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Phenotypic correlation between morphological and yield related traits of rice (*Oryza sativa* L.)

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Abstract
Rice is known as major staple food crop in India by providing food to more than 70 per cent population. An experiment was carried out in Alpha lattice design with two replications at ICAR-Indian Institute of Rice Research (ICAR-IIRR). An experiment was conducted during *kharif* season of year 2019 to study correlation and path coefficient analysis in 152 rice germplasm lines were collected. Analysis of variance showed significant differences among genotypes for all the 10 traits studied. Correlation studies revealed that grain yield per plant had positive and significant association plant height at both genotypic and phenotypic levels. Hence, these characters should be given due consideration while applying selection for increasing yield. Results of path analysis indicated that the maximum direct effects for plant height, tiller number per plant, no. of un filled grains per panicle, panicle weight as well as appreciable indirect effects were exerted by days to 50% flowering, effective number of tillers, test weight, towards grain yield per plant. Therefore, selection pressure imposed on these traits would bring improvement in grain yield of rice.

Keywords: Rice, path coefficient analysis, yield

Introduction
Rice (*Oryza sativa* L.) is one of the important staple food crops with an annual production of 759.6 million tonnes (FAOSTAT, 2018) [12]. Rice feeds more than 70 per cent population in India and contributes especially towards the global food security. However, rapidly increasing population has forced us to look for another quantum jump in rice production. Yield, being a complex trait, is composed of several components some of which affect the yield directly, while other affect indirectly. Hence, knowledge of association between Morphological, yield and its components is necessary. Selection directly based on the performance of seed yield, may not be very effective but selection based on its component characters would prove more effective as reported in other plants (Fisher, 1918). Correlation studies would provide estimates of degree of association between seed yield, its various components and also among the components. Although studies on correlation are helpful in determining the components of complex characters like seed yield, these estimates do not provide an exact information about the relative magnitude of direct and indirect influences of each of the component character on seed yield. In this context Wright (1921) [31] proposed estimation of path coefficient analysis as an important tool in partitioning the correlation coefficient into two parts, direct and indirect effects which will be useful in identifying biometrical characters to achieve desirable goal. Therefore, path-coefficient analysis is important to elucidate the intrinsic nature of association of component traits by determining the direct or indirect contribution of these traits to yield.

Materials and Methods
One hundred and fifty two (152) rice germplasm lines collected from all over India and Philippines were evaluated for yield and component traits during *Kharif* 2019 in Alpha lattice design with two replications at ICAR-Indian Institute of Rice Research (ICAR-IIRR), Rajendranagar, Hyderabad.

Thirty days old seedlings were transplanted by adopting a spacing of 15 cm between plants and 20 cm between rows. Recommended agronomic and plant protection measures for raising a healthy nursery and main crop were taken up during the experiment.

Replication-wise data on the basis of five randomly taken competitive plants were recorded on following traits: *viz*., days to fifty per cent flowering (DFF), Total number of tillers per plant (TNT), effective number of tillers (ENT), plant height (PH) (cm), number of filled grains (NFG), number of un filled grains (NUFG), panicle weight (PW) (g), panicle weight (PL) (cm), test weight (TW) (g), and yield per plant (YPP) (g). The mean of five plants for each metric trait was considered for statistical analysis using SAS software. The analysis of variance (ANOVA) was done on the basis of model described by Cochran and Cox (1950) [10] for Alpha lattice design. The genotypic and phenotype variances were calculated as per the formulae proposed by Burton and Devane, 1953 [7]. The replicated data were subjected to statistical analysis. The estimates of covariances were worked out as per Singh and Choudhary (1985) [28]. The estimates of covariances and variances were utilized in computing genotypic and phenotypic path coefficient was worked out as suggested by Wright (1921) [31].

Path coefficient analysis

The genetic architecture of grain yield is based on the overall net effect produced by various yield components interacting with one another. The association of different component characters among themselves and with yield is quite important for devising an efficient selection criterion for yield. Correlation gives only the relation between two variables, whereas path coefficient analysis allows separation of the direct effect and their indirect effects through other attributes by partitioning the correlations (Wright, 1921) [31]. Based on the data recorded on the genotypes in the present investigation, the phenotypic correlations coefficients were estimated to determine direct and indirect effects of yield and contributing characters. The results for phenotypic path coefficient analysis for yield and its component traits are presented in table.1

For the improvement of crop for higher yield prior to any breeding program, it is commandment to obtain information regarding the inter-relationship of different characters with yield and among themselves, since it facilitates the quicker assessment of high yielding and better performing genotypes in selection programmed. The phenotypic correlation coefficients were estimated among 10 traits of 152 rice germplasm, to find out the association of grain yield and other yield contributing characters (Table 1).

