Journal of Natural Sciences Research www.iiste.org
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.13, No.8, 2022

Character Association of Yield and Yield Components of Various Varieties of Rice (Oryza sativa L.)

Dimkpa[1*], S. O. N., Okoye[1] , C. C. and Efisue[2] A. A.
1. Department of Crop and Soil, River State University, P.M.B 5080, Port-Harcourt, River State, Nigeria
2. Department of Crop and Soil Science, Faculty of Agriculture, University of Port Harcourt, Rivers State, Nigeria

Abstract
Yield and yield attributing parameters are the most widely targeted traits in rice improvement programmes. The relationship between yield and yield attributing traits are important for direct and indirect selection of traits which contribute to yield. Information on the extent of association between yield and yield components is important in the simultaneous improvement of correlated traits. This study was carried out to determine the direct and indirect contributions of yield components to yield of rice and the level of association. Path Coefficient Analysis was used to evaluate the character association of yield and yield components of twenty-five rice varieties at the Rivers State University Teaching and Research Farm, Port Harcourt, during the 2019 planting season under rainfed condition and complimented by irrigation in two different planting dates. The experiments were laid out in a randomized complete block design. Data were collected on yield and yield components. Leaf area, plant height, panicle length, panicle number, panicle weight, 100-grain weight and spikelet fertility correlated positively and significantly with grain yield per stand. The path coefficient analysis indicated that panicle number (0.265) and spikelet fertility (0.219) had the highest positive direct effect on grain yield per stand. Conversely, number of grains per panicle (-0.128), days to 50% flowering (-0.114), tiller number (-0.095) and panicle length (-0.056) exerted negative direct effect on grain yield per stand with 0.674 residual effects. Therefore, direct selection for leaf area, plant height, panicle number, panicle weight, 100 grain weight, and spikelet fertility will effectively improve yield in rice.
Keywords: Grain yield, Character Association, Oryza sativa, variation, yield components
DOI: 10.7176/JNSR/13-8-02
Publication date: April 30th 2022

Introduction

Rice is the World's most important food crop (Dimkpa, 2015) and a major staple crop in Nigeria, its consumption rate increases appreciably across the social class of Nigerians (Efisue and Igoma 2019). It has grown to become a food security crop as well as a cash crop in Nigeria. And has gainfully employed a good number of people in its value chain from production to distribution. Agricultural data specialist, Gro Intelligence, puts Nigeria's rice output at 4.9 million tonnes in 2019, about 60% increase since 2013. However, this is well below local consumption put at 7 million tonnes (George, 2020), this confirms that domestic production cannot meet up with the domestic demand (Efisue &Igoma 2019).

In view of the growing population, the basic objective of the plant breeders would always be towards yield improvement in staple food crops. Yield and yield attributing parameters are the most widely targeted traits for rice improvement programmes in the world (Mukesh *et al.,* 2018). Grain yield is a complex trait and is the result of interaction of many variables (Singh *et al.,* 2017). The information on the extent of association between yield and yield components is important to bring simultaneous improvement in correlated traits. Although, knowledge of phenotypic correlation of agronomic characters with yield is indispensable in the characterization of component influences on manifesting the characters, these associations yet do not provide explicit information on the relative importance of direct and indirect effects of each componential character to yield (Baloch *et al.*, 2001). As the number of variables increase, it becomes imperative to measure the contribution of each variable towards the observed correlation. Therefore, partitioning the observed correlation coefficients into components of direct and indirect influences provide perceptions in the characterizations of more complex traits, like yield (Baloch *et al.,*2001). In that situation, path coefficient analysis provides precise information on the direct and indirect effects in order to perceive the most influencing characters to be utilized as selection criteria in breeding programmes (Baloch *et al.,* 2001). Relationship between yield and yield attributing traits are of prime importance for direct and indirect selection of traits which contribute to yield (Aditya & Bhartiya, 2013).

Correlation studies provide information on the nature and extent of association between any two traits and thereby revealing the possibility of improving one character by selection of the other pair. Grain yield which is the most important economic trait in rice is complex, it is a result of interaction of many variables (Akinwale *et al*., 2011; Ikeda *et al*., 2013). In other words, it is a polygenic character, resulting from multiple interactions between many yield components such as Leaf area, plant height, panicle length, panicle number, panicle weight, 100-grain weight, spikelet fertility and tiller number. Associations between these traits can be evaluated by

correlation analysis, which helps in the simultaneous selection of one or more than one character (Sivasankar *et al.,* 2018; Akhtar *et al*., 2011).

