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Correlation, Path Coefficient of Yield and its Components Analysis in Fluted Pumpkin (*Telfairia occidentalis Hook F.*)

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Abstract
*Twenty genotypes of fluted pumpkin (Telfairia occidentalis) collected from twenty different locations in Akwa Ibom State, Nigeria were evaluated to determine the inter- relationship(s) between yield and associated traits in a Randomized Complete Block Design. Correlation analysis showed that number of branches/plants, number of leaves/plants, length of vine/plant (cm), marketable yield and leaf yield were significantly and positively correlated with the total leaf yield per hectare (t/h). The highest positive correlation with total leaf yield per hectare(t/h) (r = 0.741**) was recorded in vine length/plant (cm) at 14 WAP. Path analysis indicated that number of leaves/plants at 14WAP and number of branches/plants at 12 WAP imparted significant direct influence on total marketable yield, hence, these traits could be used as selection criteria for improvement of marketable yield. Principal Component Analysis (PCA) was employed to evaluate the patterns of variation in these genotypes. The first two axes of the PCA captured 98.26% of the total variance. Hence, it is revealed that the selection and breeding on the basis of traits that show positive direct effect may aid in the improvement programmes of fluted pumpkin for high leaf marketable yield.*

Keywords: Fluted pumpkin, Correlation, Path Coefficient, Principal Component Analysis, Yield and its Components

Introduction

Fluted pumpkin (*Telfairia occidentalis* Hook F.*)* is one of the leaf and seed vegetable belonging to the family of the Cucurbitaceae. It is a dicotyledonous crop, originated from tropical West Africa (Shippers, 2000). This leaf vegetable is commonly cultivated in the Southern part of Nigeria (Odiaka *et al.*,2008). Recently, it has gradually gain acceptance in the North Central, where there is increase in its cultivation by small holder farmers as a source of income (Ndor *et al*., 2013). *Telfairia occidentalis* leaf is also known for high nutritional, medicinal and economic value (Akoroda, 1990; Ehiangbonare, 2008). In recent times, it has been discovered that fluted pumpkin has the potential of protecting people from devastating high blood pressure, cholesterol and diabetes (Ugwu *et al.,* 2000). Has a creeping crop in growth habit, it spreads across the ground to produce an efficient cover to the ground against erosion (Horsfall and Spiff, 2005) and produces large fruits with many large seeds.

An important crop with the above sterling attributes deserves research attention especially in the area of its genetic improvement. Crop improvement can be achieved through Plant breeding programme. Selection of high yielding genotypes depends on amount of genetic variability present and heritable important traits like yield are selected in a population. Improvement in yield as a quantitative trait often requires the improvement of a secondary trait that is positively correlated with yield (Smith *et al.*, 1978). Plant architecture – related traits are mostly quantitative traits which are frequently affected by environmental factors. Therefore, it is vital to measure the mutual interrelationship between various plant attributes and determine the component traits on which selection procedures can be based for direct and indirect genetic improvement of *T. occidentalis* yield (Silva *et al*., 2013).

The knowledge of Statistics had proved helpful in understanding these relationships and their implications for yield increase. Statistical tools such as Correlation coefficient (r), Path Coefficient Analysis, Principal Component Analysis (PCA). Regression, Genotype – by – Environment (GCE) Biplot, and others had been employed in studying the nature of relationship among yield and yield components traits and how each of these traits contributes to the yield of many crops (Uchechukwu *et al*., 2017). Steel and Torrie (1984) in their work suggested that, correlation is a significant tool for the improvement of the intensity of association between variables in plants. Correlation measures the degree to which characters vary together or measure the intensity of association within and between them. Knowledge of correlation is important in identifying important parameters in any selection programme. An understanding of yield and its associated traits is useful tool in phenotypic selection and breeding of fluted pumpkin. Knowledge of correlation among such characters like number of leaves, number of branches, vine length, fresh leaf, total weight, petiole length, vine girth, internode length, vine weight and yield of different genotypes from different locations is useful in designing effective selection and breeding programme for crop.

For the selection of a superior genotype through breeding, an understanding of the association of yield and its associated traits is essential and their heritable variation has to be understood. This can be done through the technique of "Path Coefficient Analysis" which is a powerful multivariate statistical tool and which enable researcher to understand the "path" through which causal factor (yield contributing characters) influence the yield (Therthappa, 2005). A Path Coefficient is standardized partial regression coefficient that measures the direct influence of one variate upon another (Dewey and Lu, 1959). Path analysis allows the researcher to test theoretical proportions about cause and effect without manipulating variables. Variables may be assumed to be causally related and propositions about them tested (Acquaah, 2007). Subsequently, a good understanding of the association among yield component traits and the leaf yield in fluted pumpkin will not only reduce cost and duplication of experiments, but it will increase precision in research output and bumper yield. Therefore, this study was carried out with the objective of determining the interrelationship(s) between different traits in twenty fluted pumpkin genotypes.