Results and Discussion

Days to 50% flowering

Days to 50% flowering had negative and direct effect (-0.067) on single plant yield at phenotypic level in 2019. It had indirect negative effects on single plant yield through total no. of tillers (-0.005), productive tiller number (-0.006), panicle length (-0.004), panicle weight (-0.014), no. of un filled grains (-0.005), yield per plant (-0.004). It had indirect positive effects on single plant yield through, plant height (0.003) and test weight (0.004) at phenotypic level. Yadav *et al.* (2011) reported Days to 50% flowering exhibited direct negative effect. Gour *et al.* (2017) [14] reported days to 50% flowering showed direct negative effect.

Plant height

Plant height had positive and direct effect (0.022) on single plant yield at phenotypic levels in 2019. It had indirect negative effects on single plant yield through Days to 50% flowering (-0.001122), total no. of tillers (-0.000836), productive tiller number (-0.001166), yield per plant (-0.000836). It had indirect positive effects on single plant yield through, panicle length (0.00297), panicle weight (0.004774), no. of un filled grains (0.001694), no. of filled grains (0.00473) and test weight (0.0008) at phenotypic level.

Chakraborty *et al.* (2010) [9] revealed the positive direct effect of plant height, on grain yield. Pankaj *et al.* (2010) [20] revealed the direct positive effect of plant height at maturity on yield per plant at genotypic level. Ambili and Radhakrishnan (2011) [3] reported high positive direct effect of plant height on grain yield, followed by total no. of tillers, number of productive tillers per plant, Panicle length, panicle weight, no. of filled grains, test weight. The high negative direct effect on yield was recorded for days to flowering. They concluded that yield of rice can be improved by selecting medium tall genotypes having more number of productive tillers per plant, higher straw yield and an optimum duration.

Total no. of Tillers

Total no. of Tillers had positive and direct effect (0.045) on single plant yield at phenotypic levels in 2019. It had indirect negative effects on single plant yield through plant height (-0.00171) panicle weight (-0.004815), panicle length (-0.00882), test weight (-0.00531). It had indirect positive effects on single plant yield through, Days to 50% flowering (0.003915), productive tiller number (0.04158), total no. of filled grains (0.00342), no. of un filled grains (0.00252), yield per plant (0.004995).

Saravanan and Sabesan (2009) [26] revealed the estimates of direct effects for the number of tillers per plant with high direct effect on grain yield per plant, suggesting that the improvement in grain yield will be efficient if the selection is based on these component traits. Pankaj *et al.* (2010) [20] revealed the direct positive effect of tillers per plant on yield per plant. Ravindra Babu *et al.* (2012) [25] reported that number of tillers per hill exhibited maximum direct effect on grain yield per hill at phenotypic levels. Aditya and Anuradha (2013) [1] revealed that tillers per plant exhibited positive direct effect on grain yield.

Effective no. of tillers

Productive no. of tillers had negative and direct effect (-0.107) on single plant yield at phenotypic levels in 2019. It had indirect negative effects on single plant yield through Days to 50% flowering, (-0.009844), productive tiller number (-0.098868), no. of un filled grains (-0.01177), yield per plant (-0.013161). It had indirect positive effects on single plant yield through, plant height (0.005671), panicle weight (0.008667), panicle length (0.016371), test weight (0.01284). Khan *et al.* (2009) [18] reported negative direct effect of number of productive tillers per plant on grain yield. Sarawagi *et al.* (2016) [27] reported that effective tillers per plant showed positive direct effect on grain yield per plant.

Number of filled grains

Number of filled grains had negative and direct effect (-0.162) on single plant yield at phenotypic levels in 2019. It had indirect negative effects on single plant yield through plant height (-0.03483) panicle weight (-0.07695), panicle length (-0.012636), no. of un filled grains (-0.054594), yield per plant (-0.015714). no. of tillers (-0.012312) productive tiller number (-0.01782). It had indirect positive effects on single plant yield through, test weight (0.020898). Similar results were reported by Ashok *et al.* (2016) [4], and Nithya *et al.* (2020) [35].

Number of unfilled grains

Number of unfilled grains had positive and direct effect (0.146) on single plant yield at phenotypic levels in 2019. It had indirect negative effects on single plant yield through test weight (-0.015476). It had indirect positive effects on single plant yield through, Days to 50% flowering, (0.011826) plant height (0.011242), no. of tillers (0.008176) productive tiller number (0.007592), total no. of filled grains (0.049202), panicle weight (0.028324), panicle length (0.01241), yield per plant (0.013432). Similar results found by Parimala *et al.* (2020) [21].

Panicle weight

Panicle weight had positive and direct effect (0.155) on single plant yield at phenotypic levels in 2019. It had indirect negative effects on single plant yield through, total no. of tillers (-0.016585) productive tiller number (-0.012555). It had indirect positive effects on single plant yield through, Days to 50% flowering, (0.034565) plant height (0.033635), total no. of filled grains (0.073625), no. of un filled grains (0.03007), panicle length (0.025265), test weight (0.0062), yield per plant (0.01395).

