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Interrelationship and Cause - Effect Analysis for Yield and Yield Attributing Traits in Rice (*Oryza sativa* L.) Genotypes

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Authors' contributions

This work was carried out in collaboration among all authors. Author BS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors RR, FS, YS, PJN and MV managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The basic aim of plant breeders is to improve the yielding potential of existing varieties along with creation of new high yielding varieties. This experiment was carried out to study the association of yield and yield attributing traits along with path coefficient analysis among twenty rice genotypes. Analysis of variance revealed the existence of significant differences in genotypes for all the characters studied. Grain yield had positive significant association with ear bearing tillers/m^2 (0.5395**/0.6264**), number of filled grains per panicle (0.5236**/0.5774**) and test weight (0.2575*/0.2560*) and days to 50 percent flowering (0.3294**/0.3648**), It indicates that these characters are important for yield improvement. Path coefficient analysis revealed maximum positive direct effect of number of filled grains per panicle (1.4128/1.8979), test weight(1.1812/1.5927), days to fifty percent flowering (0.2404/0.1669), ear bearing tillers (0.0159/0.1224) and panicle length(0.0710/0.0813). Selection for the traits with positive association and direct effects will be useful for the improvement in yield of rice through breeding programme.

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Keywords: Correlation; path coefficient analysis; grain yield; rice.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is the most valuable and primary food crop for more than 50 percent of the world's population. Globally rice is cultivated in an area of 161.1 million hectares with a production of 495.87 million metric tons (Statista.com 2018-2019). In India, rice is cultivated in an area of 42.94 million hectares producing 112.9 million tons with an average productivity of 2585 kg ha^{-1} [1].

In Telangana, rice is cultivated in 1.719 million hectares with a production of 5.825 million tons and an average productivity of 3387 kg ha^{-1} [1]. Due to ever increasing population and better living standards, demand for rice is also moving up various studies have shown that to meet the increasing demand for rice, production has to be increased more than 40 percent by 2030 [2].

Yield is the end product of multiplicative interaction between various yield components and this necessitates a thorough understanding of character association and direct and indirect effects contributed by each character on grain yield before launching any breeding programme. Correlation is the measure of the mutual relationship between two variables. The study of correlation may help the plant breeder to know how the improvement of one character will bring simultaneous improvement in other characters. Knowledge of correlation between grain yield and other characters is helpful in the selection of suitable plant type [3].

Path coefficient analysis, a statistical device developed by Wright [4] helps in partitioning of the correlation coefficients into direct and indirect effects of independent variable on dependent variable. As grain yield is a complex character influenced by several factors, selection based on simple correlation without taking into consideration between the component characters is not effective. Hence, path analysis is of much importance in any plant breeding programme. Correlation in combination with path analysis would give a better insight into cause and effect relationship between different pairs of characters. Dewey and Lu [5] demonstrated the utility of path coefficient analysis in plant selection and since then its application has been extended almost to every crop.

2. MATERIALS AND METHODS

The present experiment was conducted during *Kharif,* 2019 at Regional Sugarcane and Rice Research Station Farm, Rudrur, Nizamabad. The materials comprised of 20 rice genotypes. The experimental material was planted in Randomized block design with three replications. Twenty six days old seedlings were transplanted at 20 cm apart between the rows and 15 cm between the plants. All the recommended agronomic practices and plant protection measures were taken up to raise a healthy crop. Data was collected from ten randomly selected plants from each plot and the observations viz., days to fifty percent flowering, plant height, panicle length, number of productive tillers per m^2, number of filled grains per panicle, 1000 grain weight and grain yield per plot and were included in the study. Genotypic and phenotypic correlation coefficients were calculated following (Singh and Chaudhary,1995) and Path coefficient analysis were estimated according to the method suggested by[5].

3. RESULTS AND DISCUSSION

In general the genotypic correlation coefficients were slightly higher than the phenotypic correlation coefficients, indicating the masking effect of the environment in the total expression of the genotypes. [Table.1].

Genotypic and phenotypic correlations revealed that grain yield had significant and positive association with days to 50% flowering (0.3294**/0.3648**), ear bearing tillers/m^2 (0.5395**/0.6264**), number of filled grains per panicle (0.5236**/0.5774**) and test weight (0.2575*/0.2560*). The trait showed positive non -significant association with panicle length (0.0706/0.1883) at both levels. It exhibited negative significant association with plant height (-0.1844/ -0.2774*) at genotypic level and negative non significant association at phenotypic level. The results were in unison with Fiyaz et al. [6], Laxuman et al. [7], sadeghi et al. [8] and Nizam ali et al. [9] for days to fifty percent flowering. Ravindrababu et al. [10], Yadava *et al*. (2011) and Jadhav et al. [11] for plant height. Ravindrababu et al.[10], Parimala et al. [12] and Shreshta et al. [13] for panicle length. Singh *et al.* (2011), Nizam Ali et al. [9] and Jadhav et al. [11] for ear bearing tillers/m^2.

