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Inter-relationship and path analysis of different traits of two line hybrid in rice (*Oryza sativa* L.)

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Abstract: The present study was undertaken with the objective to determine the nature and magnitude of variability, degree of association between yield and it`s component characters and their direct and indirect effects on grain yield in rice. The experiment was conducted on rice in year 2013-14 at Borlaug Crop Research Center of G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. All the traits had positive correlation to seed yield per plant of rice except days to flowering at genotypic level and at the phenotypic level. At phenotypic level panicle length (0.2145) and harvest index (0.4713) had highly significant level and positive correlation to seed yield per plant. Grain number per panicle (0.1550) and panicle number per plant (0.1398) showed positive and level of significant correlation with seed yield per plant. The days to flowering (-0.1879) have highly significant level with negative correlation to seed yield per plant. Path analysis showed the positive and direct effect on seed yield per plant at genotypic and phenotypic level for panicle number per plant (0.393 and 0.380 respectively), panicle length (0.236 and 0.198), grain number per panicle (0.646 and 0.112) and harvest index (0.443 and 0.448). While days to flowering (-0.175 and -0.167) and plant height (-0.037 and -0.008) had negative direct effect. The traits which showed positive correlation and positive direct effect on seed yield per plant can be used to increase seed yield for further breeding programs and may be given due importance in selection during rice breeding programme.

Keywords: Correlation, Line X tester, Negative, Positive, Path analysis, Rice

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important staple food crop for half of the world's population. The Green Revolution technology developed at the International Rice Research Institute (IRRI) in the 1960s increased world rice production. The hybrid rice is being the new answer to the growing hunger of world population; by the way of its elevated yield potential, agronomic performance and disease resistance. Genetic variability, correlation and path coefficients are pre-requisites for improvement of any crop including rice in any trait by selection of superior genotypes (Hassan *et al.,* 2010). The knowledge of the association of various traits with rice yield and their mutual-relationship of the traits is essential in improving the selection efficiency and crop yield. Traits inter-relationship derived by correlation coefficient, given the basis for selecting the desirable plant, aiding in evaluation of relative influence of various component characters on grain yield. Path coefficient analysis discerns correlation into direct and indirect effects (Ekka *et al.* 2011). The most important criteria in any crop improvement programme is the selection of genotypes with all possible desirable yield contributing traits. The knowledge regarding relative contribution of individual traits to yield may be accomplished by correlation studies (Allard, 1960 and Chaubey *et al.* 1994). However, simple correlation does not provide the adequate information about the contribution of each factor towards yield. Therefore, the technique of path coefficient analysis is utilized to have an idea of direct and indirect contribution of a trait towards the yield (Nandan *et al.,* 2010).

MATERIALS AND METHODS

The present investigation was carried out at the Borlaug Crop Research Center of G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand (India) in 2014 *kharif* season. The material used for this study consisted of eighteen thermosensitive genetic male sterile (TGMS) lines and four testers (Table 1).

The eighteen lines were crossed with four testers during *kharif* season in 2013 using Line X Tester mating design. The resulting 72 cross combinations with 22 parents (lines and testers) grown in randomized complete block design in three replications during the 2014 *kharif* season. Data were collected from five randomized selected plants from each replication. The traits on which data were collected *viz.* Days to 50% flowering, Plant height, Panicle length, Panicle number per plant, Spikelet number per panicle, Grain number per panicle, Per cent spikelet fertility, 1000 grain weight, Harvest index and Grain yield per plant. Genotypic and phenotypic correlation coefficients

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were calculated following by Miller *et al.* (1958). Path coefficient analysis was estimated according to the method suggested by Dewey and Lu (1959).