The objectives of this study are to determine the direct and indirect contribution of yield components to the grain yield of rice and the level of association.

Materials and Methods

The experiment was carried out at the Rivers State University Teaching and Research Farm Nkpolu, Port Harcourt ($4^0 46^1$ N, $7^0 10^1$ E) during the 2019 planting season under rainfed condition complimented by irrigation. Port Harcourt is in the humid forest zone which has an average elevation of ten meters above sea level (Ikpe *et al.,* 2003). The mean annual rainfall is 2400mm, usually in a monomodal distribution lasting from March to November. There is a short dry spell between December and March with little or no rain, the wettest months are between July and October. Temperature varies from 27^0C from February to April (warmest months) to 25^0C in July and August (the coolest months). Relative humidity remains high throughout the year and varies from 78% in February (the driest month) to 89% in July and September (rainy months) (Ikpe *et al.,* 2003).

Twenty-five rice varieties were used for this study (Table 1). These comprised of seventeen (17) anther cultured Korean rice lines collected from the University of Port Harcourt Rice Germplasm, seven (7) improved rice varieties and one (1) Ebonyi landrace collected from Ebonyi State University Research Farm, Abakaliki, Ebonyi State.

In order to evaluate the yield and the yield components of the rice varieties and determine the variation among the varieties, an experiment was set up in plastic bags containing top soil mixed with pure sand in the ratio of 2:1 that was collected from the school farm, the bags were laid out in a randomized complete block design with three replications. There were two planting dates for the twenty-five (25) rice varieties, the early (June) and late (August). Each variety was planted in a 2,650cm^{3}volume nursery bag and transplanted into a bigger bag of 6,283cm^3 volume after 4 weeks for increased surface area for the root development.

NPK (15:15:15) was applied as a basal application of 200 kg ha^{-1}. Weeding was done by hand pulling on sight. The plants were irrigated equally in the absence of rainfall. The plants were shaded with palm frond from excessive sunlight and rainfall until transplanting. Three weeks after transplanting, Urea was applied at first split at the rate of 65 kg ha^{-1} and the second split at the rate of 35 kg ha^{-1} was applied at the beginning of booting stage.

The agronomic characters were measured at weekly intervals. The 'Standard Evaluation System (SES) for Rice' reference manual (IRRI, 2002) was used for all trait measurements. Measured characters include: Plant Height - was recorded using meter rule (cm), it was measured from the soil surface to the tip of the tallest leaf, Flag Leaf - the length and width of the flag leaf were measured using a meter rule and leaf area (cm^2) calculated from the values obtained, Days to 50% Flowering - days to 50% flowering was recorded for all varieties from seeding date to the day when 50% flowered, Tiller Numbers - tiller numbers were calculated per stand for each variety, Panicle Parameters - two randomly sampled panicles per variety were used for data recording for panicle traits at maturity and it includes panicle length, which was measured using meter rule, number of panicle, done by counting the panicles per stand, panicle weight, measured using an electronic balance and spikelet fertility which was calculated by dividing the number of filled seed by total seed per panicle and then converted into percentage, 100-grain weight (g), grain yield per stand (g/stand) was recorded after threshing and the 100-grain weights were measured using electronic balance.

In order to determine the character association of the yield and yield components of the various rice varieties, correlation studies and path coefficient analysis was carried out.

DATA ANALYSIS

Correlation Studies

Analysis of covariance was carried out on pairs of variables which exhibited significance ($P \leq 0.05$), using the PB Tools version 1.3 statistical software. The generated components of the covariance were used to estimate the phenotypic and genotypic correlation coefficients as suggested by Singh and Chaudhary (1985):

$$\text{Phenotypic Correlation Coefficient } (r_p) = \frac{COV_{(C1.C2)}}{\sqrt{\sigma^2{}_pC1\ .\ \sigma^2{}_pC2}}$$

$$\text{Genotypic Correlation Coefficient } (r_g) = \frac{COV_{(C1.C2)}}{\sqrt{\sigma^2{}_gC1\ .\ \sigma^2{}_gC2}}$$

Where;

$\sigma^2{}_p$ = phenotypic variance

$\sigma^2{}_g$ = genotypic variance

$COV_{(C1.C2)}$ =Covariance of characters x and y

Test of significance of correlation was done by comparing the computed values against table 'r' values given by Fisher and Yates (1963).