Table 1. Phenotypic (p) and genotypic (g) correlation coefficients among yield attributes in 20 rice genotypes

Character		DFF	PH(cm)	Pl (cm)	EBT/m^2	NFGP	1000 Tw (gr)	GY (kg/ha)
DFF	P	1	-0.4167**	0.2392	0.3594**	0.4954***	-0.5465***	0.3294**
	G	1	-0.5582	0.3455	0. 3682	0.4988	-0.5541***	0.3648**
PH CM	P		1	-0.2098	-0.2601*	-0.2250	0.2819*	-0.1844
	G		1	0.0248	-0.3426	-0.3077	0.3929**	-0.2774
PL (cm)	P			1	0.2310	0.0525	-0.0142	0.0706
	G			1	0.3414**	0.0625	-0.0130	0.1883
EBT/m^2	P				1	0.5749***	-0.3280**	0.5395***
	G				1	0.5909	-0.3481**	0.6264***
NFGP	P					1	-0.8792**	0.5236***
	G					1	-0.8913**	0.5774***
1000 Tw (gr)	P						1	0.2575*
	G						1	0.2560*
GY (kg/ha)	P							1
	G							1

and = significant at 5% and 1% level respectivelyDFF= Days to 50% flowering, PH= Plant height, PL= Panicle length, EBT/m^2=Ear bearing tillers/ m^2, NFGP = Numberof filled grains per panicle, 1000 TW=1000 Test weight and GY= Grain yield (kg/ha)*

Table 2. Phenotypic (p) and genotypic (g) path coefficients among yield attributes in 20 rice genotypes

Character		DFF	PH (cm)	PL (cm)	EBT/m^2	NFGP	1000 Tw (gr)	GY (kg/ha)
DFF	P	0.2404	0.0459	-0.0170	0.0057	0.6999	-0.6455	0.3294
	G	0.1669	0.1507	0.0281	-0.0451	0.9468	-0.8826	0.3648
PH (cm)	P	-0.1002	-0. 1102	0.0149	-0.0041	-0.3178	0.3330	-0.1844
	G	-0.0932	-0. 2700	0.0020	0.0419	-0.5840	0.6257	-0.2774
PL (cm)	P	0.0575	0.0231	0.0710	0.0037	0.0742	-0.0168	0.0706
	G	0.0577	-0.0067	0. 0813	-0.0418	0.1186	-0.0208	0.1883
EBT/m^2	P	0.0864	0.0287	-0.0164	0.0159	0.8123	-0.3874	0.5395
	G	0.0615	0.0925	0.0278	0.1224	1.1216	-0.5544	0.6264
NFGP	P	0.1191	0.0248	-0.0037	0.0092	1.4128	-1.0385	0.5236
	G	0.0833	0.0831	0.0051	-0.0723	1.8979	-1.4197	0.5774
1000 Tw (gr)	P	-0.1314	-0.0311	0.0010	-0.0052	-1.2421	1.1812	0.2575
	G	-0.0925	-0.1061	-0.0011	0.0426	-1.6917	1.5927	0.2560

*Residual effect at phenotypic level (0.6) Residual effect at genotypic level (0.4)*and** = significant at 5% and 1% level respectivelyDFF= Days to 50% flowering, PH= Plant height, PL= Panicle length, EBT/m^2=Ear bearing tillers/ m^2, NFGP = Number of filled grains per panicle, 1000 TW=1000 Test weight and GY= Grain yield/plot*

Alka et al.[14], Nizam Ali et al.[9], Katiyar et al. [15] for number of filled grains per panicle and Alka et al. [14] Sonukumar et al. [16] and Butta et al. [17] for test weight.

