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Path Coefficient Analysis and Character Association of Yield and Yield Contributing Traits of Rice Landraces

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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

An experiment was carried out during *Kharif* 2020 to estimate the direct and indirect effects of various independent characteristics on the dependent character and to assess the degree of relationship between yield and yield contributing traits of rice landraces. The experimental material consists of 188 landraces including two checks IR-64 and Jeerashankar and these genotypes were planted in Randomized Block Design with three replications. Based on correlation and path analysis studies, significant positive correlation and high direct positive effect on grain yield per plant were found for traits flag leaf length, number of tillers, number of effective tillers, panicle weight, harvesting index, panicle index, fertile spikelet per panicle and biological yield per plant.

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Itdepicted that during the formulation of criterion in the rice improvement program as well as for plant ideotype, these traits would be of significant relevance.

Keywords: Rice; landraces correlation; path coefficient analysis and ideotype.

1. INTRODUCTION

Rice (*Oryza sativa L*.) (2n=24) is a self-pollinated semi-aquatic annual grass that is a staple food in many parts of the world. It has 22 wild and two cultivated species. As per the present knowledge of this crop, in the total of 22 wild species, 14 are diploid (2n=2x=24) and 8 wild species are tetraploid (2n=4x=48) [1].Twenty-two wild species have four complexes (*O. sativa complex, O. officinalis complex, O. meyeriana complex and O. ridleyi complex*) as per their crossing compatibility.The cultivated species *Oryza sativa* and *Oryzaglaberrima* are diploid (2n=2x=24). *Oryza sativa* is planted throughout the world while *Oryzaglaberrima*, the African cultivated rice is grown in Africa. It first appeared as a wild grass in Gondwana land at least 130 million years ago [2]. Among all Asian countries, India has a diverse range of rice cultivars, landraces, and other known kinds cultivated by farmers and local entrepreneurs for centuries [3].

In 2020, global rice production was 686.50 million metric tones in an area of 164.19 million hectares with a productivity of 4608.9 kg/ha (FAO, 2022). India produced 161.75 million metric tonnes from 45 million hectares in the same year, with a productivity of 3962 kg/ha [4]. Total rice production in Madhya Pradesh was 4.77 million tonnes from 3.01 million hectares, with a productivity of 2270 kg/ha [5].

In the early 1900s, agriculture in Madhya Pradesh was mostly dependent on the cultivation of traditional cultivars. Land races that are genetically varied for yield, resistance and quality parameters. A farmer's variety is a wild relative, land race and primitive cultivar that has been cultivated and evolved by farmers in their fields for centuries [6]. Breeder's main goal is to create genetic variability which is necessary for crop genetic improvement. The scientist realized that the collection, conservation, and utilization of farmer's landraces are significant in rice improvement programs for the development of good quality rice varieties. The path coefficient analysis and correlation analysis incorporated in this research to determine the direct and indirect effects of various independent characteristics on the dependent character and to assess the degree of relationship between these traits.

The majority of the farmer's varieties are dominated by quality traits regarding aroma, good cooking quality, high percentage of head rice recovery, good adoptability, and resistance to the local pests and diseases limiting the crop yield. To utilize these genetic resources, understanding the relationship between characters is crucial for designing an effective breeding program, particularly for yield and quality traits. For this purpose, correlation analysis along with path coefficient analysis was conducted in the present investigation to determine the traits association and the direct and indirect effects of traits on yield.

2. MATERIALS AND METHODS

The current study was conducted to identify better lines for yield and quality features and for that all 188 landraces were planted in a Randomized Complete Block Design with three replications at Seed Breeding Farm, Department of Plant Breeding and Genetics, JNKVV, Jabalpur, during Kharif 2021-22. The topography and fertility of the experimental area were very similar. Coordinates for the experimental site are 23°12'52.9"N 79°56'37.8"E. The genotypes included 188 landraces including two checks IR-64 and Jeerashankar, which were grown in a three-replication randomized full block configuration. In the experimental site, 21 old seedlings were transplanted. Each genotype was planted in three rows of five meters each, with one seedling per hill, at a spacing of 15 to 20 cm. Correlation coefficients were calculated for all quantitative character's combinations at phenotypic, genotypic and environmental level by the formula given by Miller et al. [7]. The direct and indirect contribution of various characters to yield were calculated through path coefficient analysis as suggested by Wright [8] and elaborated by Dewey and Lu [9].

