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CORRELATION AND PATH COEFFICIENT ANALYSIS AMONG GRAIN YIELD AND YIELD-RELATED TRAITS OF RICE VARIETIES

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ABSTRACT: A field experiment was carried out in 2023 cropping season at the Teaching and Research farm of Joseph Sarwuan Tarka University, Makurdi to study the relationship between yield and yield related traits of rice varieties at Makurdi. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were collected on the following parameters; plant height, number of tillers/plant, panicle exertion, leaf length, panicle length, days to 50% flowering, number of spikelet, number of seed per panicle, grain yield, and number of panicle. Grain yield showed highly significant and positive correlation with number of tillers, leaf length, panicle length, spikelet number, total seed per panicle, days to 50% flowering, and panicle number. In addition, phenotypic path coefficient analysis revealed that total number of seed per panicle, panicle number and number of tiller had appreciable positive direct effect on grain yield. This suggests that selection for total number of seed per panicle, tiller number, panicle number, and spikelet number would lead to simultaneous improvement of grain yield in rice. Hence, plant breeders are to prioritize genotypes with high panicle number and total seeds per panicle, as these exert the strongest direct effects on yield and to optimize leaf length and tiller number to exploit their indirect contributions.

Key Words: Rice, Grain Yield, Yield components, Correlation, Path Coefficient Analysis

INTRODUCTION

Rice is one of the major staple foods of half of the world's population. Worldwide, more than 3.5 billion people depend on rice for more than 20 % of their daily calories (FAO, 2024). The genus Oryza, consists of several wild and two cultivated species. *Oryza sativa* L. (Asian rice) and *O. glaberrima* Steud. (African rice) are the two cultivated rice species in Asia and Africa, respectively (Ndjiondjop *et al.*, 2018). In Nigeria, rice is important for several reasons including its contribution to food security (Vange and Obi, 2006; Duvick, 1999). Nigeria's rice production was approximately 5.23 million tons in the 2023-2024 period, contributing to the global production figure of 517.8 million tons (FAO, 2024). Rice is abundant in carbohydrates and it provides enough energy to the body and aids in the normal functioning of the brain. Consumption of rice is extremely beneficial for health, simply because it does not contain harmful fats, cholesterol or sodium (Umadevi *et al.*, 2012; Anderson, 1976). Rice is rich in insoluble fibre that protects against many types of cancer. Rice bran oil extracted from the husk of rice is known to have antioxidant properties that promote cardiovascular strength by reducing cholesterol levels in the body. (Umadevi *et al.*, 2012; Anderson, 1976).

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According to USDA report (2024), rice yields rose from about 1.9 t/ha to around **2.47 t/ha** between 2015 and 2023. This still remained far below regional competitors such as Ethiopia (3.4 t/ha), South Africa (2.9 t/ha), and Kenya (4.2 t/ha).

The grain yield is a complex character, quantitative in nature and an integrated function of a number of component traits. Therefore, selection for yield per se may not be much rewarding unless other yield attributing traits are taken into consideration. Breeding and adoption of rice cultivars with enhanced yield potential is a common objective of the breeders. But yield in rice is correlated with different yield contributing traits as well as environmental factors (Rahman *et al.*, 2014; Prajapati *et al.*, 2011). These traits are also correlated among themselves (Akhtar *et al*., 2011) and develop sequentially during growth and their multiplicative product forms total grain yield. For optimum yield therefore, yield components should be in appropriate balance (Pushkaram, 2003). Such balance is assessed via correlation, which measures of the degree of relationship which exists between variables as measured by the correlation coefficient (r) (Rangaswamy, 1995). Correlation study provides a measure of association between characters and helps to identify important characters to be considered while making selection. Plant breeder have to find significant correlations among yield and yield component traits, and effect of yield component traits on grain yield to predict the superior cross combinations and to select ideal plant type with increased yield (Nagaraju *et al.,* 2013).

