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. Understanding the association of different characters is essential to determine their contribution towards yield. Evaluating both the direction and strength of correlation helps assess how improvement in one trait may lead to 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 that may aid in developing high yielding genotypes. The correlation analysis revealed that traits such as 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. Path coefficient analysis unveils that 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 maximum positive direct effect on grain yield per plant. Based on the results of this study, selection for higher biological yield, spikelet fertility and harvest index will be beneficial for obtaining higher grain yield in rice crop. These characters play a major role in shaping the single plant yield in rice on which selection pressure has to be applied for enhancing the seed yield**.**

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

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 accounts more than 25% of the global rice cultivation area 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).

"The development of high-yielding rice cultivars is imperative to meet the increasing demand for rice in the future. 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 weightin addition to environmental factors" (Chhaya et al., 2023)."To know the association of different characters was essential for determining their contribution towards yield improvement. 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).“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 the extent to which genetic components influence the relationship between traits, 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). 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 65 rice genotypes *i.e.* 60 germplasm accessions and 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 included 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 GandhiKrishi Vishwavidyalaya,Raipur,Chhattisgarhduring*Kharif*2023. The maximum temperature was 32.5°C and minimum 13.8°C during the crop growth period. The total rainfall received during crop growth period was 1362.2 mm. The experiment was taken up in Randomized Complete Block Design (RCBD) with two replications. The net plot area was 270 m sq with ba spacing of 20 cm x15 cm both row to row and plant to plant respectively. All the recommended cultural practices were applied for 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 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: Veryhigh (>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). Statistical analysis was done using OPSTAT, HAU, Hisar by Sheron OP (1998).

Results&Discussion:

"Genotypic and phenotypic correlationrefers to the relationship between different traits and their influence on the yield. Genotypic correlation examines the degree of association between the genetic factors responsible for different traits and their impact on yield. It helps plant breeders understand how closely related genetic factors contribute to yield variation"(Li et al., 2018)."Phenotypic correlation considers the observable traits and how they relate to each other and impact yield. It accounts for 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).

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 which indicated that there was genetically strong association among these traits but the phenotypic value is lessened by the significant interaction of environment"(Bhattacharyya et al., 2007).In some cases, the phenotypic correlation was higher than their genotypic correlation, indicating 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 betweengrain yield per plant and number of filled grains per plant, spikelet fertility (%), 100 seed weight(g), biological yield per plant (g) and harvest index.Plant height exhibited highly significant positive correlation with panicle length and a significant positive correlation with 100 seed weight which was supported by Srijan et al., (2016).Panicle Length (cm) showed highly significant and positive correlation with plant height(cm), number of filled grains, 100 seed weight (g) and biological yield per plant at both genotypic and phenotypic levels. The number of grains per panicle and number of filled grains per plant had significant positive correlation with grain yield per plant, consistent with the findings of Kumar et al., (2017). This indicates a strong association between the number of filled grain per plant, spikelet fertility %, 100 seed weight, biological yield per plant and harvest index traits with grain yield per plant. Selection for these traits will be useful in improving grain yield. Positive correlation between desirable traits is favorable 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 cases, an economic trade-off may be necessary to achieve an optimal balance.

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 bySeyoum et al., 2012;Sudeepti et al., 2020; for panicle number per plant (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% seed yield variability and remaining 9.6% 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.

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 the writing or editing of this manuscript.

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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**