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Studies on Correlation and Path Coefficient Analysis in Elite Lines of Rice (*Oryza sativa* L.) for Yield and Yield Related Traits

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ABSTRACT

The present investigation was carried out during *Kharif*, 2021 at Regional Agricultural Research Station (RARS), Maruteru, with an objective to study the correlation and path coefficient analysis for yield and yield related traits. The experimental material comprised of 88 elite lines including checks namely, Maruteru Samba (MTU 1224), Sravani (MTU 1239) and Maruteru Mahsuri (MTU 1262) which were evaluated in alpha lattice design with two replications. Observations on days to 50 % flowering, plant height (cm), ear bearing tillers per m^2, panicle length (cm), number of grains per panicle, spikelet fertility (%), test weight (g) and grain yield per plant (g) were recorded. The correlation studies revealed that the traits, plant height, ear bearing tillers per m^2, panicle length and number of grains per panicle had significant positive genotypic correlation with grain yield per plant. This indicates that, the enhancement of grain yield is possible by giving emphasis on selection of these characters in breeding programmes. Direct positive association towards grain yield was contributed by the traits, ear bearing tillers per m^2, panicle length, number of grains per panicle, test weight and spikelet fertility indicating the importance of these traits as selection criteria for enhancing the yield potential.

Keywords: *Alpha lattice design, Correlation, Elite lines, Path coefficient analysis and Rice.*

Rice (*Oryza sativa* L. 2n=2x=24) is the most important food crop that provides a significant portion of carbohydrates to the world's population. The rate of world's population growth has exceeded the rate of growth in food-grain production. The demand for rice is still increasing in Asia as the consumption rate is at least 90% and it is globally projected that the demand for rice will rise up to 650 million tonnes by 2050 (Chukwu *et al*., 2019). Correlation is the measure of the mutual relationship between two variables. Phenotypic correlation provides the extent to which the two variables are associated and is governed by genotypic and environmental correlation whereas genotypic correlation plays a vital role in the development and execution of suitable breeding programmes. The path coefficient analysis allows the separation of the correlation coefficients into direct as well as indirect effects. It implies whether the association of independent traits on the dependent trait, yield, is due to their direct effects or is a consequence of their indirect effects through other component traits. Path coefficient analysis was carried out by the procedure originally proposed by Wright (1921) which was subsequently elaborated by Dewey and Lu (1959) to estimate the direct and indirect effects of the individual characters on yield.

MATERIAL AND METHODS

The present investigation was carried out to assess the correlation and path analysis in the elite lines during *Kharif*, 2021. The experiment was carried out at Regional Agricultural Research Station (RARS), Maruteru, West Godavari district of Andhra Pradesh located at 81.44^0 E longitude, 26.38^0 N latitude and 5 m above mean sea level, in Godavari Zone. The experimental material comprised of 88 elite lines including checks namely, Maruteru Samba (MTU 1224), Sravani (MTU 1239), Maruteru Mahsuri (MTU 1262). The present experiment was laid out in Alpha lattice design with two replications.

Data Collection

Observations were recorded on five randomly selected plants without border effect as per the methodology given in SES, IRRI, (2014) and the average values obtained for each character was subjected to statistical analysis, except, days to 50% flowering. For days to 50% flowering the observations were recorded on plot basis. Data were collected on eight yield and yield contributing characters *viz*., days to 50% flowering, plant height (cm), ear bearing tillers per m^2, panicle length (cm), number of grains per panicle, spikelet fertility (%), test weight (g) and grain yield per plant (g).

Statistical Analysis

The data collected on individual characters were subjected to method of analysis of variance commonly applicable to alpha lattice design as per the mathematical model proposed by Williams and Patterson (1977). Test of significance for each character was carried out against the corresponding error degrees of freedom using 'F' table values given by Fisher and Yates (1963). The correlation between ten characters was calculated using the method given by Johnson *et al.* (1955). Direct and indirect effects were estimated as described by Dewey and Lu (1959). Statistical analysis was done by using software R version 4.2.0.

RESULTS AND DISCUSSION

In the present study, genotypic correlation was higher than the corresponding phenotypic correlation Table 1 for most of the traits, which can be explained by masking or modifying effects of environment on genetic association between characters (Chavan *et al*., 2022).