3. RESULTS AND DISCUSSION

3.1 Character Association

Correlation represents the extent of linear correlation between pairs of traits and serves as the foundation for selection indexes, which help

breeders to the selection of best traits for the enhancement of crop yield. Grain yield per plant exhibited positive and significant association between flag leaf length, flag leaf width, number of tillers, number of effective tillers, panicle weight, harvesting index, panicle index, total spikelet per panicle, fertile spikelet per panicle, thousand grain weight and biological yield per plant as depicted in Table 1(a),(b) &(c).The findings aligned with Saha*et al.*[10] for flag leaf length; Parimala*et al.*[11], Radha, *et al.*[12] and Singh *et al.* [13] for thousand grain weight; Kumar *et al*. [14] for flag leaf width; and Katkani*et al*. [15] for biological yield per plant.

Table 1(a). Estimates of genotypic correlation coefficient for various yield and quality attributing traits

Cha.	DFF	DTM	FLL	FLW	SL	PH	NOT	NOET	PW	HI
DFF	1.0000	0.8383	0.0779	0.2092	0.1835	0.1881	-0.0663	0.0471	0.0355	0.0235
DTM		1.0000	0.0376	0.2245	0.2047	0.2182	0.0163	0.0999	-0.0052	0.0010
FLL			1.0000	0.1286	0.1444	0.1460	0.0282	0.0281	0.2002	0.1281
FLW				1.0000	0.0894	0.0761	-0.0479	-0.0177	0.2575	0.2289
SL					1.0000	0.9709	-0.0869	-0.0211	-0.0240	-0.0658
PH						1.0000	-0.0388	0.0194	-0.0171	-0.0719
NOT							1.0000	0.8770	0.1282	0.0600
NOET								1.0000	0.0840	0.0041
PW									1.0000	0.8706
HI										1.0000
PI										
ST										
TSPP										
FSPP										
USPP										
SF										
PL										
SD										
1000GW										
BYPP										
GL										
GB										
DGL										
DGB										
L/B										
H%										
M%										
GYPP	**0.0530**	**0.0126**	**0.2027**	**0.2526**	**-0.0176**	**-0.0201**	**0.1554**	**0.1222**	**0.9792**	**0.9066**

Table 1(b). Estimates of genotypic correlation coefficient for various yield and quality attributing traits (Cont...)

Cha.	PI	ST	TSPP	FSPP	USPP	SF	PL	SD	1000GW	BYPP
DFF	0.1587	-0.248	0.4577	0.4828	0.1300	0.2671	0.0948	0.3852	-0.4482	0.0770
DTM	0.1423	-0.249	0.4410	0.4551	0.1603	0.2236	0.1513	0.3413	-0.4462	0.0666
FLL	0.0844	0.1952	0.1380	0.1050	0.1805	-0.0580	0.0548	0.1197	0.1292	0.2084
FLW	0.1421	-0.020	0.0375	0.0450	-0.0086	-0.0466	0.0275	0.0394	-0.1491	0.1776
SL	0.0372	0.0780	0.1546	0.1591	0.0583	0.0807	0.2606	0.0116	-0.1089	0.0638
PH	0.0036	0.0985	0.1774	0.1869	0.0517	0.1002	0.4851	-0.0678	-0.1355	0.0849
NOT	0.1519	0.1299	0.0878	0.0594	0.1396	-0.0396	0.1424	-0.0140	0.0426	0.2723
NOET	0.1771	0.1173	0.0703	0.0408	0.1354	-0.0902	0.1452	-0.0304	-0.0932	0.3007
PW	0.3075	0.0576	0.1061	0.1024	0.0627	0.0525	0.0419	0.0809	0.2474	0.5160
HI	0.5267	-0.055	0.0476	0.0472	0.0232	0.0632	-0.0151	0.0505	0.3026	0.0962
PI	1.0000	-0.079	0.0859	0.0952	0.0093	0.1112	-0.0939	0.1312	-0.0377	0.0956