Path Coefficient Analysis

Path coefficient analysis is a multivariate statistical method (simple standardized partial regression) that deals with a system of interrelated variables, which enables a researcher to understand the path(s) through which causal factors (yield contributing characters) produce an effect (grain yield). That is, it partitions the correlation coefficient into direct and indirect effects of the yield components on yield (Dewey and Lu, 1959). The path co-efficient simultaneous equations were obtained by the formula of Ahmed *et al*., (2002). The path diagram is given in Figure 3.

$r_{1y} = P_1 + r_{12}P_1 + r_{13}P_3$

Similarly, for r_{2y} and $r_{3y,}$

$r_{2y} = r_{21}P_1 + P_2 + r_{23}P_3$

$r_{3y} = r_{31}P_1 + r_{32}P_2 + P_3$

The residual effect is obtained as;

$P_x = 1 - P_{xy}r_{xy}$

Where,

P_x = residual effect of variable X

$P_{xy}r_{xy}$ = product of direct effect of variance X and its correlation (r) with yield (y).

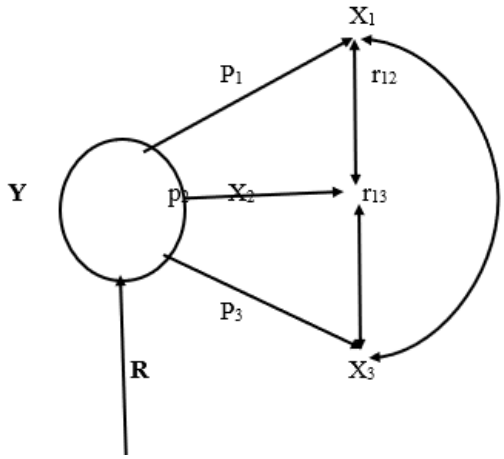

Figure 1: Path Diagram Sketch Legend (Ahmed *et al.*, 2002)

P_1= measure of the "direct" effects of X1 on the yield

P_2= measure of the "direct" effects of X2 on the yield

P_3= measure of the "direct" effects of X3 on the yield

X_1= character 1

X_2= character 2

X_1= character 3

r_{12}= correlation coefficient (r) between X1 and X2

r_{13}= correlation coefficient (r) between X1 and X3

r_{23}= correlation coefficient (r) between X2 and X3

Y= yield

R= residual effect

Path coefficients were classed according to the scales given by Lenka and Mishra (1973) as negligible (0.00 - 0.09), low (0.10 - 0.19), moderate (0.20 - 0.29), high (0.30 - 0.99), and very high (> 1.00).

Table 1. Experimental materials used in the study

S/N	Variety	Source
1.	Bg-90-2	Ebonyi State University
2.	Faro44	Ebonyi State University
3.	Faro61	Ebonyi State University
4.	Faro66	Ebonyi State University
5.	Faro67	Ebonyi State University
6.	UPN250	University of port Harcourt
7.	UPN266	University of port Harcourt
8.	UPN295	University of port Harcourt
9.	UPN318	University of port Harcourt
10.	UPN323	University of port Harcourt
11.	UPN313	University of port Harcourt
12.	UPN253	University of port Harcourt
13.	UPN288	University of port Harcourt
14.	UPN347	University of port Harcourt
15.	UPN324	University of port Harcourt
16.	UPN228	University of port Harcourt
17.	UPN336	University of port Harcourt
18.	UPN300	University of port Harcourt
19.	UPN268	University of port Harcourt
20.	UPN345	University of port Harcourt
21.	UPN349	University of port Harcourt
22.	UPN257	University of port Harcourt
23.	Okporogwu	Ebonyi State University
24.	UPIA1	University of port Harcourt
25.	UPIA2	University of port Harcourt

Results

Correlation coefficient for the various phenological and yield parameters observed among 25 rice varieties tested over two planting dates