Panicle length

Panicle length had positive and direct effect (0.046) on single plant yield at phenotypic levels in 2020. It had indirect negative effects on single plant yield through, total no. of tillers (-0.005382) productive tiller number (-0.00736), test weight (-0.000046). It had indirect positive effects on single plant yield through, Days to 50% flowering (0.00506), plant height (0.002576), total no. of filled grains (0.006486), no. of un filled grains (0.005152), yield per plant (0.002208), panicle weight (0.007498), Awaneet and Senapati (2013) [6] revealed that panicle length exhibited positive direct effect on grain yield, while 1000 grain weight exhibited negative direct effect on grain yield. Chouhan *et al.* (2014) evaluated thirty five rice accessions to assess their character association and path analysis for grain yield and yield attributing traits. Path analysis revealed positive direct effects of traits panicle length on yield per plant. Dhurai *et al.* (2016) [11] revealed that panicle length exhibited high positive direct effects on grain yield. Harsha *et al.* (2017) [15] revealed that at phenotypic level panicle length direct positive effect.

Thousand test weight

Thousand test weight had negative and direct effect (-0.145) on single plant yield at phenotypic levels in 2019. It had indirect negative effects on single plant yield through plant height (-0.005655) panicle weight (-0.0058), panicle length (-0.00232), test weight (-0.00087), yield per plant (-0.00087). It had indirect positive effects on single plant yield through, total no. of tillers (0.01711), productive tiller number (0.0174), total no. of filled grains (0.018705), no. of un filled grains (0.01537). Chakraborty *et al.* (2010) [9] revealed the positive direct effect of 1000-grain weight on grain yield. Harsha *et al.* (2017) [15] revealed that at phenotypic level, test weight showed direct positive effect.

Yield per plant

Yield per plant had negative and direct effect (-0.05) on single plant yield at phenotypic levels in 2019. It had indirect negative effects on single plant yield through, Days to 50% flowering, (-0.0033) panicle weight (-0.0045), panicle length (-0.00425), test weight (-0.0003). total no. of tillers (0.00555), productive tiller number (-0.00615), total no. of filled grains (-0.00485), no. of un filled grains (-0.0046), yield per plant (-0.05). It had indirect positive effects on single plant yield through, plant height (0.0019).

The data showed that correlation at genotypic and phenotypic levels had the same trend. The values of genotypic correlation coefficients were higher than those of their respective phenotypic correlation coefficients in most of the cases, suggesting that there was a strong and inherent association between two characters. In some cases, however, the phenotypic correlation was slightly higher than their genotypic counterpart, which implied that the non-genetic causes inflated the value of genotypic correlation because of the influence of environmental factors.

Table 1: Direct Indirect Effect Phenotypically between Morphological and yield traits in 2019

	DFF	PH	TNT	ENT	NFG	NUFG	PW	PL	TGW	YPP
DFF	-0.067	0.003417	-0.005829	-0.006164	0	-0.005427	-0.014941	-0.004958	0.004556	-0.004422
PH	-0.001122	0.022	-0.000836	-0.001166	0.00473	0.001694	0.004774	0.00297	0.000858	-0.000836
TNT	0.003915	-0.00171	0.045	0.04158	0.00342	0.00252	-0.004815	-0.00882	-0.00531	0.004995
ENT	-0.009844	0.005671	-0.098868	-0.107	-0.01177	-0.005564	0.008667	0.016371	0.01284	-0.013161
NFG	0	-0.03483	-0.012312	-0.01782	-0.162	-0.054594	-0.07695	-0.012636	0.020898	-0.015714
NUFG	0.011826	0.011242	0.008176	0.007592	0.049202	0.146	0.028324	0.01241	-0.015476	0.013432
PW	0.034565	0.033635	-0.016585	-0.012555	0.073625	0.03007	0.155	0.025265	0.0062	0.01395
PL	0	0	0	0	0	0	0	0	0	0
TGW	0.00986	-0.005655	0.01711	0.0174	0.018705	0.01537	-0.0058	-0.00232	-0.145	-0.00087
YPP	-0.0033	0.0019	-0.00555	-0.00615	-0.00485	-0.0046	-0.0045	-0.00425	-0.0003	-0.05

*Significance at 5% level, **Significance at 1% level

DFF- Days to 50% flowering, TNT- Tillers number per plant, ENT- Effective number of tillers, PH- Plant height, NFG- No. of filled grains, NUFG- No. of unfilled grains, PW- Panicle weight, PL- Panicle length, TGW- Test weight, SPY- Single plant yield,

Conclusion

Thus, it concludes that path analysis based on phenotypic correlation showed high direct effect of plant height, tiller number per plant, no. of un filled grains per panicle, panicle weight as well as appreciable indirect effects were exerted by days to 50% flowering, effective number of tillers, test weight, towards grain yield per plant. Revealing scope for considering these characters for imposing selection pressure for bringing out an improvement in rice yield. On the basis of all the above findings, it can be concluded that, while imposing selection for genetic improvement of grain yield in rice.

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