Cha.	PI	ST	TSPP	FSPP	USPP	SF	PL	SD	1000GW	BYPP
ST		1.0000	-0.0817	-0.0850	-0.0271	-0.0218	0.0839	-0.1081	0.1572	0.2144
TSPP			1.0000	0.9720	0.5739	0.2581	0.1555	0.8759	-0.2971	0.1588
FSPP				1.0000	0.3655	0.4553	0.1902	0.8283	-0.3196	0.1597
USPP					1.0000	-0.5648	-0.0468	0.5835	-0.0628	0.0730
SF						1.0000	0.1669	0.1758	-0.1184	0.0497
PL							1.0000	-0.2948	-0.1476	0.1104
SD								1.0000	-0.1982	0.1072
1000GW									1.0000	-0.1134
BYPP										1.0000
GL										
GB										
DGL										
DGB										
L/B										
H%										
M%										
GYPP	0.4837	0.0380	0.1084	0.1061	0.0591	0.0646	0.0112	0.1000	0.2230	0.4903

Table 1(c). Estimates of genotypic correlation coefficient for various yield and quality attributing traits (Cont..)

Cha.	GL	GB	DGL	DGB	L/B	H%	M%
DFF	-0.1423	-0.1799	-0.0643	-0.1297	0.0148	0.0136	0.2130
DTM	-0.3006	-0.1556	-0.1539	-0.1423	-0.1084	0.0309	0.1836
FLL	0.0480	-0.1363	0.0778	-0.1249	0.1187	-0.0413	-0.0526
FLW	-0.0502	-0.0346	-0.0305	0.0458	-0.0060	-0.0644	-0.0287
SL	-0.1210	0.0555	-0.0660	0.1205	-0.1583	-0.1795	0.0461
PH	-0.1727	0.0264	-0.0754	0.1019	-0.1755	-0.1439	0.0723
NOT	-0.1525	0.1217	-0.0405	-0.0281	-0.1754	-0.0960	-0.0736
NOET	-0.1777	0.0157	-0.0680	-0.0867	-0.1266	-0.1343	-0.0680
PW	-0.0281	0.0492	0.0024	-0.0882	-0.0021	0.1014	0.0556
HI	0.0176	0.1581	0.0712	-0.0328	-0.0559	-0.0079	0.0208
PI	-0.0290	0.1791	0.0393	0.0742	-0.1374	-0.2073	-0.0412
ST	0.0473	-0.0580	-0.0977	0.0260	0.0407	-0.0782	-0.1873
TSPP	-0.2230	-0.1271	-0.2148	-0.1601	-0.0912	0.0497	0.1329
FSPP	-0.2117	-0.1135	-0.1987	-0.1518	-0.0963	0.0637	0.1404
USPP	-0.1459	-0.1084	-0.1587	-0.1050	-0.0255	-0.0246	0.0369
SF	-0.0222	0.0525	0.0113	0.0001	-0.0827	0.0853	0.0489
PL	-0.2362	-0.0815	-0.0796	-0.0231	-0.1321	0.0873	0.1610
SD	-0.0808	-0.0972	-0.1291	-0.1388	-0.0040	-0.0034	0.0596
1000GW	0.2537	0.1556	0.2309	0.2110	0.0549	0.0231	-0.1131
BYPP	-0.1590	-0.1561	-0.1210	-0.1412	0.0252	0.1075	0.0641
GL	1.0000	0.0164	0.4442	0.1573	0.6586	0.0169	0.0064
GB		1.0000	0.1349	0.6450	-0.7318	-0.1184	0.0019
DGL			1.0000	0.1123	0.2120	0.0632	0.0234
DGB				1.0000	-0.3850	-0.0384	0.0060
L/B					1.0000	0.1156	-0.0072
H%						1.0000	0.4341
M%							1.0000
GYPP	-0.0394	0.0827	-0.0079	-0.0655	-0.0350	0.0499	0.0549

