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Analysis of Correlation and Path coefficients for Yield and its Attributes in CMS Lines and Their F_1's of Rice (*Oryza sativa* L.)

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ABSTRACT: Rice is the most important crop in India. Currently, it provides 43% of cereal output and 46% of food grain production. India has the greatest area among the countries that grow rice, with 49 million hectares, followed by China. The yield gap in rice needs to be closed to feed the world's rapidly expanding population. The use of high-yielding cultivars can make this possible. The complicated trait of seed yield is influenced by several constituent factors. The correlation and path coefficient analyses show how different traits interact with one another. To improve yield, a relevant breeding approach can be used. The present investigation was conducted at Pilikothi Farm of Tilak Dhari Degree College Jaunpur (U.P.) to analyze the amount of association of yield and its attributes and direct and indirect effects of characters on grain yield in CMS lines and their hybrids of rice (*Oryza sativa* L.) and their hybrids in randomized block design during *Kharif* 2020. For each replication of the twelve characters, the observations were made on five competing plants of a given genotype that were chosen at random from a plot. Twelve quantitative traits, including seedling height (cm), days to 50% flowering, flag leaf area (cm^2), plant height (cm), panicle bearing tillers per plant, panicle length (cm), spikelets per panicle, spikelet fertility (%), test weight (g), biological yield per plant (g), grain yield per plant (g), and harvest-index (%), were observed. The character grain yield per plant exhibited significant positive association with seedling height (cm) (0.200), flag leaf area (cm^2) (0.641), panicle bearing tillers per plant (0.550), panicle length (cm) (0.447), spikelets per panicle (0.653), spikelet fertility (%) (0.158), test weight (g) (0.290), biological yield per plant (g) (0.866) and harvest-index (%) (0.196). The path analysis showed that biological yield per plant (1.0172), followed by harvest index, had the biggest positive direct effect on grain yield per plant (0.3489). Except for the harvest index (-0.1411), which had a bad indirect effect on grain output, most of the variables under study had a positive impact on biological yield per plant. The traits highly correlated with grain yield and also have direct and indirect positive effects on yield can be selected for improvement in yield potential of these CMS rice genotypes.

Keywords: Rice, *Oryza sativa*, CMS, correlation coefficient, path coefficient, grain yield.

INTRODUCTION

In India, rice is the most significant crop. Currently, it contributes 43% to the production of cereals and 46% to the production of food grains. India has the greatest area of 49 million hectares among the nations that grow rice (Kharif rice accounts for 43.6 M ha and rabi rice 5.4 Mha), followed by China. India is the second-largest producer of rice, at 118.9 million tonnes (Ministry of Agriculture and Farmers Welfare, 2020-21). India's typical rice yield is 4.1 metric tonnes per hectare (USDA report, 2022).

Rice (*Oryza sativa* L.) is an important staple food crop of tropical and sub-tropical parts of the world for ages, distributed geographically from 50° North in central Czechoslovakia, on the equator to 35° South in Australia. Rice is grown very successfully from below sea level in the Kuttanadu region of Kerala (India) to as high an altitude of 2000 meters in the Himalayas. The cultivated rice species (*Oryza sativa* L.) originated in the tropics of South Asia and the species (*Oryza glaberrima*) is of wild species in tropical Africa. Rice is one of the most ancient plants raised in India (Vavilov, 1951).

The annual grass known as rice (*Oryza sativa* L.) is a member of the genus Oryza. There are 22 wild species in the genus Oryza (2n=24, 48), which correspond to 10 genetic types (AA, BB, CC, BBCC, CCDD, EE, FF, GG, HHJJ, and HHKK). In addition to *Oryza sativa*, *Oryza glaberrima* is also widely grown in Africa (Brar and Khush, 1986).

Since the expression of the grain yield in rice depends on several additional plant traits, it has a very complex existence similar to that of other crops. Since yield is the result of multiplicative interactions between different yield components, components are a better way to understand the genetic architecture of grain yield in rice than yield itself. The correlation coefficient reveals the interrelationships between the yield and its constituent parts. The knowledge of character associations can be utilized to identify some characters that may not have much value on their own but are helpful as indications of the more significant characters under examination, forecast the correlation of response to directed selection, and build selection indices.

In light of the foregoing information, the current study was carried out to shed light on the correlations among traits and direct and indirect effects of yield attributing traits on grain yield of CMS rice lines and their F_1s.

MATERIALS AND METHODS

The current investigation was carried out at Tilak Dhari Post Graduate College's Pilikothi Farm in Jaunpur (UP). The soil type of the experimental area is defined as sandy loam, and it is located in the sub-tropical region of the Indo-Gangetic plain. This location is 83 metres above mean sea level and is situated between 25.74°N latitude and 82.69°E longitude. District Jaunpur experiences a semi-arid environment with hot summers and chilly winters. 83.10 cm of rain falls on average each year.