Although correlation coefficients are helpful in decomposing the components of complex traits like yield they do not provide an exact picture of relative importance of direct and indirect influence of each component character (Vange and Okoh 2011). Such a complex scheme of relationship could be partitioned by path coefficients analysis (Gunjan, 2012). Generally, a path coefficient analysis is needed to clarify relationships between characteristics, because correlation coefficients describe relationships in a simple manner. Path coefficient analysis shows the extent of direct and indirect effects of the causal components on the response component (Tuncturk and Ciftci, 2005).

In addition path coefficient analysis partitions the influence of correlated traits into direct and indirect effects and gives a measure of the magnitude (weight) of the yield components on the grain yield. This information is helpful to the breeder to determine and choose which traits to use as indirect selection indices for grain yield improvement in a breeding program. The aim of this study was to create several trait selection criteria for rice yield enhancement by using correlation and path coefficient analyses to find characteristics that have a direct effect on grain yield improvement in rice genotypes

MATERIALS AND METHOD

The study was carried out at the Teaching and Research farm of Joseph Sarwuan Tarka University, Makurdi (latitude 7°41”N, longitude 8°28’’E, and 97 m above sea level). A total of 55 rice genotypes were sourced from the National Cereal Research Institute (NCRI) research station. Each genotype was sown on a seed bed, with a distance of 0.5 m apart. A total of 55 plots were established and the seed were sown using dibbling method. The experiment was laid out in a Randomized Complete Block Design with three replications. Rice seedlings were transplanted into plots spaced 0.5 meters between plots and 1 meter between blocks. Intra-row spacing between plant stands was 30 cm. Transplanting was carried out two weeks after planting. Fertilizer application was carried out in three splits. A basal of 200 kg/ha NPK 15:15:15 was applied 29 days after planting, top dressed with urea at the rate of 65 kg/ha at the tillering stage and at the rate of 35 kg/ha at the booting stage. Data were collected on the following parameters; plant height, tillering number, panicle exertion, leaf length, panicle length, days to 50% flowering, spikelet number, number of seed per panicle, grain yield, panicle number.

Estimation of phenotypic and genotypic correlation coefficient (r)

Correlation coefficient (r) is a measure of the association between two or more than two variables. The phenotypic correlation and genotypic correlation coefficients between two variables including genotype were estimated as described by Singh and Chaudhary (1985).

Path coefficient analysis

Path coefficient analysis was calculated using as suggested by Dewey and Lu (1959) to deter-mine direct and indirect effect of different variables on grain yield. 15

RESULTS

Correlation among Yield and Yield related Traits

The result of correlation analysis as shown in Table 1. The coefficients of correlation reveals that Plant height recorded a significant positive correlation with panicle exertion (0.428*) and spikelet number

(0.213*), but showed positive non-significant correlation with grain yield per plant.

Number of tiller per plant recorded positive significant phenotypic correlation with leaf length (0.230*), panicle length (0.289*), spikelet number (0.730**), panicle number (1.00**), and grain yield per plant (0.553**).

Panicle exertion recorded positive significant correlation with plant height (0.428*), and non-significant correlation with grain yield per plant, spikelet number, days to 50% flowering, total number of seed per panicle and panicle number.

Leaf length showed positive significant correlation with days to 50% flowering (0.363*), spikelet number (0.205), tiller number (0.230*), total number of seed per panicle (0.483*8), panicle number (0.230*) and grain yield per plant (0.488**). Panicle length showed positive significant correlation with spikelet number (0.309**), total number of seed per panicle (0.197*), number of tiller per plant (0.289*), panicle number (0.230*), and grain yield per plant 0.362*). Days to 50% flowering showed positive significant correlation to total number of seed per panicle (0.417*), leaf length (0.369*) and grain yield per plant (0.217*).

Spikelet number showed significant positive correlation with panicle number (0.703**), grain yield per plant (0.454**), plant height (0.213*), tiller number (0.730**), leaf length (0.235*) and panicle length (0.309**).