RESULTS AND DISCUSSION

The analysis of variance revealed significant level of variations among all the lines for all the characters studied in rice and same findings observed by Malik and Singh (2013) in rice crop. At genotypic level (Table 2) the days to flowering was positively correlated to the all the characters except harvest index and grain yield per plant in rice while plant height showed negative correlation with panicle number per plant, percent spikeletes fertility, 1000 grain weight and harvest index. Panicle number per plant was positively correlated with days to 50 percent flowering, plant height, percent spikeletes fertility, 1000 grain weight and grain yield per plant while panicle length had positive relationship with days to 50 percent flowering, plant height, spikeletes number per panicle, grain number per panicle, harvest index and grain yield per plant. The result for panicle length was accordance with Hasan *et al.* (2010). Spikeletes number per panicle positively correlated with days to 50 percent flowering, plant height, panicle length, grain number per panicle, 1000 grain weight and grain yield per plant while grain number per panicle showed positive correlation to all the traits except for panicle number plant and percent spikeletes fertility. The percent spikeletes fertility percentage had positive correlation with days to 50 percentages flowering, panicle number per plant, harvest index and grain yield per plant while harvest index indicated positive correlation with grain yield per plant, panicle length, grain number per panicle, percent spikeletes fertility and 1000 grain weight. The grain yield per plant was positively correlated with 1000 grain weight, this finding for grain yield per plant were also observed by Ekka *et al.* (2011) and Akhtar *et al.* (2011), for harvest index observed by Surek and Beser (2013), for days to 50 percent flowering by Reddy *et al.* (2013) and for percent spikeletes fertility by Kumar *et al. (*1998).

At phenotypic level (Table 3) days to flowering had high level of significant and negatively correlated to the harvest index and grain yield per plant while plant height was negatively correlated with panicle number per plant, percent spikeletes fertility, 1000 grain weight and harvest index. Panicle number per plant was showed significant level and positively correlated with days to 50 percent flowering, 1000 grain weight and grain yield per plant. Panicle length had high level of significant and positive correlation with plant height, spikeletes number per plant and grain yield per plant. Spikeletes number per panicle was positively and high level of significantly correlated with days to 50 percent flowering, grain number per panicle, panicle length and 1000 grain

Table 1. Details of parents used in the study for correlation and path analysis.

S. N.	TGMS (code)	TGMS Lines	Parentage	Source
1	TGMS-1	UPRI-99-70-1	UPRI 95-140 TGMS / UPRI 95-141	GBPUAT, Pantnagar
2	TGMS-2	UPRI-99-71-1	UPRI 95-140 TGMS / UPRI 95-150 // UPRI 95-162	GBPUAT, Pantnagar
3	TGMS-3	UPRI-99-71-2	UPRI 95-140 TGMS / UPRI 95-150 // UPRI 95-162	GBPUAT, Pantnagar
4	TGMS-4	UPRI-99-73-1	UPRI 95-140 TGMS / IR 36 // IR Basmati	GBPUAT, Pantnagar
5	TGMS-5	UPRI-99-73-2	UPRI 95-140 TGMS / IR 36 // IR Basmati	GBPUAT, Pantnagar
6	TGMS-6	UPRI-99-73-3	UPRI 95-140 TGMS / IR 36 // IR Basmati	GBPUAT, Pantnagar
7	TGMS-7	UPRI-99-73-4	UPRI 95-140 TGMS / IR 36 // IR Basmati	GBPUAT, Pantnagar
8	TGMS-8	UPRI-99-74-3	UPRI 95-140 TGMS / IR BB 21 // IR Basmati	GBPUAT, Pantnagar
9	TGMS-9	UPRI-99-79-1	UPRI 95-140 TGMS / UPRI 95-141 // UPRI 95-162	GBPUAT, Pantnagar
10	TGMS-10	UPRI-99-60-1	UPRI 95-140 TGMS / UPRI 95-141	GBPUAT, Pantnagar
11	TGMS-11	UPRI-99-72-1	UPRI 95-140 TGMS / UPRI 95-150 // UPRI 95-161	GBPUAT, Pantnagar
12	TGMS-12	UPRI-99-72-3	UPRI 95-140 TGMS / UPRI 95-150 // UPRI 95-161	GBPUAT, Pantnagar
13	TGMS-13	UPRI-99-72-4	UPRI 95-140 TGMS / UPRI 95-150 // UPRI 95-161	GBPUAT, Pantnagar
14	TGMS-14	UPRI-99-74-1	UPRI 95-140 TGMS / IRBB-21 // IR Basmati	GBPUAT, Pantnagar
15	TGMS-15	UPRI-99-74-4	UPRI 95-140 TGMS / IR BB 21 // IR Basmati	GBPUAT, Pantnagar
16	TGMS-16	UPRI-99-75-1	UPRI 95-140 TGMS / IRBB-21 // UPRI-95-150	GBPUAT, Pantnagar
17	TGMS-17	UPRI-99-78-1	UPRI 95-140 TGMS / IR 66159-131-4-3-2	GBPUAT, Pantnagar
18	TGMS-18	UPRI-97-60-8	UPRI 95-140 TGMS / UPRI 95-140-1	GBPUAT, Pantnagar
19	Tester	Pant Basmati-1	Pusa Basmati / IET 12603 (UPR 908-11-1-1-5)	GBPUAT, Pantnagar
20	Tester	Pant Dhan-4	UPRI-74-14 (BG 90-2) / IR 262 // Remadja	GBPUAT, Pantnagar
21	Tester	Pant Dhan-12	Govind / UPRM 201-1-1	GBPUAT, Pantnagar
22	Tester	UPRI-93-287R	MDC 19340	GBPUAT, Pantnagar

Table 2. Genotypic correlation of different characters of TGMS lines.

