

Characters association and selection criteria for irrigated ecosystem in rice (*Oryza sativa* L.) genotypes

Abstract

Grain yield in rice is a complex quantitative trait influenced by various yield determining traits besides environmental factors. The association of different characters is essential to determine their contribution towards yield. Understanding both the direction and strength of correlation is employed to evaluate how the improvement in one trait may result in enhancements or simultaneous changes in other traits. The current study aimed to determine correlation and path coefficients among the seventy rice accessions for eight traits to establish selection criteria which might help to develop genotypes for high yielding. The results of correlation analysis showed traits like number of filled grains per plant, spikelet fertility (%), 100 seed weight (g), biological yield per plant (g) and harvest index had positive significant association with the grain yield per plant. The direct and indirect effects through path coefficient analysis unveils maximum positive direct effect of panicle length, panicle number per plant, number of filled grains per panicle, spikelet fertility, 100 seed weight, biological yield per plant and harvest index on grain yield per plant. From the results obtained from the present study, it can be concluded that selection for higher biological yield, spikelet fertility and harvest index will be useful for obtaining higher grain yield in rice crop. These plant characters play a major role in shaping the single plant yield in rice on which selection pressure has to be applied for increasing the seed yield.

Keyword: Rice, Quantitative Character, Association analysis, Selection criteria,

Introduction:

Rice (*Oryza sativa* L.) is one of the most important grains for global nutrition and the primary source of energy for people in Asia, Africa, and Latin America (Fukagawa and Ziska, 2019). India comprises more than 25% of the rice cultivation culture area in of the world and is the world's second-biggest rice producer. This crop also plays an important role in the food supply and country's food security in India. (Rathna Priya et al. 2019).

Rice cultivars with better yields are desperately needed to meet future consumer demands. Grain yield in rice is a complex quantitative trait influenced by various component traits such as the number of tillers per plant, panicle length, number of grains per panicle, and thousand-grain weight besides environmental factors. The association of different characters was essential to determine their contribution towards yield. Understanding both the direction and strength of correlation is employed to evaluate how the improvement in one trait may result in enhancements or simultaneous changes in other

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traits. The correlation coefficient can be a valuable tool for pinpointing characteristics that hold minimal or negligible importance within the selection process [Singh et al. 2014 \(29\)](#). Correlation studies provide an opportunity to study the magnitude and direction of association among different traits with grain yield and their direct and indirect effect on grain yield. Correlation analysis offers insights into the nature and strength of relationships among different traits, enabling the identification of key component traits. These component traits serve as the basis for selecting traits that can be genetically improved to enhance grain yield. [\(Hallauer et al., 1998\)](#). Genotypic correlation assesses how genetic components influencing various traits are related, while phenotypic correlation considers the combined effects of both genetic and environmental factors.

Path analysis, on the other hand, evaluates how individual yield component traits contribute to overall grain yield, accounting for both direct and indirect effects. Path analysis is used to determine the extent of the contribution made by individual yield component trait to the ultimate grain yield, encompassing both direct and indirect effects [Nithya et al., 2009 \[32\]](#). Path analysis goes beyond simple correlations by partitioning the observed correlation between yield and a contributing trait into direct and indirect effects. This allows breeders to identify traits that directly influence yield and those that exert their influence indirectly through other contributing traits.

Such insights are essential for breeders and scientists working on rice improvement programs, as they enable the identification of key traits that can be targeted for crop enhancement through selective breeding or genetic modification. In view of above, the present research investigation was undertaken to find out the association and path analysis for yield and its contributing traits.

Materials and Methods

Plant Material: The experimental material was comprised of total 65 rice genotypes i.e. 60 germplasm accessions with 5 checks (PUSA 44, IR 64, JAYA, PUSA SAMBA 1850 and MTU 1010) listed in [Table 1 received](#) from DBT Network Rice Project “Mainstreaming rice diversity in varietal development through genomic predictions”.