Total number of seed per panicle showed positive significant correlation with leaf length (0.483*), panicle length (0.197*), grain yield per plant (0.701**). Panicle number showed positive significant correlation with tiller number (1.00**), leaf length (0.230*), panicle length (0.289*) spikelet number (0.703**) and grain yield per plant (0.553**). Grain yield per plant showed highly significant and positive correlation with tiller number (0.553*), leaf length (0.448*), panicle length (0.362*), spikelet number (0.454*), total seed per panicle (0.701**), days to 50% flowering (0.217*), and panicle number (0.533**).

Table 1: Phenotypic correlation coefficient among the traits

Traits	Plant Height	Tillering Ability	Panicle Exertion	Leaf Length	Panicle Length	Days to 50% Flowering	Spikelet Number	Seeds Per Panicle	Panicle Number
Plant Height	1								
Tillering Ability	0.043NS	1							
Panicle Exertion	0.428*	-0.047NS	1						
Leaf Length	0.017NS	0.230*	-0.459NS	1					
Panicle Length	0.067NS	0.289*	0.028NS	0.115NS	1				
Days to 50% Flowering	-0.318NS	0.066NS	0.751NS	0.363**	0.059NS	1			
Spikelet Number	0.213*	0.730**	0.082NS	0.205*	0.309**	-0.020NS	1		
Seeds Per Panicle	0.056NS	0.043NS	-0.373NS	0.483**	0.197*	0.417**	0.075NS	1	
Panicle Number	0.043NS	1.000**	-0.047NS	0.230*	0.289*	0.066NS	0.703**	0.043NS	1
Seed YIELD	0.114NS	0.553**	-0.163NS	0.448**	0.362**	0.217*	0.454**	0.701**	0.553**

Note:* and ** Indicate significance at 0.05 and 0.01 probability levels respectively. NS =Non Significant

Path Coefficient Analysis

The results of phenotypic path coefficient analysis is presented in Table 2. It revealed that total number of seed per panicle (0.671), had the maximum direct effect on grain yield, and followed by panicle number (0.242) and tiller number (0.242). The direct effect of leaf length (0.036), and panicle length (0.076) and panicle exertion (0.047) was positive but of low magnitude to grain yield. On the other hand plant height (-0.009), days to 50% flowering (-0.082) and spikelet number (-0.016) had negative direct effect on grain yield.

Indirect effect of plant height (0.038), tiller number (0.029), leaf length (0.324), leaf width

(0.002), panicle length (0.132), days to 50% flowering (0.280), spikelet number (0.050) and panicle number (0.029) via total number of seed per panicle supported direct contribution to grain yield. Leaf length (0.324) and days to 50% flowering (0.280) contributed to grain yield via total number of seed per panicle. Therefore improvement of these traits via total number of seed per panicle will give a higher grain yield.

TABLE 2: Phenotypic path coefficient analysis showing direct and indirect effect of different character on yield

Variables	Plant Height	Tillering Ability	Panicle Exertion	Leaf Length	Panicle Length	Days to 50% Flowering	Spikelet Number	Seeds Per Panicle	Panicle Number	Grain yield correlation
Plant Height	**-0.00927**	0.010554	0.010554	0.00064	0.005132	0.026303	-0.00347	0.038201	0.010554	**0.114NS**
Tillering Ability	-0.000404	**0.242522**	-0.00227	0.008313	0.022097	-0.00551	-0.01144	0.029455	0.242522	**0.553****
Panicle Exertion	-0.003979	-0.01153	**0.0478**	0.016586	0.0021861	0.0620655	-0.001348	-0.250643	-0.011537	**-0.163NS**
Leaf Length	-0.000164	0.055802	-0.02195	**0.03613**	0.0088137	-0.030016	-0.003336	0.324801	0.055802	**0.448****
Panicle Length	-0.000625	0.0703097	0.001371	0.004177	**0.076223**	-0.004899	-0.005031	0.13272	0.070309	**0.362****
Days to 50% Flowering	0.002955	0.016186	-0.03594	0.013135	0.0045231	**-0.082565**	0.000328	0.280669	0.016186	**0.217***
Spikelet Number	-0.001984	0.1705418	0.003961	0.007409	0.0235727	0.0016686	**-0.0162**	0.050762	0.170541	**0.454****
Seeds Per Panicle	-0.000528	0.0106346	-0.01784	0.01747	0.0150601	-0.034498	-0.001229	**0.67173**	0.010634	**0.701****
Panicle Number	0.000404	0.2425225	-0.00227	0.008313	0.0220978	-0.00551	-0.011441	0.029455	**0.24252**	**0.553****