3.2 Path Coefficient Analysis

The standardized partial regression coefficient divides the correlation coefficient into measures of direct and indirect effects of a set of independent factors on the dependent variable, which is known as path analysis. The genotypic path analysis used in this study revealed that the direct positive effect towards grain yield/plant was recorded for flag leaf length, stem length, number of tillers, number of effective tillers per plant, panicle weight, harvest index, panicle index, fertile spikelet per panicle, panicle length, spikelet density and biological yield per plant, it revealed the genuine relation among these traits and selection based on these traits will be rewarding as depicted in Table 2 (a),(b) & (c).The results were in propinquity with Norain et al. [16] for flag leaf length and number of tillers; Ashok et al.[17], Sarkaret al.[18] and Mukeshet al.[19] for number of effective tillers per plant; Sameer et al. (2016) for panicle weight; Katkaniet al.[15] for biological yield per plant; and Zarbafiet al.[20] for number of fertile spikelet's per panicle.

Whereas the negative direct effect on the grain yield per plant was shown by the traits viz., days to maturity, plant height, stem thickness, grain length, grain width, decorticated grain length, decorticated grain breadth and grain length breadth ratio. This finding is not in agreement with findings of Ekka*et al.*[21] for grain length.

Table 2(a). The direct and indirect effects of various independent characteristics on grain yield are depicted in a genotypic path table

Cha.	DFF	DTM	FLL	FLW	SL	PH	NOT	NOET	PW	HI
DFF	-0.0017	-0.0015	-0.0001	-0.0004	-0.0003	-0.0003	0.0001	-0.0001	-0.0001	0.0000
DTM		-0.0132	-0.0005	-0.0030	-0.0027	-0.0029	-0.0002	-0.0013	0.0001	0.0000
FLL			0.0122	0.0016	0.0018	0.0018	0.0003	0.0003	0.0024	0.0016
FLW				-0.0178	-0.0016	-0.0014	0.0009	0.0003	-0.0046	-0.0041
SL					0.0561	0.0544	-0.0049	-0.0012	-0.0013	-0.0037
PH						-0.0561	0.0022	-0.0011	0.0010	0.0040
NOT							0.0077	0.0068	0.0010	0.0005
NOET								0.0203	0.0017	0.0001
PW									0.8297	0.7224
HI										0.1139
PI										
ST										
TSPP										
FSPP										
USPP										
SF										
PL										
SD										
1000GW										
BYPP										
GL										
GB										
DGL										
DGB										
L/B										
H%										
M%										
GYPP	0.0530	0.1026	0.2027	0.2526	-0.0176	-0.0201	0.1554	0.1222	0.9792	0.9066

Table 2(b). The direct and indirect effects of various independent characteristics on grain yield are depicted in a genotypic path table (Cont…)

Cha.	PI	ST	TSPP	FSPP	USPP	SF	PL	SD	1000GW	BYPP
DFF	-0.0003	0.0004	-0.0008	-0.0008	-0.0002	-0.0005	-0.0002	-0.0007	0.0008	-0.0001
DTM	-0.0019	0.0033	-0.0058	-0.0060	-0.0021	-0.0029	-0.0020	-0.0045	0.0059	-0.0009
FLL	0.0010	0.0024	0.0017	0.0013	0.0022	-0.0007	0.0007	0.0015	0.0016	0.0025
FLW	-0.0025	0.0004	-0.0007	-0.0008	0.0002	0.0008	-0.0005	-0.0007	0.0027	-0.0032
SL	0.0021	0.0044	0.0087	0.0089	0.0033	0.0045	0.0146	0.0007	-0.0061	0.0036
PH	-0.0002	-0.0055	-0.0099	-0.0105	-0.0029	-0.0056	-0.0272	0.0038	0.0076	-0.0048
NOT	0.0012	0.0010	0.0007	0.0005	0.0011	-0.0003	0.0011	-0.0001	0.0003	0.0021
NOET	0.0036	0.0024	0.0014	0.0008	0.0028	-0.0018	0.0030	-0.0006	-0.0019	0.0061
PW	0.2552	0.0478	0.0880	0.0850	0.0520	0.0435	0.0348	0.0671	0.2052	0.4281
HI	0.0600	-0.0063	0.0054	0.0054	0.0026	0.0072	-0.0017	0.0058	0.0345	0.0110
PI	0.1585	-0.0126	0.0136	0.0151	0.0015	0.0176	-0.0149	0.0208	-0.0060	0.0151
ST		-0.0011	0.0001	0.0001	0.0000	0.0000	-0.0001	0.0001	-0.0002	-0.0002
TSPP			22.8166	-22.1782	-13.0954	-5.8882	-3.5490	-19.9861	6.7781	-3.6224
FSPP				20.0221	7.3185	9.1159	3.8086	16.5841	-6.3985	3.1977
USPP					5.7231	-3.2325	-0.2676	3.3394	-0.3596	0.4176
SF						-0.0120	-0.0020	-0.0021	0.0014	-0.0006
PL							0.0224	-0.0066	-0.0033	0.0025
SD								0.0705	-0.0140	0.0076
1000GW									-0.0181	0.0021
BYPP										0.0238
GL										
GB										
DGL										
DGB										
L/B										
H%										
M%										
GYPP	0.4837	0.0380	0.1084	0.1061	0.0591	0.0646	0.0112	0.1000	0.2230	0.0827