CORRELATION STUDIES

Days to 50% flowering showed a significant and positive genotypic correlation with plant height (0.563**), panicle length (0.544**), test weight (0.318 **) and grain yield per plant (0.262*). These results were in accordance with Lilly *et al*. (2018) for test weight, Akbar *et al*. (2021) for plant height, panicle length and grain yield per plant. Plant height (0.536**), ear-bearing tillers per m^2 (0.165*), panicle length (0.524**), test weight (0.297**) and grain yield per plant (0.236**) exhibited significant and positive phenotypic correlation with days to 50% flowering. These results were in conformity with Chavan *et al*. (2022) for number of ear-bearing tillers. These results denote that increase in duration of crop provides opportunity to increase ear bearing tillers per plant. Selection of long duration lines would be desirable as it increases number of ear bearing tillers.

Plant height showed significant and positive genotypic association with days to 50 % flowering (0.563**), panicle length (0.630**), number of grains per panicle (0.215*) and grain yield per plant (0.305**). These results were similar to the reports of Akbar *et al*. (2021) and Nath *et al*. (2021). Days to 50% flowering (0.536**), panicle length (0.582**), number of grains per panicle (0.200**), test weight (0.192*) and grain yield per plant (0.279**) demonstrated significant and positive phenotypic correlations with plant height. Similar result was observed by Chavan *et al*. (2022) for test weight. These results indicated that increase in plant height results in large source for photosynthesis and sink in terms of longer panicles, increased number of grains per panicle, test weight and grain yield per plant.

The ear bearing tillers per m^2 showed a significant positive phenotypic association with days to 50% flowering (0.165*), grain yield per plant (0.442**) and significant negative association with number of grains per panicle (-0.173*). Similar result was reported by Chavan *et al*. (2022) for days to 50% flowering. Significantly positive genotypic associations with grain yield per plant (0.530**) and significantly negative associations with the number of grains per panicle (-0.229*) were found for ear bearing tillers per m^2. Above pattern of results were identical to the findings of Tushara *et al*. (2013) and Akbar *et al*. (2021) for total number of grains per panicle and grain yield. According to these findings, more emphasis should be placed on this trait ear bearing tillers per m^2, in order to achieve higher yields.

Panicle length showed a significant and positive genotypic correlation with days to 50% flowering (0.544**), plant height (0.630**), test weight (0.357**) and grain yield (0.226**). The results were in agreement with Sadimantara *et al*. (2021) and Singh *et al*. (2022). Days to 50% flowering (0.524**), plant height (0.582**), test weight (0.324**) and grain yield (0.215**) all showed significant and positive phenotypic correlations with panicle length. Shorter panicle length is one of the causal factors for yield reduction (Kato *et al*., 2014). It would be advantageous to use lines with longer panicles because they would produce greater test weight, which would ultimately impact on yield.

The number of grains per panicle showed a significant positive phenotypic correlation with plant height (0.200**) and grain yield (0.276**) but a significant negative correlation with test weight (-0.665**) and ear bearing tillers (-0.173*). The results were in similarity with Debsharma *et al*. (2020) and Barhate *et al*. (2021) for test weight, plant height and grain yield per plant. The number of grains per panicle revealed a significant positive genotypic correlation with plant height (0.215*) and grain yield per plant (0.299**) and a significant negative association with ear bearing tillers per m^2 (-0.229*) and test weight (-0.700**). The findings suggest that an increase in no. of grains per panicle boosts grain yield per plant. Indirectly selecting lines with more grains per panicle would be beneficial, since it could result in better grain yields.