Result of Pearson's correlation coefficient for 11 phenological and yield parameters of 25 rice varieties over the two planting dates is presented in **Table 2**. Among the phenological parameters, leaf area (0.338) and plant height (0.244) correlated positively and significantly ($P \leq 0.05$) with grain yield per stand, while among the yield parameters, panicle length (0.188), panicle number (0.374), panicle weight (0.327), 100-grain weight (0.201) and spikelet fertility (0.374) correlated positively and significantly with grain yield per stand. Spikelet fertility had significant positive correlation with leaf area (0.293), panicle length (0.222), panicle number (0.312), panicle weight (0.315), and number of grains per panicle (0.269). 100-grain weight correlated significantly and positively with panicle length (0.174) and panicle weight (0.22). Number of grains per panicle correlated significantly and positively with all parameters except plant height, days to 50% flowering and 100-grain weight. Panicle weight correlated significantly and negatively with days to 50% flowering (-0.181) while correlating positively and significantly with all other parameters except tiller number. Panicle number had significant positive correlation with all parameters except 100-grain weight. Similarly, panicle length correlated significantly and positively with all parameters except days to 50% flowering. Significant positive correlation was also observed between tiller number and days to 50% flowering (0.368) and between plant height and leaf area (0.327).

Table 2: Pearson's correlation coefficient for 11 phenological and yield parameters observed among the 25 rice varieties tested over two different planting dates

Characters	Leaf area (cm^2)	Plant height (cm)	Days to 50% flowering	Tiller number	Panicle length (cm)	Panicle number	Panicle weight (g)	Number of grains per panicle	100-grain weight (g)	Spikelet fertility
Plant height (cm)	0.327**									
Days to 50% flowering	0.111	-0.003								
Tiller number	0.129	-0.024	0.368**							
Panicle length (cm)	0.563**	0.273**	0.114	0.239**						
Panicle number	0.483**	0.192*	0.169*	0.211**	0.444**					
Panicle weight (g)	0.436**	0.178*	-0.181*	0.073	0.292**	0.248**				
Number of grains per panicle	0.464**	0.048	0.014	0.21**	0.481**	0.272**	0.379**			
100-grain weight (g)	0.102	0.146	-0.076	0.127	0.174*	0.097	0.220**	0.017		
Spikelet fertility	0.293**	0.111	-0.131	0.057	0.222**	0.312**	0.315**	0.269**	0.094	
Grain yield per stand (g/stand)	0.338**	0.244**	-0.155	-0.066	0.188*	0.374**	0.327**	0.086	0.201*	0.374**

*, ** = Significant at P≤0.05 and 0.01, respectively.

Path coefficient analysis between grain yield per plant and other phenological and yield parameters over two planting dates

The path coefficients analysis for direct and indirect effects of the phenological and yield parameters on grain yield is presented in **Table 3**. Panicle number (0.265) and spikelet fertility (0.219) had the highest positive direct effect on grain yield per plant. In addition, both had significant (P ≤ 0.05) positive correlation (0.374) with grain yield per plant. Also, both parameters gave negligible indirect effects through all other parameters. Leaf area also had high positive direct effect (0.162) on grain yield per plant with positive indirect effects majorly through panicle number (0.128). Other parameters such as panicle weight (0.132), 100-grain weight (0.111), and plant height (0.095) exerted positive direct effect on grain yield per stand. However, number of grains per panicle (-0.128), days to 50% flowering (-0.114), tiller number (-0.095), and panicle length (-0.056) exerted negative direct effect on grain yield per stand. The path analysis revealed a residual effect of 0.674.

Table 4.5: Path coefficient analysis between grain yield per plant and other phenological and yield parameters