Three CMS lines with "wild abortive" (WA) cytoplasm were used as the experimental material for this study, along with 15 different rice genotypes as testers (males). The rice section of the Department of Genetics and Plant Breeding at the A.N.D. University of Agriculture & Technology, Kumarganj, Ayodhya, selected these distinct superior genotypes from their genetic stock collection. In order to produce 45 F_1s, the crosses were created using a "line x tester" mating scheme (Kempthorne, 1957).

A randomized block design with three replications was used to examine the final group of 45 F_1s and their 18 parents in Kharif, 2020. On the 21st of June 2020, the seeds for each entry were seeded in separate plots, and 30 days later, on the 20th of July 2020, mature seedlings were transplanted, one seedling per hill, in single-row plots measuring 3 meters in length with inter- and intra-row spacing of 20 and 15 cm, respectively. To cultivate a high-quality crop, all suggested cultural practices were followed.

For each replication of the twelve characters, the observations were made on five competing plants of a given genotype that were chosen at random from a plot. Twelve quantitative traits, including seedling height (cm), days to 50% flowering, flag leaf area (cm^2), plant height (cm), panicle bearing tillers per plant, panicle length (cm), spikelets per panicle, spikelet fertility (%), test weight (g), biological yield per plant (g), grain yield per plant (g), and harvest-index (%), were observed. The correlation and path coefficients weranalyzeded following Searle (1961) and Dewey and Lu (1959) respectively.

RESULTS AND DISCUSSION

Correlation coefficients. Table 1(a) and (b) respectively provide the estimates of the phenotypic and genotypic correlation coefficients derived between the twelve characters under consideration.

As shown in the table, all of the variables under study at the phenotypic level showed a highly significant and positive connection with the grain yield per plant (g), with the exception of the days to 50% flowering (0.071) and plant height (0.002).

Seedling height exhibited a highly significant and positive association with panicle-bearing tillers per plant (0.257) followed by spikelets per panicle (0.223), spikelets fertility % (0.213), biological yield per plant (0.165), and test weight (0.154). It also possessed a significant negative correlation with days to 50% flowering (-0.248). Additionally, Bughio *et al*. (2009); Tiwari and Jatav (2014); Choudhary *et al*. (2021) reported in rice a considerable positive relationship of grain yield with the aforementioned trait.

Days to 50% flowering showed positive and significant phenotypic correlation with biological yield per plant (0.192) followed by flag leaf area (0.184), plant height (0.150), and significant negative correlation with spikelets fertility % (-0.146). Flag leaf area (cm) showed a positive and highly significant phenotypic correlation with biological yield per plant (0.0.594), panicle length (0.403), test weight (0.369), panicle bearing tillers per plant (0.340), plant height (0.276), spikelets fertility (0.264) and harvest index (0.181) respectively. Most of these results show similar values to the findings Kiani and Nematzadeh (2012) recorded**.**

Plant height exhibited a highly significant and positive phenotypic correlation with only trait *i.e.,* test weight (0.359), and also a significant negative association with spikelets per panicle (-0.169). The association of plant height with different morphological and physiological traits has also been reported in rice by Bhadru *et al*. (2011).

Further, panicle-bearing tillers per plant was positively correlated with biological yield per plant (0.509) followed by spikelets per panicle (0.445), panicle length (0.412), and test weight (0.198) respectively. Panicle length (cm) showed a positive phenotypic association of a significant degree with biological yield per plant (0.476) followed by test weight (0.309), spikelets per panicle (0.227), and spikelets fertility (0.180). Spikelets per panicle recorded a positive and significant phenotypic correlation with biological yield per plant (0.643) followed by test weight (0.223) and spikelets fertility (0.195) while spikelets fertility % possessed a highly significant and positive correlation with biological yield per plant (0.196). These results show agreement with the earlier noted by Abdala *et al.* (2016).

Biological yield per plant (g) recorded a highly significant and positive correlation with test weight (0.270). The remaining estimates of phenotypic correlations in this analysis were non-significant. The positive associations between these characters have also been reported by Kishore *et al.* (2007); Saleh *et al.* (2020); Choudhary *et al*. (2021).

In general, the estimations of the genotypic correlation coefficients between the twelve features in Table 1(b) were greater in size than the corresponding phenotypic correlation coefficients but similar in sign.

Path coefficient analysis. Tables 2(a) and (b) present, respectively, the direct and indirect effects of eleven traits on grain yield per plant determined using path coefficient analysis employing correlations at phenotypic and genotypic levels.