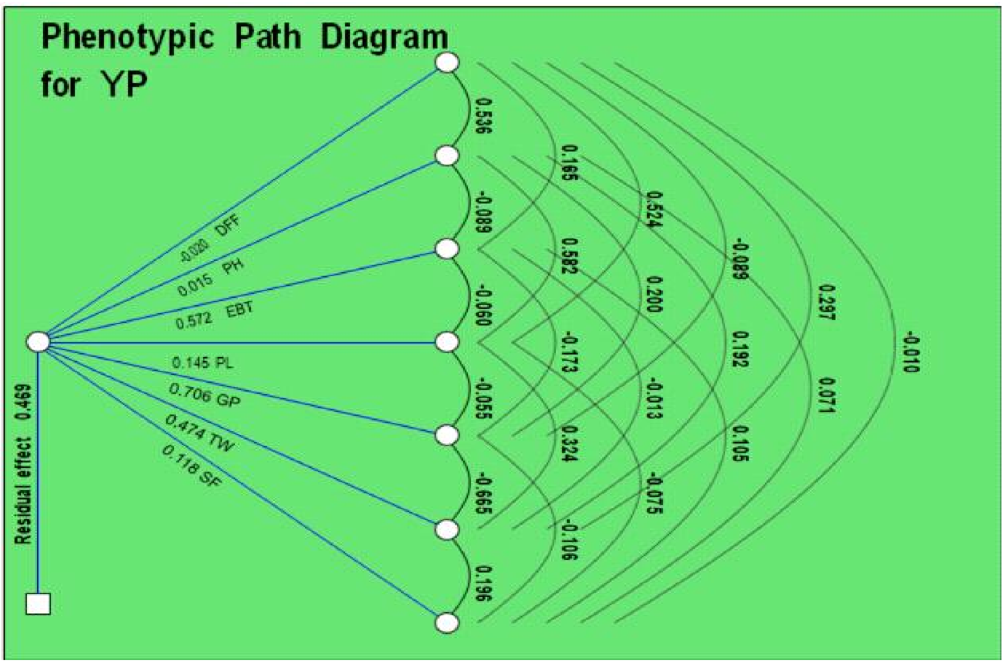

Fig. 1: Phenotypic path diagram depicting direct and indirect effects on grain yield

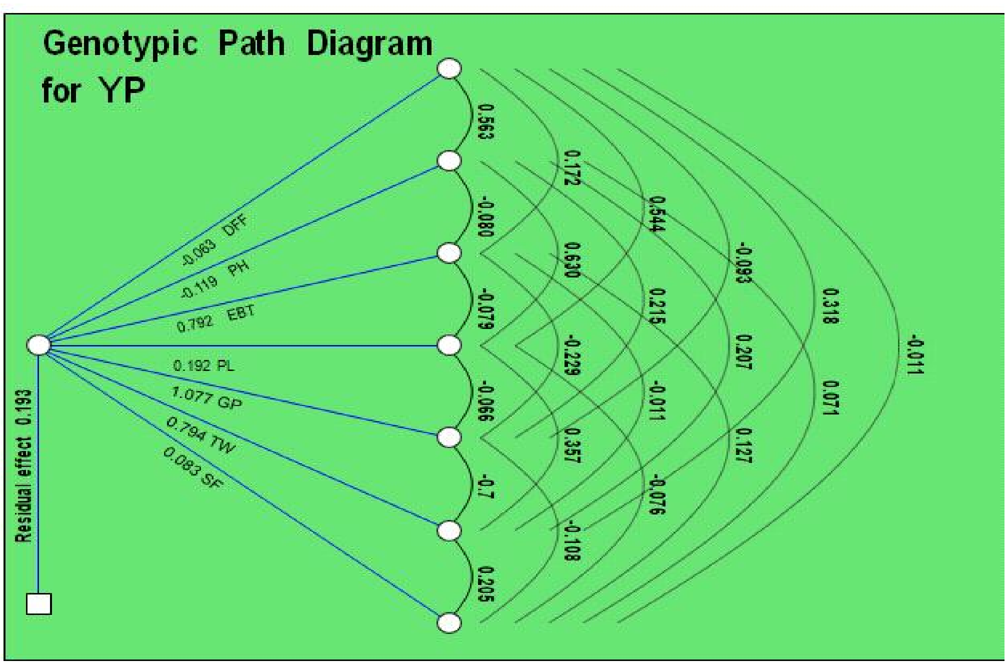

Fig. 2: Genotypic path diagram depicting direct and indirect effects on grain yield

Table. 1: Estimates of genotypic and phenotypic correlation among yield and yield component traits in rice

Character		Days to 50% flowering (days)	Plant height (cm)	Ear bearing tillers per m^2	Panicle length (cm)	Number of grains per panicle	Test weight (g)	Spikelet fertility (%)	Grain yield per plant (g)
Days to 50% flowering (days)	r_g	1	0.563**	0.172	0.544**	-0.093	0.318**	-0.011	0.262*
	r_p	1	0.536**	0.165*	0.524**	-0.089	0.297**	-0.010	0.236**
Plant height (cm)	r_g		1	-0.080	0.630**	0.215*	0.207	0.071	0.305**
	r_p		1	-0.089	0.582**	0.200**	0.192*	0.071	0.279**
Ear bearing tillers per m^2	r_g			1	-0.079	-0.229*	-0.011	0.127	0.530**
	r_p			1	-0.060	-0.173*	-0.013	0.105	0.442**
Panicle length (cm)	r_g				1	-0.066	0.357**	-0.076	0.226**
	r_p				1	-0.055	0.324**	-0.075	0.215**
Number of grains per panicle	r_g					1	-0.700**	-0.108	0.299**
	r_p					1	-0.665**	-0.106	0.276**
Test weight (g)	r_g						1	0.205	0.073
	r_p						1	0.196**	0.064
Spikelet fertility (%)	r_g							1	0.207
	r_p							1	0.187*
Grain yield per plant (g)	r_g								1
	r_p								1

r_p = Phenotypic correlation coefficient, r_g = Genotypic correlation coefficient, *Significant at 5% level and **Significant at 1% level