Table 3: Genotypic path coefficient analysis showing direct and indirect effect of different characters on yield

Variables	Plant Height	Tillering Ability	Panicle Exertion	Leaf Length	Panicle Length	Days to 50% Flowering	Spikelet Number	Seeds Per Panicle	Panicle Number	Grain yield correlation
Plant Height	**-0.07677**	-0.106928	0.301628	0.068992	0.0089543	-0.130129	0.020747	0.017197	-0.106928	**0.037ns**
Tillering Ability	0.052404	**0.156651**	-0.17082	0.030232	0.0932928	0.0800072	-0.081523	-0.170444	0.156651	**0.076ns**
Panicle Exertion	-0.040272	-0.046535	**0.57502**	-0.324338	-0.048945	-0.275022	0.018593	-0.437335	-0.046535	**-0.553ns**
Leaf Length	-0.010801	0.0096572	-0.3803	**0.4904**	0.0610241	0.2193584	0.036193	0.6287	0.009657	**0.014****
Panicle Length	-0.006268	0.1332408	-0.25659	0.272841	**0.109684**	0.0959297	-0.110219	0.058162	0.13324	**0.431****
Days to 50% Flowering	0.032644	0.0409529	-0.51674	0.351503	0.0343811	**0.30604**	-0.020049	0.419718	0.040952	**0.675****
Spikelet Number	0.071336	0.5719422	-0.47884	-0.794926	0.5414269	0.2747917	**-0.02232**	-1.712551	0.571942	**-1.295ns**
Seeds Per Panicle	-0.002197	-0.044434	-0.4185	0.513092	0.0106167	0.2137639	0.063636	**0.6009**	-0.044434	**0.871****
Panicle Number	0.052404	0.1566516	-0.17082	0.030232	0.0932928	0.0800072	-0.081523	-0.170444	**0.15665**	**0.076****

The genotypic path coefficient analysis showing direct and indirect effect of different characters on yield and other traits is presented in Table 3. The indirect effect of plant height (0.010), leaf length (0.055), panicle length (0.070), days to 50% flowering (0.016), spikelet number (0.070), total number of seed per panicle (0.010) and panicle number (0.242) contributed indirectly to higher grain yield via tiller number. Panicle number (0.242) and spikelet number (0.170) gave a higher indirect contribution to grain yield via tiller number.

The direct effect of plant height (0.010), tiller number (0.242), leaf length (0.055), panicle length (0.070), days to 50% flowering (0.016), spikelet number (0.170), and total number of seed per panicle (0.0100 contributed directly to higher grain yield via panicle number. The indirect effect of spikelet number (0.170), and tiller number (0.242), to grain yield was via panicle number.