Table 1: List of rice genotypes including in the study

S. No	Genotypes	S.No	Genotypes	S.No	Genotypes
1	IC282460	23	IC460221	45	IC256786
2	IC596554	24	IC282473	46	IC115682
3	IC512614	25	IC464245	47	IC460201X
4	IC463323	26	IC462086	48	IC464139
5	IC464658	27	IC311127	49	IC132917
6	IC467188	28	IC591542	50	IC466224
7	IC466210	29	IC466755	51	IC512882
8	IC459039	30	IC464409	52	IC449740X
9	IC579771	31	IC99435	53	IC465001

10	IC463204	32	IC462765	54	IC466765
11	IC579740	33	IC619258	55	IC390434
12	IC464340	34	IC464128	56	IC458791
13	IC463722	35	IC37076	57	IC206805
14	IC462058	36	IC517898	58	IC514505
15	IC463042	37	IC388862	59	IC114773
16	IC203141	38	IC454516	60	IC377915
17	IC145649	39	IC464668	61 (CH1)	PUSA 44
18	IC591528	40	IC463076	62 (CH2)	IR 64
19	IC558270	41	IC462098	63 (CH3)	JAYA
20	IC459792	42	IC466664	64 (CH4)	PUSA SAMBA 1850
21	IC458102	43	IC463929	65 (CH5)	MTU 1010
22	IC568227	44	IC247997		

Field Experiments: This investigation was carried out at the Research-cum-Instructional Farm, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh during *Khari* 2023. The experiment was conducted in Randomized Complete Block Design (RCBD) with two replications in transplanted condition. The net plot area was 270 m sq with both row to row and plant to plant distance of 20 cm x 15 cm. Recommended cultural practices were applied for all the treatments. Observations were recorded for Plant height (cm) (PH), panicle length (cm) (PL), Panicle numbers per plant (PNP), number of filled grains per panicle (FGPP), spikelet fertility (%) (SF), 100 seed weight (g) (100SW), biological yield per plant (g) (BYPP), grain yield per plant (g) (GYPP) and harvest index (%) (HI) on single plant basis on five randomly selected plants from each plot. Means across two replications were calculated for each character and used for data analysis.

Statistical analysis: Statistical analysis of all characters was done following Dewey and Lu (1959) for path analysis and Singh and Chaudhary (1977) for correlation coefficient analysis. The strength of direct and indirect effect values scaled according to Lenka and Mishra (1973) as follows: Very high (>0.40), High (0.30 to 0.39), Moderate (0.20 to 0.29), Low (0.10 to 0.19) and Negligible (0.00 to 0.09).

Results & discussion :

Genotypic and phenotypic correlations in rice yield refer to the relationships between different traits or characteristics and their influence on the yield of rice crops. The genotypic correlation examines the degree of association between the genetic factors (genes) responsible for different traits and the resulting yield. It helps plant breeders understand how closely related genetic factors contribute to yield variation Li et al., 2018 (30). Phenotypic correlation considers the observable traits or characteristics in the plant

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(phenotype) and how they relate to each other and impact yield. It considers the combined effects of genetics and environmental conditions. Both genotypic and phenotypic correlations play a crucial role in understanding the complex interactions between various traits and their effects on rice yield (Jayasudha et al., 2010) (31)

The genotypic and phenotypic correlation for nine metric traits with yield is mentioned in Table 2. Results showed that genotypic correlation coefficient was higher than phenotypic correlation coefficient for most of the traits that indicated that there was genetically strong association among the traits but the phenotypic value is lessened by the significant interaction of environment (Bhattacharyya et al., 2007) (Bhattacharyya et al., 2007). The phenotypic correlation in some cases was higher than their genotypic correlation, which indicates the suppressing effect of the environment that can alter the expression of characters at the phenotypic level.

At both genotypic and phenotypic levels, highly significant and positive correlations were observed for grain yield per plant with number of filled grains per plant, Spikelet fertility (%), 100 seed weight (g), Biological yield per plant (g) and harvest index. Plant height had highly significant positive correlation with panicle length and significant positive correlation with 100 seed weight which was supported by Srijan et al. (2016). Correlation between Panicle Length (cm) and plant height (cm), number of filled grains, 100 seed weight (g) and biological yield per plant were highly significant and positive correlation at both levels. Number of grains per panicle and number of filled grains per plant had significant positive correlation with yield per plant and these results are in consistent with the findings of Kumar et al. (2017). It indicates strong association of number of filled grain per plant, spikelet fertility %, 100 seed weight, biological yield per plant and harvest index traits with grain yield per plant and selection for these traits will be useful in improving grain yield. Positive correlation between desirable traits is favourable because it helps in simultaneous improvement of both the characters. On the other hand, negative correlation will hinder the simultaneous expression of both characters with high values. In such situation some economic compromise has to be made.