Character	Days to 50% flowering	Plant height	Panicle number per Plant	Panicle length	Spikelets number per panicle	Grain number per panicle	Percent spikeletes fertility	1000 Grain weight	harvest index	Grain yield per plant
Days to 50% Flowering	1.0000	0.1527	0.2128	0.1452	0.2182	0.2569	0.0453	0.0922	-0.4244	-0.1976
Plant Height		1.0000	-0.1237	0.5925	0.1356	0.0867	-0.1566	-0.2192	-0.0829	0.0218
Panicle Number Per Plant			1.0000	-0.1798	-0.2406	-0.2481	0.0381	0.2375	-0.2404	0.1403
Panicle Length				1.0000	0.2258	0.1975	-0.1496	-0.0358	0.1449	0.2318
Spikelets Number Per Panicle					1.0000	0.9263	-0.4831	0.2090	-0.0267	0.1054
Grain Number Per Panicle						1.0000	-0.0882	0.1924	0.0750	0.1591
Percent Spikeletes Fertility							1.0000	-0.0435	0.2279	0.0948
1000 Grain Weight								1.0000	0.0130	0.0553
Harvest Index									1.0000	0.4865
Grain Yield Per Plant										1.0000

Table 3. Phenotypic correlation of different characters of TGMS lines.

Character	Days to 50% flowering	Plant height	Panicle number per plant	Panicle length	Spikelets number per panicle	Grain number per Panicle	Percent spikeletes fertility	1000 Grain weight	harvest index	Grain yield per plant
Days to 50% Flowering	1.0000	0.1192	0.2048**	0.1209	0.2050**	0.2367**	0.0318	0.0829**	-0.3899**	-0.1879**
Plant Height		1.0000	-0.1026	0.4729**	0.1204	0.0767	-0.1155	-0.1985	-0.0771	0.0226
Panicle Number Per Plant			1.0000	-0.1569*	-0.2359**	-0.2435**	0.0408	0.2233**	-0.2298**	0.1398*
Panicle Length				1.0000	0.2004**	0.1718	-0.1220	-0.0254	0.1304	0.2145**
Spikelets Number Per Panicle					1.0000	0.8976**	-0.4438**	0.1991**	-0.0272	0.1025
Grain Number Per Panicle						1.0000	-0.0763	0.1811**	0.0644	0.1550*
Percent Spikeletes Fertility							1.0000	-0.0626	0.2122**	0.0871
1000 Grain Weight								1.0000	0.0075	0.0493
Harvest Index									1.0000	0.4713**
Grain Yield Per Plant										1.0000

Table 4. Genotypic path of grain yield per plant.

Character	Days to 50% flowering	Plant height	Panicle number per plant	Panicle length	Spikelets number per panicle	Grain number per panicle	Percent spikeletes fertility	1000 Grain weight	Harvest index
Days to 50% Flowering	**-0.1758**	-0.0269	-0.0374	-0.0255	-0.0384	-0.0452	-0.0080	-0.0162	0.0746
Plant Height	-0.0058	-0.0378	0.0047	-0.0224	-0.0051	-0.0033	0.0059	0.0083	0.0031
Panicle Number Per Plant	0.0838	-0.0487	0.3935	-0.0708	-0.0947	-0.0976	0.0150	0.0935	-0.0946
Panicle Length	0.0344	0.1403	-0.0426	0.2369	0.0535	0.0468	-0.0354	-0.0085	0.0343
Spikelets Number Per Panicle	-0.0996	-0.0619	0.1098	-0.1031	-0.4565	-0.4228	0.2205	-0.0954	0.0122
Grain Number Per Panicle	0.1662	0.0561	-0.1605	0.1278	0.5992	0.6469	-0.0571	0.1245	0.0485
Percent Spikeletes Fertility	-0.0068	0.0235	-0.0057	0.0224	0.0724	0.0132	-0.1499	0.0065	-0.0342
1000 Grain Weight	-0.0058	0.0138	-0.0150	0.0023	-0.0132	-0.0121	0.0027	-0.0631	-0.0008
Harvest Index	-0.1881	-0.0368	-0.1065	0.0642	-0.0118	0.0332	0.1010	0.0058	0.4433
Grain Yield Per Plant (correlation)	-0.1976	0.0218	0.1403	0.2318	0.1054	0.1591	0.0948	0.0553	0.4865

Table 5. Phenotypic path of grain yield per plant.