At the phenotypic as well as genotypic level, the highest positive direct effect on grain yield per plant was exerted by biological yield per plant (1.0172,) followed by harvest index (0.3489). The direct effects of the remaining characters were too low to be considered important. Most of the traits under study exerted a positive effect on grain yield per plant *via* biological yield per plant except harvest index (-0.1411) which possessed a negative indirect effect on grain yield as presented in the table. The rest of the traits did not exert a substantial extent of indirect effects on grain yield *via* any of the traits. These characters have also been identified as major direct contributors to grain yield by Kiani and Nematzadeh (2012); Abdala *et al.* (2016); Choudhary *et al.* (2021). The estimate of residual factors (0.1318) obtained in path analysis was low indicating the little influence of external factors that were not included in the study.

Table 1(a): Estimates of phenotypic correlation coefficients between 12 traits in rice.

Characters	Seedling height cm	Days to 50% flowering	Flag leaf area (cm²)	Plant height (cm)	Panicle bearing tillers/plant	Panicle length (cm)	Spikelet's per panicle	Spikelets fertility (%)	Biological yield per plant (g)	Harvest index (%)	Test weight (g)	Grain yield per plant (g)
Seedling height cm	1.000	-0.248**	0.081	0.035	0.257**	0.142	0.223**	0.213**	0.165*	0.021	0.154*	0.200**
Days to 50% flowering		1.000	0.184*	0.150*	-0.019	-0.019	-0.088	-0.146*	0.192**	-0.078	-0.065	0.071
Flag leaf area (cm²)			1.000	0.276**	0.340**	0.403**	0.264**	-0.001	0.594**	0.181*	0.369**	0.641**
Plant height (cm)				1.000	-0.131	0.121	-0.169*	0.136	0.096	-0.050	0.359**	0.002
Panicle bearing tillers/plant					1.000	0.412**	0.445**	0.125	0.509**	0.113	0.198**	0.550**
Panicle length (cm)						1.000	0.227**	0.180*	0.476**	-0.069	0.309**	0.447**
Spikelet's per panicle							1.000	0.195**	0.643**	0.049	0.223**	0.653**
Spikelets fertility (%)								1.000	0.196**	0.007	0.128	0.158*
Biological yield per plant (g)									1.000	-0.122	0.270**	0.866**
Harvest index (%)										1.000	0.130	0.196**
Test weight (g)											1.000	0.290**
Grain yield per plant (g)												1.000

*,**. Significant at 5% and 1% probability levels, respectively

Table 1(b): Estimates of genotypic correlation coefficients between 12 traits in rice.

	Seedling height cm	Days to 50% flowering	Flag leaf area (cm²)	Plant height (cm)	Panicle bearing tillers/plant	Panicle length (cm)	Spikelet's per panicle	Spikelets fertility (%)	Biological yield per plant (g)	Harvest index (%)	Test weight (g)	Grain yield per plant (g)
Seedling height cm	1.000	-0.310**	0.138	0.054	0.322**	0.140	0.282**	0.312**	0.218**	-0.019	0.249**	0.258**
Days to 50% flowering		1.000	0.257**	0.194**	-0.032	0.030	-0.108	-0.180*	0.247**	-0.160*	-0.161*	0.080
Flag leaf area (cm²)			1.000	0.296**	0.429**	0.558**	0.277**	0.033	0.652**	0.224**	0.505**	0.712**
Plant height (cm)				1.000	-0.169*	0.122	-0.175*	0.213**	0.108	-0.105	0.442**	-0.020
Panicle bearing tillers/ plant					1.000	0.563**	0.521**	0.170*	0.596**	0.125	0.217**	0.671**
Panicle length (cm)						1.000	0.294**	0.172*	0.617**	-0.169*	0.474**	0.564**
Spikelet's per panicle							1.000	0.269**	0.655**	0.065	0.274**	0.693**
Spikelets fertility (%)								1.000	0.270**	-0.047	0.183*	0.215**
Biological yield per plant									1.000	-0.139	0.314**	0.930**
Harvest index (%)										1.000	0.175*	0.237**
Test weight (g)												0.372**
Grain yield per plant (g)												1.000

*,**. Significant at 5% and 1% probability levels, respectively

Table 2(a): Estimates of phenotypic direct and indirect effects of 11 characters on grain yield per plant in rice.