Materials and Methods

Twenty genotypes of fluted pumpkin were collected from twenty different locations in the tropical rainforest in Nigeria. The genotypes used were freshly harvested fruits that were relatively of the same age. The seeds were extracted on the same day and was used for the experiment. The experiment was carried out in the month of May 2017 at the Teaching and Research Farm of the Michael Okpara University of Agriculture, Umudike, Abia State. The site is located at the tropical rainforest zone in the South East, Nigeria. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Plots of 1.5m x 1.5m with 0.5m inter-plot spacing was used. The seeds were sown directly on flat on each of the plots with one seed per hole at the spacing of 1m x 1m with the plant density of 10,000 plants/hectare. Weeding was done manually at three weekly intervals.
Observations were made on the following traits in the course of this study at 12 and 14 weeks after planting (WAP).

i. Number of Branches: The number of branches was collected by visual counting of the branches on each harvested vine
ii. Number of Leaves: The number of leaves was collected by visual counting of the number of leaves on each harvested vine
iii. Vine Length (cm): The vine length was determined with the aid of a measuring tape after harvesting the vine
iv. Fresh Leaf Weight (g): It was determined with the aid of a sensitive weighing balance after harvesting the vine
v. Marketable Leaf yield (g): This was obtained with the aid of a sensitive weighing balance after harvesting the vine.

The data obtained were subjected to analysis of variance (ANOVA) using Genstat Discovery Edition 4 (Genstat, 2007) software. Person Correlation Coefficient was used to estimate the linear relationships between the yield and yield related traits (Ofori, 1996). This was analysed using Statistical Package for Social Science (SPSS) for windows 2012 version 21.0. The Path Coefficient Analysis was used to qualify and measure. The direct influence of one variable (independent variable) upon leaf yield (dependent variable) and permits the separation of the Coefficient into components of direct and indirect effects (Dewey and Lu, 1959). Principal Component Analysis (PCA) was used to identify patterns in data and express the data in such a way as to highlight their similarities and differences (Everitt and Hothorn, 2011).

Results and Discussion

Table 1: Correlation Coefficient between different agronomic and yield traits

	VL@12 WAP	NL @12 WAP	NB@ 12 WAP	MY @12 WAP	LY@ 12 WAP	VL@ 14 WAP	NL@ 14WAP	NB@ 14 WAP	MY @14 WAP	LY@14 WAP	TMY	TLY	TMYH	TLYH	L/TMY
VL @12 WAP	1														
NL @12 WAP	0.157	1													
NB @12 WAP	0.103	0.786**	1												
MY@12 WAP	0.295**	0.596**	0.515**	1											
LY @12 WAP	0.297**	0.481**	0.509**	0.799**	1										
VL @14 WAP	0.306**	0.479**	0.496**	0.772**	0.847**	1									
NL @14 WAP	0.173	0.715**	0.608**	0.663**	0.585**	0.587	1								
NB @ 14WAP	0.169	0.567**	0.552**	0.632**	0.591**	0.578**	0.801**	1							
MY@ 14WAP	0.284**	0.587**	0.493**	0.936**	0.792**	0.787**	0.699**	0.638**	1						
LY @14WAP	0.311**	0.523**	0.535**	0.830**	0.899**	0.883**	0.667**	0.667**	0.873**	1					
TMY	0.189**	0.514**	0.423**	0762**	0.638**	0.562**	0.578**	0.517**	0.795**	0.661**	1				
TLY	0.256**	0.495**	0.501**	0.741**	0.812**	0.741**	0.601**	0.633**	0.743**	0.876**	0.743**	1			
TMYH	0.189**	0.514**	0.423**	0.762**	0.638**	0.562**	0.578**	0.517**	0.795**	0.661**	1.000**	0.743**	1		
TLYH	0.256**	0.495**	0.501**	0.741**	0.812**	0.741**	0.601**	0.633**	0.743**	0.876**	0.743**	1.000**	0.743**	1	
L/TMY	0.117	-0.283**	-0.091	-0.130	0.117	0.156	-0.147	-0.041	-0.182*	0.140	-0.473**	0.151	0.473**	0.151	1