Table 2(c). The direct and indirect effects of various independent characteristics on grain yield are depicted in a genotypic path table (Cont…)

Cha.	GL	GB	DGL	DGB	L/B	H%	M%
DFF	0.0002	0.0003	0.0001	0.0002	0.0000	0.0000	-0.0004
DTM	0.0040	0.0020	0.0020	0.0019	0.0014	-0.0004	-0.0024
FLL	0.0006	-0.0017	0.0009	-0.0015	0.0014	-0.0005	-0.0006
FLW	0.0009	0.0006	0.0005	-0.0008	0.0001	0.0011	0.0005
SL	-0.0068	0.0031	-0.0037	0.0068	-0.0089	-0.0101	0.0026
PH	0.0097	-0.0015	0.0042	-0.0057	0.0098	0.0081	-0.0041
NOT	-0.0012	0.0009	-0.0003	-0.0002	-0.0013	-0.0007	-0.0006
NOET	-0.0036	0.0003	-0.0014	-0.0018	-0.0026	-0.0027	-0.0014
PW	-0.0233	0.0408	0.0020	-0.0732	-0.0017	0.0841	0.0462
HI	0.0020	0.0180	0.0081	-0.0037	-0.0064	-0.0009	0.0024
PI	-0.0046	0.0284	0.0062	0.0118	-0.0218	-0.0328	-0.0065
ST	-0.0001	0.0001	0.0001	0.0000	0.0000	0.0001	0.0002
TSPP	5.0872	2.9009	4.9004	3.6529	2.0806	-1.1347	-3.0318
FSPP	-4.2378	-.2728	-3.9780	-3.0401	-1.9286	1.2748	2.8117
USPP	-0.8349	-0.6205	-0.9081	-0.6007	-0.1458	-0.1410	0.2113
SF	0.0003	-0.0006	-0.0001	0.0000	0.0010	-0.0010	-0.0006
PL	-0.0053	-0.0018	-0.0018	-0.0005	-0.0030	0.0020	0.0036
SD	-0.0057	-0.0069	-0.0091	-0.0098	-0.0003	-0.0002	0.0042
1000GW	-0.0046	-0.0028	-0.0042	-0.0038	-0.0010	-0.0004	0.0020
BYPP	-0.0038	-0.0037	-0.0029	-0.0034	0.0006	0.0026	0.0015

Cha.	GL	GB	DGL	DGB	L/B	H%	M%
GL	-0.0137	-0.0002	-0.0061	-0.0022	-0.0090	-0.0002	-0.0001
GB		-0.0118	-0.0016	-0.0076	0.0086	0.0014	0.0000
DGL			-0.0011	-0.0001	-0.0002	-0.0001	0.0000
DGB				0.0154	-0.0059	-0.0006	0.0001
L/B					-0.0011	-0.0001	0.0000
H%						-0.0062	-0.0027
M%							0.0198
GYPP	-0.0394	0.0827	0.0079	-0.0655	-0.0350	0.0499	0.0549

4. CONCLUSION

Critical analysis of results obtained from character association and path analysis indicated that flag leaf length, number of tillers, number of effective tillers, panicle weight, harvesting index, panicle index, fertile spikelet per panicle and biological yield per plant possessed both positive association and high positive direct effects. Hence, selection for these traits could bring improvement in yield and yield components.

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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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