Path coefficient analysis is a valid statistical method for dividing correlation coefficients into direct and indirect effects. It was used to partition the observed correlation coefficients between grain yield per plant as dependent variable and its component traits into direct and indirect effects. The estimates of path coefficients for quality and yield attributing traits on grain yield are furnished in Table 3.

Path coefficient analysis was used to partition the observed correlation coefficients between grain yield per plant as dependent variable and its component traits into direct and indirect effects. Panicle length, Panicle number per plant, Number of filled grains per panicle, Spikelet fertility, 100 seed weight, biological yield per plant and harvest index had direct positive effect on grain yield per plant with the highest contribution of biological yield per plant (Table 2). Similar findings were reported for Panicle length by Seyoum et al. (2012), Sudeepti et al., (2020); for panicle number per plant

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(Gunasekaran et al., 2017) and 100 seed weight by Devi et al., (2017). Direct positive effect of the aforesaid characters on grain yield indicated that selection of these traits is directly helpful for the improvement of yield. The highest positive indirect effect on grain yield per plant was recorded by biological yield per plant followed by harvest index via 100 seed weight. Similar findings were recorded by Saran et al. (2023), in which the path association analysis revealed that biological yield had the maximum effect on seed yield, followed by Harvest index, Panicle length and so on. High direct effect along with positive and high indirect effects through other traits provides a better chance for a character to be selected in breeding programs (Gour et al. 2017). Number of filled grain per plant, spikelet fertility %, 100 seed weight, biological yield per plant and harvest index had positive direct effect and exhibited significant positive correlation with grain yield per plant, indicating a true relationship among these traits.

In this study, plant height had direct negative direct effect on grain yield per plant, similar to the results of Lakshmi et al., 2020. Negative direct effect of plant height on grain yield per plant indicated that tallness in rice lowers the yield due to high accumulation of photosynthates in vegetative parts as compared to reproductive parts (i.e. seed formation and grain filling) and lodging susceptibility (Zahid et al. 2006).

Panicle length exhibited negative correlation with grain yield per plant along with positive direct effect on grain yield. The direct effect of panicle length was seemed to be neutralized by its considerable indirect negative effects via plant height, panicle number per plants, spikelet fertility. The same result was recently reported by Kumar et al. (2017). If the correlation of a character with yield is negative but its direct effect is positive and high, a restricted simultaneous selection model should be followed, i.e. restrictions are to be imposed to nullify the unwanted indirect effects in order to make use of the direct effect (Rashid et al. 2010; Archana et al., 2018).

The residual value in path analysis represents the amount of unexplained variance in the dependent variable(s) after accounting for the variance explained by the independent variables through the path model. In the present investigation the residual effect was 0.096 which means that the characters in the path analysis explained 90.4% expressed the seed yield variability by 91.5% and remaining 9.68.5% needs additional characterization. This indicated that the majority of yield attributing traits are taken into account in this study.

CONCLUSIONS

The correlation coefficients and direct effects of the traits related to grain yield indicated that there are strong positive direct effects and highly significant positive associations between grain yield and the following traits Spikelet fertility, biological yield per plant and harvest index. These findings suggest that for improvement of rice grain yield, selection should be focused on the above mentioned characteristics to achieve higher grain yields. From the results obtained from the present study, it can be concluded that selection

for higher biological yield, spikelet fertility and harvest index will be useful for obtaining higher grain yield in rice crop during kharif season.