** Correlation is significant at the 0.01 level (2 – tail) * Correlation is significant at the 0.05 level (2 – tail)

NB = Number of branches, NL = Number of leaves, VL = Vine length (cm), LY = Leafy yield (g), MY = Marketable yield (kg), TMY = Total marketable yield (kg), TLY = Total leafy yield(kg), TMYH = Total marketable yield/hectare (t/ha), TLYH = Total** leafy **yield/hectare (t/ha), L/TMY = Leafy/Total marketable yield, WAP = Weeks after planting

The linear Correlation Coefficient (r) among the examined traits in Table 1. Highly significant and positive correlation was found between leaf/total marketable yield and total marketable yield (t/ha) (r = 0.473**) while the most significant negative association were observed between leaf/total marketable yield and marketable yield at 14 WAP (- 0.182*). Positive and non – significant association between leaf/total marketable yield and vine length at 12 WAP (0.117), leaf yield at 12 WAP (0.117), vine length at 14 WAP (0.156), total leaf yield (0.151) and total leaf yield per hectare (0.151), while negative and non – significant relationships exist between leaf/total marketable yield and number of branches at 12 WAP (- 0.091), marketable yield at 12 WAP (- 0.130), number of leaves at 14 WAP (0.041) Table. Also high significant positive correlation was observed between leaf yield ant total leaf yield per hectare (r = 1.000**), total marketable yield per hectare (t/h) and total leaf yield per hectare (t/h) (r = 0.876**), marketable yield at 14 WAP and total leaf yield per hectare (t/h) (r = 0.743**), number of branches/plant at 14 WAP and total leaf yield per hectare (t/h) (r = 0.633**), number of leaves/plant at 14 WAP and total leaf yield per hectare (t/h) (r = 0.601**), vine length (cm) at 14 WAP and total leaf yield per hectare (t/h) (r = 0.741**), leaf yield at 12 WAP and total leaf yield per hectare (t/h) (r = 0.812**), marketable yield at 12 WAP and total leaf yield per hectare (t/h) (r = 0.501**), number of leaves at 12 WAP and total leaf yield per hectare (t/h) (r = 0.495**) and vine length / plant (cm) and total leaf yield per hectare (t/h) (r = 0.356**)

Table 1. Chukwudi *et al.*, (2007) reported similar significant and positive result in analysis of leaf yield components in fluted pumpkin. The correlation coefficients obtained in this study suggested that increased number of branches will increase that leaf yield of fluted pumpkin. Obi (2011) noted that negative correlation coefficient between two traits indicated that an increase in the value of one variable trait coincides with decrease in the other variable trait. The significant difference observed among the genotypes implies that the genotypes are different from one another and this might be because of differences in genetic background of the genotypes. Significant and positive correlation between two characters suggest that these characters can improved simultaneously in selection programme (Hayes *et al*., 1995, Fayeun *et al*., 2012).

Correlation Coefficient measures the mutual relationship or interdependence of two random variables or traits (Obi, 2011). It may not indicate a cause and effect of the relationship between the traits, but reflects the strength as well as direction of the relationship that exist. Linear correlation between yield and several of its components can present a confusing picture due to inter – relationship between component traits themselves (Sunil & Mudasir, 2013) hence Path Coefficient Analysis. The Path analysis permits the separation of direct effects from that of indirect effects through other related traits by partitioning the genotypic correlation coefficients (Dewey and Lu, 1959). Path analysis of the marketable yield was carried out to unlock the direct and indirect contributions of yield associated traits on the marketable yield of the *T. occidentalis* leaves and presented in Table 2.

Table 2: Path Coefficient Analysis (Direct, Indirect and Residual effects) of agronomic traits on total marketable yield of *T. occidentalis*

