	-0.0101	0.0043	0.0029	0.0098	0.0046	0.0027	**-0.0591**	-0.0276
	P	-0.0039	-0.0027	-0.0105	-0.0066	-0.0029	0.0056	-0.0035	0.0031	-0.0010	-0.0014	-0.0048	-0.0023	-0.0013	**0.0300**	-0.0296

Genotypic Residual effect =0.2789; Phenotypic Residual effect=0.4711; BOLD Values Are Direct Effects

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

fertility, hulling percentage, milling percentage and head rice recovery at both genotypic and phenotypic levels. In contrast, it showed significant negative associations with number of productive tillers, 1000-grain weight and kernel breadth, while associations with kernel length, L/B ratio, and zinc content were generally weak or non-significant. These results indicate that grain yield is largely influenced by major yield-contributing and processing quality traits, whereas some grain size and nutritional traits may have trade-offs with yield. Overall, selection strategies should prioritize traits positively associated with yield while carefully managing negatively associated traits to achieve balanced improvement. Residual effect in path analysis represents the unexplained portion of variation in grain yield after considering the studied traits and is calculated as $\sqrt{(1 - R^2)}$. In the present study, the residual effect was 0.2787 at the phenotypic level and 0.4789 at the genotypic level, indicating that the traits included in the analysis explained 72.13% and 52.11% of the variation in yield, respectively. The remaining variation (27.87% at phenotypic and 47.89% at genotypic levels) was attributed to other unmeasured factors. The results emphasize the importance of traits such as plant height (0.7201), number of grains per panicle (0.6571), spikelet fertility (0.6858) and head rice recovery (0.4043), which exhibited strong direct effects and should be prioritized in selection for yield improvement. The results discussed above are presented in Tables 1 and 2.

Conclusion

The current investigation revealed that plant height, number of grains per panicle, spikelet fertility, and head rice recovery were significantly and positively associated with grain yield per plant at both genotypic and phenotypic levels, and each exerted a positive direct effect on yield in path-coefficient analysis. In addition, these traits displayed significant positive interdependence with multiple yield-contributing characters, indicating that indirect selection through them would also favorably influence overall yield architecture. Consequently, concurrent selection for increased plant height, more grains per panicle, higher spikelet fertility and improved head rice recovery can be effectively employed as a selection strategy to enhance grain yield and post-harvest quality.

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