	Leaf area (cm^2)	Plant height (cm)	Days to 50% flowering	Tiller number	Panicle length (cm)	Panicle number	Panicle weight (g)	Number of grains per panicle	100-grain weight (g)	Spikelet fertility	Grain yield per stand (g/stand)
Leaf area (cm^2)	**0.162**	0.031	-0.013	-0.012	-0.031	0.128	0.057	-0.059	0.011	0.064	0.338**
Plant height (cm)	0.053	**0.095**	0.000	0.002	-0.015	0.051	0.023	-0.006	0.016	0.024	0.244**
Days to 50% flowering	0.018	0.000	**-0.114**	-0.035	-0.006	0.045	-0.024	-0.002	-0.008	-0.029	-0.155
Tiller number	0.021	-0.002	-0.042	**-0.095**	-0.013	0.056	0.010	-0.027	0.014	0.012	-0.066
Panicle length (cm)	0.091	0.026	-0.013	-0.023	**-0.056**	0.117	0.038	-0.062	0.019	0.049	0.188*
Panicle number	0.078	0.018	-0.019	-0.020	-0.025	**0.265**	0.033	-0.035	0.011	0.068	0.374**
Panicle weight (g)	0.071	0.017	0.021	-0.007	-0.016	0.066	**0.132**	-0.049	0.024	0.069	0.327**
Number of grains per panicle	0.075	0.005	-0.002	-0.020	-0.027	0.072	0.050	**-0.128**	0.002	0.059	0.086
100-grain weight (g)	0.017	0.014	0.009	-0.012	-0.010	0.026	0.029	-0.002	**0.111**	0.021	0.201*
Spikelet fertility	0.047	0.011	0.015	-0.005	-0.012	0.083	0.042	-0.034	0.010	**0.219**	0.374**

Residual Effect = 0.67

Estimates of phenotypic direct effect (bold and diagonal) and indirect effect (off-diagonal, on the row) of individual parameter on grain yield per plant via other independent parameters of 25 rice varieties tested over two different planting dates.

Discussion

Correlation among Traits

The knowledge of correlation between characters of economic importance is very important and central to selection, since it is usually concerned with changing two or more characters simultaneously (Prasuna, 2012). In other words, correlation studies reveal the direction of selection and the number of characters to be considered in improving any economic important parameter such as grain yield. Grain yield is a quantitative and polygenic parameter; governed by a large number of genes. The influence of each character on grain yield could be known through correlation studies with a view to determining the extent and nature of relationships prevailing among yield and yield attributing parameters. Significant positive correlation between two parameters gives an indication that such parameters can be improved simultaneously in a selection programme due to the strong relationship that exist between them (Hayes *et al.,* 1955, Eleweanya *et al.,* 2015). Hence, grain yield per stand which correlated significantly and positively with leaf area, plant height, panicle length, panicle number, panicle weight, 100-grain weight and spikelet fertility in this study, implies that rice grain yield per plant can be indirectly selected for, by considering any of these parameters. Seyoun *et al.,* (2012), Pandey *et al.,* (2012) and Akhi*et al.,* (2016) have reported positive significant correlation of grain yield with spikelet fertility. Also, positive significant correlation of plant height (Zhao *et al.,* 2020), 100-grain weight (Gyawali*et al.,* 2018), panicle length (Khonaki *et al.,* 2013; Asante *et al.,* 2019), and leaf area (Pandey *et al.,* 2012; Gyawali *et al.,* 2018 and Saha *et al.,* 2019) with grain yield per plant had been earlier reported. However, the result is at variance with that of Konate *et al.,* (2016) who reported non-significant correlation between grain yield per plant and leaf area, plant height, panicle number, panicle weight, 100-grain weight and spikelet fertility. This study showed putative traits that could be used for indirect selection for grain yield improvement in rice crop

Path Coefficient Analysis

Correlation studies are limited in its measurement as it only measures the mutual association between and among parameters without regards to causation. The cause of association between parameters is often measured by path coefficient analysis that partitions correlation coefficient into components of direct and indirect causes of association (Kishore *et al.*, 2015; Kalyan *et al.*, 2017). This partitioning provides actual information on the contribution of parameters and thus, forms the basis for selection to improve yield. In the present study, path coefficient analysis was carried out at the phenotypic level with grain yield per plant as the dependent variable and yield parameters as independent variables. Spikelet fertility, panicle number, leaf area, panicle weight and 100-grain weight had positive direct effects on grain yield per stand, an indication that direct selection for these traits will improve grain yield per stand in rice. The result conforms with that reported by Seyoun *et al.,* (2012) for spikelet fertility and Saha *et al.,* (2019) for leaf area and 100-grain weight. The negative direct effects observed for number of grains per panicle and days to flowering indicate that these parameters only contribute to grain yield mainly through their high and positive indirect effects on other characters. The residual effect of 0.674 recorded for the phenotypic path coefficient which is similar to that reported by Kishore *et al.,* (2015) indicates that the ten parameters studied in the path analysis only explained about 33 percent of the observed variability in grain yield per plant. The remaining 67 percent might be due to some other factors such as some parameters which were not studied, for instance climate change effects.