DISCUSSION

Grain yield showed highly significant and positive correlation with number of tillers, leaf length, panicle length, spikelet number, total seed per panicle, days to 50% flowering, and panicle number. This suggests that selection for total number of seed per panicle, tiller number, panicle number, and spikelet number would lead to simultaneous improvement of grain yield in rice. Significant positive correlation of grain yield with panicle number and number of seeds per panicle was reported by Akinwale *et al*. (2011). The study of Kamlesh *et al*. (2015) who reported significant positive correlation between grain yield and spikelet number corroborates with the present findings. Bhadru *et al*. (2011) and Patel *et al*. (2014) also reported significant positive phenotypic correlation of days to 50 per cent flowering with grain yield per plant. Significant positive phenotypic correlation of panicle length with grain yield per plant was also reported by Bhadru *et al*. (2011) and Patel *et al.* (2014), The findings that panicle number and tiller number strongly correlate with yield aligns with Johnson *et al*. (2024), who reported a "robust positive correlation of effective tillering with panicle number and yield" in Nigerian upland rice. Similarly, Saran *et al*. (2023) noted significant positive associations between grain yield and panicle-related traits (e.g., effective tillers, filled grains).The high correlation between total seeds per panicle and yield (r=0.701∗∗*r*=0.701∗∗) mirrors Berie and Dejene (2024), who emphasized that yield relies on "panicle number per plant, grains per panicle, and weight per grain". The observation that spikelet number correlates with yield but exhibits a negative direct effect in path analysis underscores the need to distinguish between direct and indirect influences. The showed a significant phenotypic correlation of leaf length with yield (r=0.488∗∗), is consistent with Johnson *et al*. (2024), who noted leaf length as a "pivotal determinant" for yield. However, plant height had a non-significant correlation with yield in this study, contrasting with Johnson *et al*.'s observation of positive genotypic correlations between plant height and culm length. Also, Number of tiller per plant recorded positive significant phenotypic correlation with leaf length, panicle length, spikelet number, panicle number, and grain yield. Previously positive significant correlation of number of tillers per plant with panicle number was reported by Seyoum *et al*. (2012) and Patel *et al*. (2014). Saberan *et al*. (2009), Patel *et al*. (2014) and Karande *et al*. (2017) also reported significant positive phenotypic correlation of number of tiller per plant, with grain yield per plant. Thus, traits showing positive significant correlation with grain yield should be given priority while breeding for increase yield in rice.

The phenotypic path coefficient analysis revealed that total number of seed per panicle, panicle number and number of tillers had appreciable positive direct effect on grain yield. Positive direct effect of these traits on grain yield indicated their importance in determining this complex trait and therefore should be kept in mind while practicing selection aimed at the improvement of grain yield. Abdourasmane *et al*. (2016) reported positive direct effect of total number of seed per panicle and tiller number on grain yield. Similarly, Mulugeta *et al*. (2015) reported similar results for tiller number. Several authors (Bhadru *et al*., 2011) have reported a positive direct effect of days to 50% flowering on yield. Panicle number showed a highly significant correlation with grain yield (r=0.553∗∗) and a direct effect of 0.242 in path analysis. Vange *et al*. (1999) underscored that number of panicles per unit area is the most critical yield component, accounting for 89% of grain yield variation. This mirrors our findings, where panicle number directly contributed to yield via both phenotypic correlation and path effects. The total seeds per panicle had the strongest direct effect on yield (0.671) and the highest correlation (r=0.701∗∗). Vange *et al*. (1999) highlighted grain density (closely linked to seeds per panicle) as a vital yield indicator. Base on the result of the present study, total number of seed per panicle, panicle number, hundred seed weight and tiller number gave a high influence on grain yield directly and other traits influenced grain yield indirectly and positively through them, therefore selection for high yield in rice should place maximum emphasis on these traits.

CONCLUSION

Correlation and path analysis reveal that the total number of seeds per panicle, tiller number, panicle number, and spikelet number influenced grain yield either directly or indirectly. Therefore, these traits should be included in the breeding programme of upland rice. The phenotypic path coefficient analysis revealed that the trait total number of seed per panicle, panicle number, and tiller number exerted high and favorable direct effects on grain yield. The favorable direct effects of these traits on grain yield indicate that, other variables kept constant, improvement of these traits will increase grain yield.

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