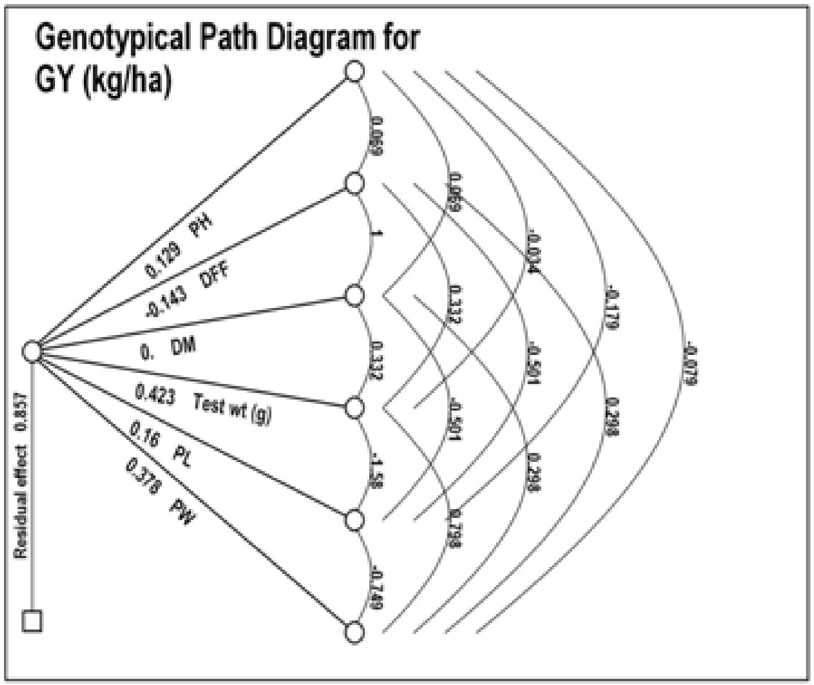

Fig 1. Genotypical path diagram for GY

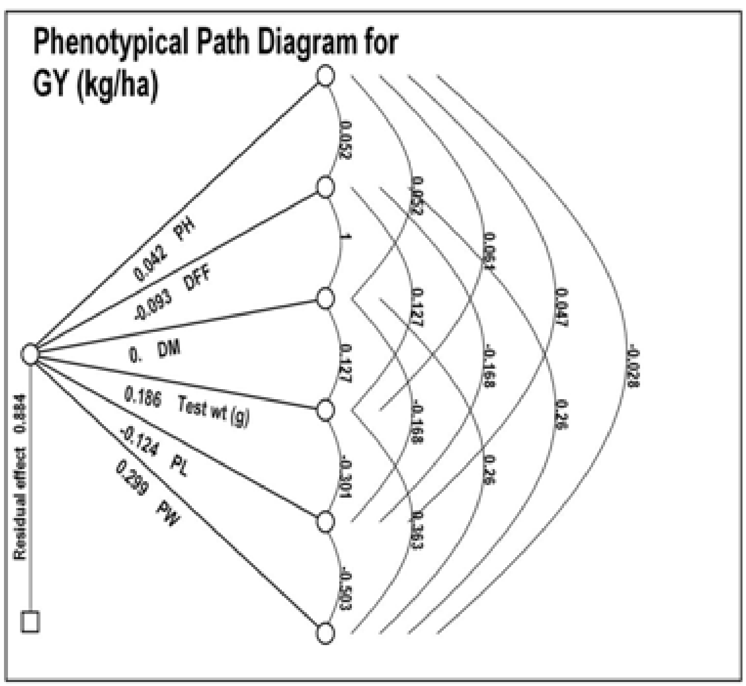

Fig. 2. Phenotypical path diagram for GY

Among inter correlations the character days to 50% flowering showed positive significant correlation at both genotypic and phenotypic levels with grain yield (0.3294**/0.3648**), number of filled grains per panicle (0.4954**/0.4988**), ear bearing tillers/m^2 (0.3594**/0.3682**).This trait showed positive significant (0.2392/0.3455*) at genotypic level and positive but non-significant at phenotypic level in panicle length. This trait showed negative significant correlation at both levels in test weight (-0.5465**/-0.5541**) and plant height(-0.4167**/-0.5582**). Such results are in concurrence with the findings of Alka et al. [14] for plant height, Prasanna et al.[18], Nizam Ali *et al.* [9] for panicle length, Katiyar et al. [15] for number of filled grains per panicle and test weight.

Plant height showed positive significant association with test weight (0.2819*/0.3929**) at both levels. It showed positive but non-significant association at genotypic level with panicle length (0.0248). The trait expressed significant negative association at both phenotypic and genotypic level with ear bearing tillers/m^2 (-0.2601*/-0.3426**). It showed negative and significant association at genotypic level only with number of filled grains per panicle (-0.3077**) and grain yield (-0.2774**). It expressed negative but non-significant association at phenotypic level with grain yield (-0.1844), number of filled grains per (-0.2250/) and panicle length (-0.2098). This is in accordance with the findings of Parimala et al. [12] for panicle length. Butta et al. [17] and Parimala et al. [12] for ear bearing tillers/$m^{2,}$ and number of filled grains per panicle. Sonukumar et al. [16] for test weight.