References

- Archana R, Sudha M, Vishnu V and Fareeda G. 2018. Correlation and path coefficient analysis for grain yield, yield components and nutritional traits in rice (*Oryza sativa* L.). International Journal of Chemical Studies, 6: 189-195.
- Bhattacharyya R, Roy B, Kabi MC and Basu AK. 2007. Character association and path analysis of seed yield and its attributes in rice as affected by bio-inoculums under tropical environment. Tropical Agricultural Research Extension, 10: 23–28.
- Devi KR, Chandra BS, Lingaiah N, Hari Y and Venkanna V. 2017. Analysis of variability, correlation and path coefficient studies for yield and quality traits in rice (*Oryza Sativa* L.). Agricultural Science Digest, 37(1): 1–9.
- Dewey DR and Lu KH. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. Agronomy Journal, 5: 515-518.
- Fukagawa NK and Ziska LH. 2019. Rice: Importance for global nutrition. J Nutr Sci Vitaminol (Tokyo). 65: 52-53.
- Gour L, Koutu GK, Singh SK, Patel DD, Shrivastava A and Singh Y. 2017. Genetic variability, correlation and path analyses for selection in elite breeding materials of rice (*Oryza sativa* L.) genotypes in Madhya Pradesh. The Pharma Innovation Journal, 6(11): 693–696.
- Gunasekaran K, Sivakami R, Sabariappan R, Ponnaiah G, Nachimuthu VV and Pandian BA. 2017. Assessment of genetic variability, correlation and path coefficient analysis for morphological and quality traits in rice (*Oryza sativa* L.). Agricultural Science Digest, 37: 251-256.
- Hallauer AR and Miranda Filho JD. 1998. Quantitative genetics in maize breeding. Ames. Iowa State University Press. 10:468.
- Jayasudha S and Sharma D. 2010. Genetic parameters of variability, correlation and path-coefficient for grain yield and physiological traits in rice (*Oryza sativa* L.) under shallow lowland situation. Electronic Journal of Plant Breeding. 1(5):1332- 1338.
- Kumar S, Bhuvaneshwari S, Devi EL, Sharma SK, Ansari MA, Singh IM, Singh YR and Prakash N. 2017. Estimation of genetic variability, correlation and path analysis in short duration rice genotypes of Manipur. Journal of Agri Search, 4(2): 112–118.
- Lakshmi VGI, Sreedhar M, Gireesh C and Vanisri S. 2020. Genetic variability, correlation and path analysis studies for yield and yield attributes in African rice (*Oryza glaberrima* L.) germplasm. Electronic Journal of Plant Breeding, 11: 399- 404.

- Lenka D and Mishra B. 1973. Path coefficient analysis of yield in rice varieties. *Indian Journal of Agricultural Sciences*, 43: 376-379
- Li F, Xie J, Zhu X, Wang X, Zhao Y, Ma X, Zhang Z, Rashid MA, Zhang Z, Zhi L and Zhang S. 2018. Genetic basis underlying correlations among growth duration and yield traits revealed by GWAS in rice (*Oryza sativa* L.). *Frontiers in plant science*. 9:650.
- Nithya N, Beena R, Stephen R, Abida PS, Jayalekshmi VG, Viji MM and Manju RV. 2020. Genetic variability, heritability, correlation coefficient and path analysis of morphophysiological and yield related traits of rice under drought stress. *Chemical Science Review and Letters*. 9
- Rashid MH, Parveen S and Bhuiyan MSR. 2010. Genetic variability, correlation and path coefficient analysis in nineteen *Brassica rapa* germplasm. *Journal of Sher-e Bangla Agricultural University*, 4(1): 84–89.
- Rathna Priya TS, Nelson ARLE, Ravichandran K and Antony U. 2019. Nutritional and functional properties of coloured rice varieties of South India: a review. *J. Ethn. Food*. 6: 1-11.
- Saran D, Gauraha D, Sao A, Sandilya VK and Kumar R. 2023. Correlation and Path Coefficient Analysis for Yield and Yield Attributing Traits in Rice (*Oryza sativa* L.). *International Journal of Plant & Soil Science*, 35(18): 94-101.
- Seyoum M, Alamerew S and Bantte K. 2012. Genetic variability, heritability, correlation coefficient and path analysis for yield and yield related traits in upland rice (*Oryza sativa* L.). *Journal of Plant Sciences*, 7(1): 13–22.
- Singh AK, Nandan R and Singh PK. 2014. Genetic variability and association analysis in rice Germplasm under rainfed conditions. *Crop Research*. 47(1-3):7–11.
- Singh RK and Chaudhury BD. 1985. Biometrical method in quantitative genetic analysis. Kalyani Publishers, Ludhiana, New Delhi, India. pp. 318.
- Srijan A, Kumar SS, Raju CD and Jagadeeshwar R. 2016. Character association and path coefficient analysis for grain yield of parents and hybrids in rice (*Oryza sativa* L.). *Journal of Applied and Natural Science*, 8(1): 167–172.
- Sudeepthi K, Srinivas T, Kumar BNVS, Jyothula DPB and Umar SkN. 2020. Assessment of genetic variability, character association and path analysis for yield and yield component traits in rice (*Oryza sativa* L.). *Electronic Journal of Plant Breeding*, 11: 144-148.
- Zahid MA, Akhtar M, Sabir M, Manzoor Z and Awan TH. 2006. Correlation and path analysis studies of yield and economic traits in Basmati rice (*Oryza sativa* L.). *Asian Journal of Plant Science*, 5: 643–645.