Conclusion

It could be concluded from this study, that since the path coefficient analysis indicated that panicle number and spikelet fertility had the highest positive direct effect on grain yield per stand and conversely, number of grains per panicle, days to 50% flowering, tiller number and panicle length exerted negative direct effect on grain yield per stand with 0.674 residual effects. Therefore, direct selection for leaf area, plant height, panicle number, panicle weight, 100 grain weight, and spikelet fertility will effectively improve yield in rice.

References

Aditya, J.P., & Bhartiya, A. (2013). Genetic variability, correlation and path analysis for quantitative characters in rainfed upland rice of Uttarakhand hills. Journal of Rice Research, 6(2), 24-34.

Ahmed, S., Malaviya, A. B. & Majumdar, A. B. (2010). Genetic divergence and variability in fodder maize. *Forage Research,*35, 223-226.

Akhiet, A. H., Miah, M. A. K., Ivy, N. A., Islam, A. & Islam, M. Z. (2016). Association of Yield and Yield Related Traits in Aromatic Rice (*Oryza sativa* L.). *Bangladesh Journal of Agricultural Resource,* 41(3), 387-396.

Akhtar, N., Nazir, M. F., Rabnawaz, A., Mahmood, T., Safdar, M. E., Asif, M. & Rehman, A. (2011). Estimation of heritability, correlation and path coefficient analysis in fine grain rice (*Oryza sativa* L.) *Jornal of Animal and Plant Science.* 21(4), 660-664.

Akinwale, M. G., Gregorio, G., Nwilene, F., Akinyele, B. O., Ogunbayo, S. A. & Odiyi, A. C. (2011).

Heritability and correlation coefficient analysis for yield and its components in rice (*Oryza sativa* L.). *African Journal of Plant Science,* 5(3), 207-212.

Asante, M. D., Adjah, K. L. & Annan-Afful, E. (2019). Assessment of Genetic Diversity for Grain Yield and Yield Component Traits in some Genotypes of Rice (*Oryza Sativa* L.). *Journal of Crop Science and Biotechnology,* 22(2), 123-130. http://doi.org/10.1007/s12892-019-0008-0xcv

Baloch, M. J., Lakho, A. R., Bhutto, H., & Solangi, M. Y. (2001). Path Coefficient Analysis for Assessing Direct and Indirect Effects of Yield Components on Seed Cotton Yield in Gossypium hirsutum L.*OnLine Journal of Biological Sciences* 1 (5), 354-355.

Dewey, D. R. & Lu, K. H. (1959). A correlation and path-coefficient analysis of components of crested wheat grass seed production. *Agronomy Journal.* 51, 515-518.

Efisue A.A., &Igoma E.E. (2019). Screening Oryza Sativa L. for Salinity Tolerance During Vegetative Stage for the Coastal Region of Niger-Delta Nigeria. Journal of Plant Sciences7 (1), 21-26.

Eleweanya, N. P., Uguru, M. I., Eneobong, E. E. & Okocha, P. I. (2015), Correlation and path coefficient analysis of grain yield related characters in maize (*Zea mays* L.) under Umudike conditions of South Eastern Nigeria. *Agro-science.*4(1): 24-28.

Fisher, G. and Yates, M. (1963). Statistical tables for biological, Agricultural and Medical Research. 6th Ed. Oliver and Boyd, Edinburg and London.Pp. 62-63.

Gyawali, S., Poudel, A. & Poudel, S. (2018). "Genetic Variability and Association Analysis in Different Rice Genotypes in Mid-Hill of Western Nepal". *Acta Scientific Agriculture* 2(9), 69-76.

Hayes, H. K., Immer, F. R. & Smith, D. C. (1955). Methods of Plant Breeding, 2nd ed.; McGraw-Hill Book Co.: New York, NY, USA, P 551.

Ikeda, M., Miura, K., Aya, K., Kitano, H. & Matsuoka, M. (2013). Genes offering the potential for designing yield-related traits in rice. *Current Opinion in Plant Biology,* 16, 213-220.

Ikpe, F. N., Onwoye L. G., and Gichuru M. P., (2003) Nutrient recycling potentials in cropping systems of South-Eastern Nigeria. Nutrient cycling agrosystem 67. 129-136.