Panicle length exhibited positive and significant association with ear bearing tillers/ m^2 (0.3414**) at genotypic level. It expressed positive but non-significant association at both genotypic and phenotypic levels with seed yield per plant (0.0706/0.1883), number of filled grains per panicle (0.0525/0.0625) and ear bearing tiller (0.2314) at phenotypic level. This trait showed negative but non–significant association at both genotypic and phenotypic levels with test weight (-0.0142/-0.0130). Similar results were observed by Parimala et al. [12] for grain yield. Butta et al. [17] ear bearing tillers/m^2. Prasanna et al. [19] for number of filled grains per panicle.

Ear bearing tillers/m^2 showed positive and significant association at both genotypic and phenotypic level with grain yield (0.5395**/0.6264**), number of filled grains per panicle (0.5749**/0.5909**). This trait showed negative significant association at both genotypic and phenotypic levels with test weight (-0.3280**/-0.3481**). The results are in accordance with Nizam Ali *et al.* [9] for grain yield and number of filled grains per panicle. Prasanna et al. [18] and Sonukumar et al. [16] for test weight.

Number of filled grains per panicle has positive significant association at both levels with grain yield (0.5236**/0.5774**).This trait showed negative significant association at both genotypic and phenotypic levels with test weight (-0.8792**/-0.8913**) Similar results were reported by Nizam Ali et al. [9] and Katiyar et al. [15] for grain yield. Prasanna et al. [18] for test weight.

Test weight showed positive and significant association with grain yield (0.2575*/0.2560*) at phenotypic and genotypic levels. This indicates that, if other characters are held constant, improvement in these characters shall reflect in an increased seed yield. This is in accordance with the findings of Alka et al. [14], Sonukumar et al. [16] and Butta et al. [17] for grain yield.

The direct contribution of days to 50% flowering to grain yield was positive (0.2404/0.1669) at genotypic and phenotypic level. It showed indirect positive influence on grain yield at genotypic and phenotypic level through plant height (0.0459/0.1507), number of grains per panicle (0.6999/0.9468). The indirect effect through test weight (-0.6455/-0.8826) was negative at both levels. The indirect effect through panicle length (-0.0170) was negative at phenotypic level and ear bearing tillers/m^2 (-0.0451) was negative at genotypic level. This trait had positive effect on grain yield, so it can be used as selection criteria for yield improvement. The results are in agreement with Jadhav et al.[11], Alka et al. [14], Sonu kumar et al. [16] and Katiyar et al.[15] for single plant yield and Prasanna et al.[18], Sonukumar et al.[16] for panicle length and Katiyar et al. [15], Ravindra babu et al. [10] for ear bearing tillers/m^2 and Prasanna et al.[18], Sonukumar et al. [16] for number of filled grains per panicle and test weight.

The direct contribution of plant height on grain yield was negative (-0.1102/-0.2700) at genotypic and phenotypic levels. Panicle length (0.0149/0.0020) and test weight (0.3330/0.6257) showed indirect positive effect on grain yield at both levels. Whereas, the indirect positive effect through ear bearing tillers/m^2 (0.0419) at genotypic level. The indirect negative effect through days to fifty percent flowering (-0.1002/-0.0932) and number of filled grains per panicle (-0.3178/-0.5840) at both levels. Whereas, the indirect negative effect through ear bearing tillers/m^2 (-0.0041) at phenotypic level. This trait showed negative non-significant association with grain yield (-0.1844/-0.2774) at both levels. Hence, response of genotypes for selection of this trait will be poor. Similar findings were reported by Alka et al.[14], Butt et al.[17], Katiyar et al. [15] for grain yield and Prasanna et al. [18] for days to fifty percent flowering and panicle length. Sonukumar et al.[16], Katiyar et al.[15], Parimala et al. [12] for ear bearing tillers/ m^2 , number of filled grains per panicle and test weight.

Panicle length exhibited positive direct effect on yield (0.0710/0.0813) at both genotypic and phenotypic levels. The indirect positive effect on yield through days to 50% flowering (0.0575/0.0577), number of filled grains per panicle (0.0742/0.1186) at both levels. Whereas, the plant height (0.0231) and ear bearing tillers (0.0037) showed indirect positive effect on yield at phenotypic level. The indirect negative effect on yield through test weight (-0.0168/-0.0208) at both levels. Whereas, the plant height (-0.0067) and ear bearing tillers/m^2 (-0.0418) showed indirect negative effect on yield at genotypic level. This trait showed positive non-significant association with grain yield (0.0706/0.1883) at both levels. So, direct selection of this trait could be more effective in improving grain yield. The results are in accordance with Sonukumar et al. [16] and Ekka et al. [19] for grain yield. Prasanna et al.[18], Parimala et al. [12] and Sonukumar et al. [16] for days to fifty percent flowering, plant height, number of filled grins per panicle and test weight.