Table 2. Correlation coefficient among yield and its components.

Characters	r	Plant height (cm)	Panicle length (cm)	Panicle numbers per plant	Number of filled grains per plant	Spikelet fertility (%)	100 seed weight (g)	Biological yield per plant (g)	Harvest Index (%)	Grain yield per plant (g)
Plant height (cm)	P	1	0.441**	-0.351**	0.002	0.107	0.234*	0.134	-0.354**	-0.137
	G	1	0.503**	-0.373**	0.014	0.182*	0.239*	0.163	-0.381**	-0.159
Panicle length (cm)	P		1	-0.306**	0.211*	-0.195*	0.227*	0.255*	-0.404**	-0.094
	G		1	-0.396**	0.290**	-0.545**	0.340**	0.312**	-0.510**	-0.097
Panicle numbers per plant	P			1	-0.404**	0.001	-0.279*	-0.166	0.292**	0.155
	G			1	-0.475**	0.070	-0.269*	-0.260*	0.323**	0.126
Number of filled grains per plant	P				1	0.082	0.017	0.405**	-0.108	0.359**
	G				1	-0.017	0.039	0.455**	-0.123	0.395**
Spikelet fertility (%)	P					1	0.101	0.024	0.187*	0.266*
	G					1	-0.001	0.024	0.296**	0.444**
100 seed weight(g)	P						1	0.174*	0.118	0.264*
	G						1	0.188*	0.108	0.324**
Biological yield per plant(g)	P							1	-0.479**	0.459**
	G							1	-0.514**	0.471**
Harvest Index(%)	P								1	0.376**
	G								1	0.378**
Grain yield per plant(g)	P									1
	G									1

* Significant at 5 percent level of significance

** Significant at 1 percent level of significance

Table 3. Estimates of genotypic path coefficient (direct and indirect effects) for various yield attributing traits on grain yield.

Characters	Plant height (cm)	Panicle length (cm)	Panicle number per plant	Number of filled grains per panicle	Spikelet fertility (%)	100 seed weight (g)	Biological yield per plant(g)	Harvest Index (%)	Grain yield per plant (g)
Plant height (cm)	-0.326	0.245	-0.090	0.002	0.103	0.027	0.102	-0.223	-0.159
Panicle length (cm)	-0.164	0.487	-0.095	0.047	-0.309	0.039	0.195	-0.298	-0.097
Panicle numbers per plant	0.122	-0.193	0.241	-0.078	-0.040	-0.031	-0.162	0.189	0.126
Number of filled grains per panicle	-0.005	0.142	-0.114	0.165	-0.010	0.005	0.284	-0.072	0.395**
Spikelet fertility (%)	-0.059	-0.266	0.017	-0.003	0.567	-0.001	0.015	0.173	0.444**
100 seed weight (g)	-0.078	0.166	-0.065	0.075	0.014	0.021	0.624	0.300	0.324**
Biological yield per plant(g)	-0.053	0.152	-0.063	0.075	0.014	0.021	0.624	-0.300	0.471**
Harvest Index(%)	0.124	-0.249	0.078	-0.020	0.168	0.012	-0.321	0.585	0.378**

Residual=0.096

* Significant at 5 percent level of significance

** Significant at 1 percent level of significance