Table. 2: Estimates of genotypic and phenotypic direct and indirect effects on grain yield in rice

Character		Days to 50% flowering (days)	Plant height (cm)	Ear bearing tillers per m^2	Panicle length (cm)	Number of grains per panicle	Test weight (g)	Spikelet fertility (%)	Grain yield per plant (g)
Days to 50% flowering (days)	G	**-0.063**	-0.067	0.136	0.104	-0.100	0.252	-0.001	0.262*
	P	**-0.020**	0.008	0.094	0.076	-0.063	0.141	-0.001	0.236**
Plant height (cm)	G	-0.035	**-0.119**	-0.063	0.121	0.231	0.165	0.006	0.305**
	P	-0.011	**0.015**	-0.051	0.085	0.141	0.091	0.008	0.279**
Ear bearing tillers per m^2	G	-0.011	0.010	**0.792**	-0.015	-0.247	-0.009	0.011	0.530**
	P	-0.003	-0.001	**0.572**	-0.009	-0.122	-0.006	0.012	0.442**
Panicle length (cm)	G	-0.034	-0.075	-0.063	**0.192**	-0.071	0.284	-0.006	0.226*
	P	-0.011	0.009	-0.034	**0.145**	-0.039	0.154	-0.009	0.215**
Number of grains per panicle	G	0.006	-0.026	-0.181	-0.013	**1.077**	-0.556	-0.009	0.299**
	P	0.002	0.003	-0.099	-0.008	**0.706**	-0.316	-0.013	0.276**
Test weight (g)	G	-0.020	-0.025	-0.009	0.069	-0.754	**0.794**	0.017	0.073
	P	-0.006	0.003	-0.007	0.047	-0.470	**0.474**	0.023	0.064
Spikelet fertility (%)	G	0.001	-0.008	0.101	-0.015	-0.116	0.163	**0.083**	0.207
	P	0.00021	0.001	0.060	-0.011	-0.075	0.093	**0.118**	0.187*

Direct effects on main diagonal, G: Genotypic path coefficient, P: Phenotypic path coefficient,
Residual effects (G): 0.192, Residual effects (P): 0.469

Days to 50% flowering (0.318**) and panicle length (0.357**) showed significant positive genotypic associations with test weight, while number of grains per panicle (-0.700**) showed a significant negative genotypic association. Above pattern of results were also revealed by Lilly *et al*. (2018) for days to 50% flowering, Vennela *et al*. (2021) for panicle length and Barhate *et al*. (2021) for number of grains per panicle. Test weight showed a significant negative genotypic association with number of grains per panicle (-0.665**), but a significant positive phenotypic association with days to 50% flowering (0.297**), plant height (0.192*), spikelet fertility (0.196**) and panicle length (0.324**). These results were in accordance with Chavan *et al*. (2022) for plant height and spikelet fertility.

Test weight (0.196**) and grain yield per plant (0.187*) showed a significant positive phenotypic association with spikelet fertility. The results were in accordance with Akbar *et al*. (2021) for grain yield per plant and Chavan *et al*. (2022) for test weight. These results indicated that the lines with more fertile grains per panicle recorded higher grain yield.

The number of grains per panicle (0.299**), plant height (0.305**), ear-bearing tillers (0.530**), panicle length (0.226**), and days to 50% flowering (0.262*) manifested significant and positive correlation with grain yield per plant. The results were in similarity with Edukondalu *et al*. (2017) for total number of ear bearing tillers and panicle length, Sharma *et al*. (2020) for days to 50% flowering and number of grains per panicle, Vennela *et al*. (2021) for plant height. The phenotypic relationship between grain yield per plant was significant and positive for days to 50% flowering (0.236**), plant height (0.279**), ear-bearing tillers per m^2 (0.442**), panicle length (0.215**), number of grains per panicle (0.276**), and spikelet fertility (0.187*). These findings were in agreement with the reports of Naik *et al.* (2005) and Akbar *et al*. (2021).