Characters	Seedling height cm	Days to 50% flowering	Flag leaf area (cm²)	Plant height (cm)	Panicle bearing tillers/plant	Panicle length (cm)	Spikelets per panicle	Spikelets fertility (%)	Biological yield per plant (g)	Harvest index (%)	Test weight (g)	Grain yield per plant (g)
Seedling height cm	**0.0223**	0.0143	0.0107	-0.0023	0.0081	0.0043	0.0191	-0.0045	0.1242	0.0052	-0.0015	0.200**
Days to 50% flowering	-0.0055	**-0.0577**	0.0244	-0.0099	-0.0006	-0.0006	-0.0075	0.0031	0.1445	-0.0197	0.0006	0.071
Flag leaf area (cm²)	0.0018	-0.0106	**0.1325**	-0.0182	0.0107	0.0122	0.0226	0.0000	0.4475	0.0456	-0.0036	0.641**
Plant height (cm)	0.0008	-0.0087	0.0366	**-0.0657**	-0.0041	0.0037	-0.0145	-0.0028	0.0727	-0.0125	-0.0035	0.002
Panicle bearing tillers/plant	0.0057	0.0011	0.0451	0.0086	**0.0315**	0.0125	0.0381	-0.0026	0.3832	0.0284	-0.0019	0.550**
Panicle length (cm)	0.0032	0.0011	0.0534	-0.0080	0.0130	**0.0303**	0.0195	-0.0038	0.3585	-0.0175	-0.0030	0.447**
Spikelets per panicle	0.0050	0.0051	0.0349	0.0111	0.0140	0.0069	**0.0857**	-0.0041	0.4841	0.0124	-0.0022	0.653**
Spikelets fertility (%)	0.0048	0.0084	-0.0001	-0.0089	0.0040	0.0055	0.0167	**-0.0209**	0.1478	0.0017	-0.0013	0.158*
Biological yield per plant (g)	0.0037	-0.0111	0.0787	-0.0063	0.0160	0.0144	0.0551	-0.0041	**0.7535**	-0.0307	-0.0026	0.866**
Harvest index (%)	0.0005	0.0045	0.0240	0.0033	0.0036	-0.0021	0.0042	-0.0001	-0.0919	**0.2520**	-0.0013	0.196**
Test weight (g)	0.0034	0.0037	0.0489	-0.0236	0.0062	0.0094	0.0191	-0.0027	0.2031	0.0327	**-0.0097**	0.290**

Residual factors: 0.13189, Bold figures indicate direct effects.

Table 2(b): Estimates of genotypic direct and indirect effects of 11 characters on grain yield per plant in rice.

Characters	Seedling height cm	Days to 50% flowering	Flag leaf area (cm²)	Plant height (cm)	Panicle bearing tillers/plant	Panicle length (cm)	Spikelets per panicle	Spikelets fertility (%)	Biological yield per plant (g)	Harvest index (%)	Test weight (g)	Grain yield per plant (g)
Seedling height cm	**0.0321**	0.0330	0.0022	-0.0040	0.0018	0.0008	-0.0068	-0.0167	0.2219	-0.0066	0.0005	0.258**
Days to 50% flowering	-0.0100	**-0.1066**	0.0042	-0.0142	-0.0002	0.0002	0.0026	0.0097	0.2508	-0.0559	-0.0003	0.080
Flag leaf area (cm²)	0.0044	-0.0274	**0.0163**	-0.0216	0.0024	0.0034	-0.0067	-0.0018	0.6637	0.0783	0.0010	0.712**
Plant height (cm)	0.0017	-0.0207	0.0048	**-0.0729**	-0.0010	0.0007	0.0043	-0.0114	0.1096	-0.0365	0.0009	-0.020
Panicle bearing tillers/plant	0.0103	0.0035	0.0070	0.0124	**0.0057**	0.0034	-0.0127	-0.0091	0.6063	0.0437	0.0004	0.671**
Panicle length (cm)	0.0045	-0.0032	0.0091	-0.0089	0.0032	**0.0060**	-0.0072	-0.0092	0.6275	-0.0591	0.0010	0.564**
Spikelets per panicle	0.0091	0.0115	0.0045	0.0128	0.0030	0.0018	**-0.0243**	-0.0144	0.6662	0.0226	0.0006	0.693**
Spikelets fertility (%)	0.0100	0.0192	0.0005	-0.0155	0.0010	0.0010	-0.0065	**-0.0536**	0.2751	-0.0164	0.0004	0.215**
Biological yield per plant (g)	0.0070	-0.0263	0.0106	-0.0079	0.0034	0.0037	-0.0159	-0.0145	**1.0172**	-0.0484	0.0006	0.930**
Harvest index (%)	-0.0006	0.0171	0.0037	0.0076	0.0007	-0.0010	-0.0016	0.0025	-0.1411	**0.3489**	0.0004	0.237**
Test weight (g)	0.0080	0.0172	0.0082	-0.0323	0.0012	0.0029	-0.0067	-0.0098	0.3196	0.0611	**0.0020**	0.372**

Residual factors: -0.02061, Bold figures indicate direct effects.

CONCLUSION

Characters from the current study, such as biological yield per plant, harvest index, and number of tillers per plant, showed a positive relationship between grain yield. Additionally, these traits have shown a direct and favourable impact on grain yield, in addition, proven to have a favourable indirect impact on grain production through the other. These CMS rice genotypes can have their yield potential increased by choosing features that are highly associated with grain yield and have both direct and indirect beneficial effects on yield.

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Conflict of Interest. None.

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