International Rice Research Institute (IRRI) (2002) standard evaluation system for rice (SES) Rice Science for a better world. Rice Knowledge Bank. Pp. 56 Publishers, New Delhi, pp 318.

Kalyan, B., Radha Krishna, K. V. & Rao, L. V. S. 2017) Correlation coefficient analysis for yield and its components in rice (*Oryza sativa* L.) genotypes. *International journal of current Microbiology and Applied Sciences. 6(7), 2425-2430.*

Kishore, N. S., Srinivas, T., Nagabhushanam, U., Pallavi, M. & Sameera, S. K. (2015). Genetic Variability, Correlation and Path Analysis for Yield and Yield Components in Promising Rice (*Oryza sativa* L.) Genotypes. *SAARC Journal of Agriculture,* 13(1), 99-108.

Kohnaki, M. E., Kiani, G. & Nematzadeh, G. (2013). Relationship between Morphological Traits in Rice Restorer Lines at F3 Generation using Multivariate Analysis. *International journal of Advanced Biological and Biomedical Research,* 1(6), 572-577.

Konate, A. K., Zongo, A., Kam, H., Sanni, A. & Audebert, A. (2016). Genetic variability and correlation analysis of rice (*Oryza sativa* L.) inbred lines based on agromorphological traits. *African Journal of Agricultural Research,* 11(35), 3340-3346.

Lenka, D. & Mishra, B. (1973). Path coefficient analysis of yield in rice varieties. *Indian Journal of Agricultural Science.* 43, 376-379.

Libby George (2020) A growing problem: Nigerian rice farmers fall short after borders close. Reuters: Commodity news.

Mukesh,M., Vidyabhushan, J., Anand,K., Mankesh., K.&Shweta, K. (2018)Correlation and path coefficient analysis in rice (Oryza sativa L.) genotypes for yield and itsattributing traits. *Journal of Pharmacognosy and Phytochemistry* 4, 285-290.

Otung Gabriel (2017). Rice production in Nigeria increases to 5.8m tonnes *leadership.ng* 100 (1-3).

Pandey, V. R., Singh, P. K., Verma, O. P. & Pandey, P. (2012). Inter-relationship and Path Coefficient Estimation in Rice under Salt Stress Environment. *International Journal of Agricultural Research,* 7, 169-184.http://doi.org/10.3923/ijar.2012.169.184

Prasuna, R. C. (2012). "Studies on Heterosis and Combining Ability for Yield sorghum (*Sorghum Bicolor*L. Moench)". MSc thesis, Crop Science Dept., Acharya N.G. Ranga Agricultural University. Rajendranagar, Hyderabad – 500 030, 140.

Saha, S. R., Hassan, L., Haque, M. A., Islam, M. M. & Rasel, M. (2019). Genetic variability, heritability, correlation and path analyses of yield components in traditional rice (*Oryza sativa* L.) landraces. *Journal of Bangladesh Agricultural University,* 17(1), 26–32. https://doi.org/10.3329/jbau.v17i1.40659

Seyoum, M., Alamerew, S. & Bantte, K. (2012). Genetic Variability, Heritability, Correlation Coefficient and Path Analysis for Yield and Yield Related Traits in Upland Rice (*Oryza sativa* L.). *Journal of Plant Sciences* 7(1), 13-22.

Singh, K, Punia, M. S.,Singh, V.,& Jagdale, V. (2017). Inter-Generation Correlation and Regression Analysis in F2 and F3 Generations of Wheat. *International Journal of Pure and Applied. Bioscience,* 5 (6), 809-816.

Singh, R. K. & Chaudhary, B. D. (1985). Biometrical Methods in Quantitative Analysis, Kaljuni Publishers, New Delhi, pp 318.

Sivasankar, R., Suresh, B. G., Ashish, S. & Sudheer, T. R. (2018). Correlation and Path Coefficient Analysis in Elite Germplasm of Rice (Oryza sativa L.). *International Journal of Current Microbiology and Applied Sci*ence, 7(7), 3454-3459 https://doi.org/10.20546/ijcmas.2018.707.400

Zhao, H., Mo, Z., Lin, Q., Pan, S., Duan, M., Tan, H., Wang, S. & Tang, X. (2020). Relationships between grain yield and agronomic traits of rice in southern China. *Chilean Journal of Agricultural Research,* 80(1), 26-31. http://dx.doi.org/10.4067/S0718-58392020000100072.