	Vinln12	Lvn12	Bra12	Mkty12	Lvy12	Vln14	Lvn14	Bra14	Mkty 14	Lvy14	Totlv yd	Totm kyd
Vinln12	**-0.01401**	-0.00163	0.00361	-0.02637	0.0387	-0.02318	0.0090	-0.01141	0.302	-0.29121	0.203	0.189
Lvn12	-0.00220	**-0.01037**	0.02751	-0.05326	0.0626	-0.03631	0.0373	-0.03827	0.624	-0.49024	0.392	0.513
Bra12	-0.00145	-0.00816	**0.03499**	-0.04604	0.0662	-0.03762	0.0317	-0.03726	0.524	-0.50108	0.397	0.423
Mkty12	-0.00413	-0.00618	0.01802	**-0.08941**	0.1041	-0.05852	0.0345	-0.04262	0.996	-0.77790	0.587	0.762
Lvy12	-0.00417	-0.00499	0.01780	-0.07146	**0.1302**	-0.06423	0.0305	-0.03987	0.842	-0.84233	0.643	0.637
Vln14	-0.00428	-0.00497	0.01736	-0.06903	0.1103	**-0.07579**	0.0306	-0.03902	0.837	-0.82802	0.587	0.562
Lvn14	-0.00243	-0.00742	0.02127	-0.05925	0.0762	-0.04446	**0.0522**	-0.05408	0.744	-0.62537	0.476	0.577
Bra14	-0.00237	-0.00588	0.01932	-0.05647	0.0769	-0.04383	0.0418	**-0.06748**	0.678	-0.62529	0.501	0.516
Mkty14	-0.00398	-0.00609	0.0172	-0.08372	0.1031	-0.05964	0.0365	-0.04303	**1.064**	-0.81867	0.588	0.794
Lvy14	-0.00435	-0.00542	0.01870	-0.07420	0.1170	-0.06695	0.0348	-0.04501	0.929	**-0.93732**	0.694	0.661
Totlvyd	-0.00359	-0.00513	0.01753	-0.06626	0.1057	-0.05619	0.0313	-0.04269	0.790	-0.82085	**0.792**	0.743
residual												0.210

Marketable yield at 14 WAP had the highest positive direct effect on the total marketable yield of *T. occidentalis* (1.065) and it also had the strongest total positive influence on the total marketable yield of *T. occidentalis* leaves (0.7948). Positive direct effects were also obtained for leaf yield at 12 WAP (0.1302), number of branches at 12 WAP (0.0349), number of leaves at 14 WAP (0.0522), total leaf yield (0.7925). Moreover, leaf yield, number of branches at 14WAP respectively had moderated and negative direct effects on the *Telfairia occidentalis* total marketable yield while number of leaves and vine length at 12 WAP respectively had weak and negative direct effects on total marketable yield. Marketable yield at 14 WAP and leaf yield at 12 WAP were also observed to have the highest negative indirect effect on the fluted pumpkin total marketable yield.

The total effects of all the traits were high and positive and this is due to their high direct effects and moderate indirect effects through total marketable yield (Table 2). The residual effect (0.2102) is relatively low indicating that the characters considered in this study successfully explained variation existing in the fluted pumpkin genotypes. Positive and high total effects of these traits to yield reveals their importance in determining the total marketable yield in fluted pumpkin and it is an indication that improvement of these traits might have positive outcome on fluted pumpkin leaves total marketable yield. This result is comparable to what was reported by Odiaka, (2005), Chukwudi *et al*., (2017) and Eze & Nwofia (2016).

Table 3: Eigenvector values for Principal Components using agronomic traits of *Telfairia occidentalis.*

Parameters	PC 1	PC 2
Number of branches	- 0.01801	- 0.01639
Number of leaves	-0.01677	- 0.00549
Vine length	- 0.18253	- 0.31241
Leaf yield	- 0.14870	- 0.183102
Marketable yield	- 0.23861	- 0.13236
Total leaf yield	- 0.52531	- 0.69001
Total marketable yield	- 0.78172	0.61234
Leaf/ total marketable yield	- 0.00003	- 0.00402
Percentage variation	**87.82**	**10.44**

The Principal Component Analysis (PCA) was employed using the data collected on the agronomic traits. The results of the PCA of agronomic traits measured were presented in Table 3. The result showed that the first two components contributed 98.26% of the variability among the twenty genotypes evaluated.

The PC 1 and PC 2 accounted for 87.82% and 10.44% of the total variation respectively. The first principal component axis was not affected by any trait but total marketable yield showed a high positive loading in the second principal component axis. These traits could therefore be considered during the crop improvement through selection. Prasad *et al*., (2010) reported that PCA helps to identify traits that have substantive and meaningful contribution towards the observed variations.

Conclusion

The relationship that exists among yield traits studied and leaf yield of *Telfairia occidentalis* emphasized that leaf yield can be improved through the use of plants with broad leaves and high number of long branches as parents. Hence, selection of *T. occidentalis* crops for higher leaf yield should be based on the number of branches per plant, area of leaves per plant and vine length per plant. Tremendous variability was observed among the genotypes as shown by Correlation, Path analysis and Principal Component Analysis and there exist room for improvement of high yielding fluted pumpkin genotypes.

Recommendations

The results of the various analysis carried out point to the fact that number of leaves/plant, number of branches/plant, vine length/plant contribute immensely to leaf yield of *T. occidentalis*. They should therefore be considered as important selection indices for *T. occidentalis* improvement aimed at developing high yielding varieties.

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