Positive direct effect (0.0159/0.1224) at genotypic and phenotypic levels was exhibited by ear bearing tillers on grain yield. The indirect positive influence on grain yield through days to 50% flowering (0.0864/0.0615), plant height (0.0287/0.0925) and number of filled grains per panicle (0.8123/1.1216) at both genotypic and phenotypic levels. Whereas the panicle length (0.0278) showed indirect positive effect on yield at genotypic level. This trait showed indirect negative effect on yield through test weight (-0.3874/-0.5544) at both levels. This trait had positive effect on grain yield, so it can be used as selection criteria for yield improvement. Similar findings were reported by Jadhav et al.[11], Butta et al. [17] and Katiyar et al. [15] for grain yield and Prasanna et al. [18] for plant height and Prasanna et al. [18], Parimla et al.[12], Katiyar et al. [15] and Sonukumar et al. [16] for number of filled grains per panicle and test weight.

Number of filled grains per panicle exhibited positive direct effect on yield (1.4128/1.8979) at both genotypic and phenotypic levels. The indirect effects *via* days to fifty percent flowering (0.1191/0.0833) and plant height (0.0248/0.0831) were positive at both levels. Panicle length (0.0051) showed positive indirect effect at genotypic levels and ear bearing tillers (0.0092) showed positive indirect effect at phenotypic level. This trait showed indirect negative effect on yield through test weight (-1.0385/-1.4197) at both levels. This trait showed significant positive association with grain yield (0.5236/0.5774) at both levels. Hence, simple selection could be more effective for improving grain yield based on this trait. The results are in agreement with Parimala et al. [12], Butta et al. [17] and Jadhav et al. [11] for grain yield. Prasanna et al. [18] and Katiyar et al. [15] for days to fifty percent flowering and plant height and Parimala et al. [12] for ear bearing tillers/ m^2 and test weight.

The direct contribution of test weight on grain yield was positive (1.1812/1.5927) at genotypic and phenotypic levels. The indirect positive effect on yield through ear bearing tillers/m^2 (0.0052/0.0426) number of filled grains per panicle (1.2421/1.6917) at genotypic and phenotypic levels. The indirect negative effect on yield through days to 50% flowering (-0.1314/-0.0925), plant height (-0.0311/-0.1061) at both genotypic and phenotypic levels. The indirect positive effect on yield through panicle length (0.0010/-0.0011) at phenotypic level and negative effect at genotypic level. Hence, simple selection could be more effective for improving single plant yield based on this trait. Similar findings were reported by Alka et al. [14], Jadhav et al. [11], Shreshta et al. [13] and Parimala et al. [12] for grain yield. Ravindra babu et al. [10], Katiyar et al. [15], Prasanna et al. [18] and Parimala et al.[12] for days to fifty percent flowering, plant height and panicle length, Parimala et al. [12] for ear bearing tillers /m^2 and number of filled grains per panicle.

4. CONCLUSION

The association between grain yield and its contributing characters indicated that the grain yield had positive and highly significant association with ear bearing tillers and number of filled grains per panicle, 1000 grain weight and Days to fifty percent flowering. Positive but non- significant association was observed for panicle length. Negative non-significant correlation was observed for plant height. This clearly indicates that these traits will increase grain yield and hence while making selection for yield more emphasis should be given to this characters.

The results of path coefficient analysis based on the genotypic and phenotypic correlation coefficient. The trait number of filled grains per panicle showed high positive direct effects on grain yield followed by 1000 grain weight, days to fifty percent flowering and ear bearing tillers .The traits panicle length showed positive but low direct effects on grain yield. This indicated that selection for these characters is likely to bring about an overall improvement in grain yield directly.

In the present study, the residual effect (0.6) at phenotypic level, (0.4) at genotypic level was high in magnitude which showed that some other important yield contributing characters which contributed to yield had to be included. From the above results, it could be inferred that the characters, number of filled grains per panicle, 1000 grain weight, days to fifty percent flowering and ear bearing tillers were to be given prime importance as they revealed a significant positive correlation coefficient and a high positive direct effect compared to other traits.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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