Character	Days to 50% flowering	Plant height	Panicle number per plant	Panicle length	Spikelets number per panicle	Grain number per panicle	Percent spikeletes fertility	1000 Grain weight	Harvest index
Days to 50% Flowering	-0.1671	-0.0199	-0.0342	-0.0202	-0.0343	-0.0396	-0.0053	-0.0138	0.0652
Plant Height	-0.0010	-0.0087	0.0009	-0.0041	-0.0010	-0.0007	0.0010	0.0017	0.0007
Panicle Number Per Plant	0.0780	-0.0391	0.3809	-0.0598	-0.0899	-0.0927	0.0156	0.0850	-0.0875
Panicle Length	0.0241	0.0941	-0.0312	0.1989	0.0399	0.0342	-0.0243	-0.0050	0.0260
Spikelets Number Per Panicle	0.0298	0.0175	-0.0343	0.0291	0.1454	0.1305	-0.0645	0.0289	-0.0039
Grain Number Per Panicle	0.0265	0.0086	-0.0273	0.0192	0.1006	0.1121	-0.0085	0.0203	0.0072
Percent Spikeletes Fertility	0.0023	-0.0085	0.0030	-0.0090	-0.0328	-0.0056	0.0738	-0.0046	0.0157
1000 Grain Weight	-0.0055	0.0132	-0.0149	0.0017	-0.0132	-0.0120	0.0042	-0.0665	-0.0005
harvest Index	-0.1749	-0.0346	-0.1031	0.0585	-0.0122	0.0289	0.0952	0.0034	0.4486
Grain Yield Per Plant (correlation)	-0.1879	0.0226	0.1398	0.2145	0.1025	0.1550	0.0871	0.0493	0.4713

weight while grain number per panicle showed positive and high level of significant correlation with 1000 grain weight, days to 50 percent flowering, Spikeletes Number Per Panicle and significant with grain yield per plant., High level of significant and positive correlation was observed between percent spikeletes fertility and harvest index. The 1000 grain weight also showed the same relation with days to 50 percent flowering, panicle number per plant, spikeletes number per plant and grain number per plant while harvest index with grain yield per plant and percent spikeletes fertility. The grain yield per plant showed high level of significant and positive correlation with harvest index and panicle length.

Path analysis indicated the all the traits were positively correlated to the grain yield per plant except days to flowering. At genotypic level negative direct effect on grain yield per plant observed for days to 50 percent flowering (-0.1758), plant height (-0.0378), spikeletes number per panicle (-0.4565), percent spikeletes fertility (-0.1499) and 1000 grain weight (-0.0631) while positive direct effects of panicle number per plant (0.3935), panicle length (0.2369), grain number per panicle (0.6469) and harvest index (0.4433). The same findings for direct effect on grain yield per plant by different traits also observed by different researchers for panicle number per plant by (Paul and Nanda, 1994; Yadav and Bhushan, 2001), for panicle length (Babu *et al.,* 2012), for grain number per panicle (Islam *et al.,* 2015) and for harvest index (Surek and Beser, 2013). High indirect effect was observed on grain yield per plant of spikeletes number per panicle through percent spikeletes fertility, grain number per panicle. Other traits showed very minor indirect effect on grain yield per plant and the residual effect was 0.7767.

At phenotypic level the path analysis indicated that (Table -5), all the traits had positive direct effect on grain yield per plant except days to flowering, plant height and 1000 grain weight that showed negative direct effect. Spikeletes number per panicle showed high indirect effect on grain yield per plant through grain number per panicle (0.1305) while high negative indirect effect observed on grain yield per plant of plant height through grain number per panicle (-0.0007) while the overall residual effect was 0.7912.

Conclusion

The traits panicle number per plant, panicle length, grain number per panicle and harvest index of rice showed high direct effect on grain yield per plant and also showed high positive correlation to the grain yield per plant. Hence in the two line breeding system for hybrid development by incorporation these traits can be break the yield barrier in rice or may be given due importance in selection during rice breeding programme. The correlation and path analysis would be very useful statistic measures for the selection of yield increasing traits.

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