PATH COEFFICIENT ANALYSIS

The path coefficient analysis allows the separation of the correlation coefficients into direct as well as indirect effects of the independent variable on the dependent variable. It implies whether the association of independent traits on the dependent trait, yield, is due to their direct effects or is a consequence of their indirect effects through other component traits. Correlation in combination with path analysis gives a better insight into cause and effect relationship between characters.

The direct and indirect effects of the seven characters on grain yield per plant was estimated by path coefficient analysis using genotypic as well as phenotypic correlation coefficients and the results were presented in the Table. 2. Phenotypic and genotypic path diagrams showing direct and indirect effects on grain yield per plant were presented in Fig. 1. and Fig. 2. respectively.

The direct effect of ear bearing tillers per m^2 on grain yield per plant was observed to be high and positive (0.792, 0.572) at genotypic as well as phenotypic levels, indicating the effectiveness of direct selection for this trait in improvement of grain yield per plant. These results were in agreement with the findings of Deepthi *et al*. (2022), Jasmine *et al*. (2022) at both genotypic and phenotypic levels. At genotypic level the trait number of ear bearing tillers per m^2 possessed negative indirect effect on grain yield per plant *via* days to 50% flowering, panicle length, number of grains per panicle and test weight. Apart from the negative indirect effect, this trait also possessed positive indirect effects on grain yield per plant *via* plant height and spikelet fertility. At phenotypic level this trait possessed negative indirect effect on grain yield per plant *via* days to 50% flowering, plant height, panicle length, number of grains per panicle and test weight. It also had positive indirect effects on grain yield per plant *via* spikelet fertility.

Direct effect of panicle length on grain yield per plant was observed to be low and positive (0.192, 0.145**)** at genotypic and phenotypic levels, proving that improving grain yield per plant through direct selection for this trait is effective. Similar results were reported by Mounika *et al*. (2022) at genotypic level and phenotypic level.

The direct effect of the trait, number of grains per panicle on the grain yield per plant was observed to be very high and positive (1.077) at genotypic level; high and positive (0.706**)** at phenotypic level, so direct selection for this trait would be rewarding for yield improvement. These results were in conformity with the findings of Saha *et al*. (2019) at genotypic level and phenotypic level. At genotypic level the trait number of grains per panicle, possessed negative indirect effect on grain yield per plant *via* plant height, ear bearing tillers per m^2, panicle length, test weight and spikelet fertility. Apart from the negative indirect effect, this trait also possessed positive indirect effects on grain yield per plant *via* days to 50% flowering. At phenotypic level the trait number of grains per panicle, possessed negative indirect effect on grain yield per plant *via* ear bearing tillers per m^2, panicle length, test weight and spikelet fertility. This trait also had positive indirect effects on grain yield per plant *via* days to 50% flowering and plant height.

Direct effect of test weight on grain yield per plant was observed to be high and positive (0.794, 0.474) at genotypic and phenotypic levels, yield improvement would benefit from direct selection for this trait. The results were in agreement with the findings of Jasmine *et al*. (2022) at genotypic level and Hossain *et al*. (2020) at phenotypic level.

Direct effect of spikelet fertility on grain yield per plant was observed to be negligible and positive (0.083) at genotypic level; low and positive (0.118) at phenotypic level. In order to increase grain yield, direct selection for this trait would be advantageous. The results were in agreement with the findings of, Kishore *et al*. (2018) at genotypic level and phenotypic level.

Residual effect

Residual effects were 0.193 at genotypic and 0.469 at phenotypic levels. This indicated that only about 80.7 (genotypic) and 53.1 (phenotypic) per cent of the variability in grain yield was explained by the variables studied in the current investigation. As a result, other characteristics besides the studied characters also contributed to grain yield per plant in the selection programme.

CONCLUSION

The correlation studies revealed that the traits, plant height, ear bearing tillers per m^2, panicle length and number of grains per panicle had significant positive genotypic correlation with grain yield per plant. This indicates that, the enhancement of grain yield is possible by giving emphasis on selection of these characters in breeding programmes. Direct positive association towards grain yield was contributed by the traits, ear bearing tillers per m^2, panicle length, number of grains per panicle, test weight and spikelet fertility indicating the importance of these traits as selection criteria for enhancing the yield potential.

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