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METRIC ASSOCIATIONS AND PATH ANALYSIS IN SWEET POTATO (*Ipomoea batatas (L.) Lam.*) IN JOS-PLATEAU NIGERIA.

[1]Goler, E. E., [2]Namo, O. A. T. and [3]Mwanja, Y. P.

[1]Department of Botany, Faculty of Science, PMB 146, Federal University Lafia, Nasarawa State, Nigeria.
[2]Department of Plant Science and Technology, PMB 1076, University of Jos, Plateau State, Nigeria.
[3]Department of Botany and Plant Biotechnology, University of Johannesburg, P.O. Box 524, Auckland Park, 2006, South Africa

Corresponding author: goler1104@yahoo.com

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ABSTRACT

A study was carried out on the metric associations and path analysis in sweet potato (*Ipomoea batatas* (L.) Lam.) in Jos – Plateau. Fourteen (14) clones namely, E2, E6, E8, E10, CIPMAT 3, CIPMAT 31, CIPMAT 32, TIS 8441, TIS 86/0356, TIS 87/0087, TIS 2532.OP.1.13, EX-IGBARIAM, WAGABOLIGE and 440168 were laid out in a randomized complete block design (RCBD) in three replications. The results showed that, mean tuber weight, tuber length, tuber girth, petiole length, mean number of tubers per plant, leaf area and leaf area index were positively and significantly correlated with total tuber yield. Relative growth rate was highly correlated with vine length, tuber length, tuber girth, mean number of tubers per plant, leaf area and leaf area index. Total tuber yield, relative growth rate, tuber length, tuber girth and mean number of tubers per plant were negatively, but non- significantly correlated with dry matter content. Path coefficient analysis showed that mean tuber weight and tuber length exerted a high direct positive influence on total tuber yield while vine length exerted the highest indirect positive effect via tuber length on total tuber yield. The results show that leaf area index, mean number of tubers per plant, petiole length, tuber girth, tuber length and mean tuber weight are important yield indices that are useful in the selection of sweet potato clones for improved tuber yield.

Keywords: *Correlations, path analysis, yield*

INTRODUCTION

Sweet potato (*Ipomoea batatas*) is a trailing perennial which is usually treated as an annual plant and belongs to the family Convolvulaceae. It is an important root and tuber crop which has the potential to provide food at a time when the staple diet is in short supply (Kowal and Kassam, 1978). Currently, several Sweet potato clones have been introduced and are being cultivated, however, yield is a complex characteristic that is influenced by different factors for which functional relationships are difficult to understand. The yield of Sweet potato as in other crops, is a complex terminal outcome to which there are diverse interrelated developmental routes. Thus when practising selection for improved yield output, a good knowledge of the parameters and yield components is necessary, because when such genetically controlled features and performances can be observed and measured, then conditions exist for breeding programmes aimed at creating strains with desired features or characters that can be improved upon (Haynes and Wholey, 1972). Thamburaj and Muthukrishnan (1976) noted that, studies on variability, correlations and path analysis help breeders in making useful selections. Thus, work on tropically adapted clones of Sweet potato will help breeders to select desirable attributes that can be improved upon as this will go a long way in harnessing the potentials of Sweet potato to alleviate food crisis situations in the tropical sub-regions.

Functional relationships or degree of association between two or more variables are important in biological systems and statistical relationships among these biological variables can provide information that will help to explain the underlying basis of variations which will help in predicting of complex biological systems (Sokal and Rohlf, 1996). Correlation is a measure of the degree of the relationship which exists between variables. Correlation coefficient gives an insight into the nature of the interrelationships and interdependencies amongst variables, indicatingwhether they are correlated or not (Rangaswamy, 1995). Given a dependent variable Y and independent variable X, the correlation coefficient 'r' is obtained by using the standard formula

$$r(x,y) = \frac{\sum xy - \frac{(\sum x)(\sum y)}{n}}{\sqrt{\left[\left(\sum x^2 - \frac{(\sum x)^2}{n}\right)\left(\sum y^2 - \frac{(\sum y)^2}{n}\right)\right]}}$$

A correlation (r) value of +1 indicates perfect positive correlation, while r value of -1indicates a perfect negative correlation and r value of 0 indicates no correlation (Thomas and Jackson 1978). Path analysis is used to describe the direct dependencies among a set of variables, thus it is an extension of the regression model used to test the fit of the correlation matrix against two or more causal models which are being compared by the researcher (Path analysis, 2008). The use of the method requires a cause and effect situation among the variables of which there may or may not be any mutual interrelationship between individual variables within a closed system. Path analysis is particularly sensitive to model specification, because the failure to include relevant causal variables or inclusion of extraneous variables often substantially affects the path coefficients, which are used to assess the relative importance of various direct and indirect causal paths to the dependent variable. Therefore, it can be viewed as a standard regression coefficient showing the direct effect of an independent variable on a dependent variable in the path model. Thus when the path model has two, or more causal variables, path coefficients measure the extent of the effect of one variable on another in the path model controlling the other prior variables, using standardized data or a correlation matrix as input (Path analysis, 2008).

MATERIALS AND METHODS

The experiment was carried out at the Potato Research Farm of the National Root Crops
Research Institute (NRCRI) located at Kuru in Plateau State, North-Central Nigeria (09°44'N, 08°47'E; altitude 1,293.2 m above sea level).
Fourteen (14) clones of sweet potato were used namely, E2, E6, E8, E10, CIPMAT 3, CIPMAT 31, CIPMAT 32, TIS 8441, TIS 86/0356, TIS 87/0087, TIS 2532. OP.1.13, EX-IGBARIAM, WAGABOLIGE and 440168 which were laid out in a randomized complete block design with 3 replications. Land preparation was done manually. The net plot, which measured 3×3 m, consisted of 3 rows,each measuring 3×1 m. Vine cuttings of about 20 cm long were planted on each row at 30cmintra- row spacing and 100 cm inter-row spacing. Planting was done on July 11, 2013.

The plots were first weeded manually at 6 weeks after planting (6WAP), 9WAP and 14WAP. At 7WAP, the plots received a blanket application of fertilizer NPK (15:15:15) at the rate of 60 kg ha-1 each of nitrogen, phosphorus and potassium, which was equivalent to 120g per plot.

Growth traits were measured out at 9WAP, 13WAP, 17WAP and 21WAP; where on each sampling date, two (2) plants were harvested from each plot and separated into different parts namely, leaves, stems, and roots or tubers.

Leaf area was measured using the leaf disc method of Watson (1947), as modified by Bremner and Taha (1966) and reported by Ifenkwe (1975). The leaf area was determined using the formula:

$$\textbf{Leaf Area (LA)} = \frac{\text{Area of 1 disc X number of disc X total dry matter}}{\text{Dry weight of disc}}$$

Leaf area index (LAI) is the ratio of the leaf area to the area of the ground covered by the sampled plant (Harper, 1983). This was calculated using the formula:

$$\textbf{Leaf Area Index (LAI)} = \frac{\text{Total leaf area}}{\text{Land area occupied by sampled plant}}$$

Relative Growth Rate (RGR) is the increase in weight per unit of original weight at a time interval. It is used to measure the efficiency of dry matter production and was calculated using the formula:

$$\textbf{Relative Growth Rate (RGR)} = \frac{\ln W2 - \ln W1}{t2 - t1}$$

Where w_1 and w_2 = total dry weight at time t_1 and t_2(30 days) and ln = natural logarithm

Mean Vine Length was estimated by sampling three (3) plants from each plot and the vine measured from the base to the tip using a measuring tape

Petiole Length was estimated by sampling three (3) leaves each from two (2) plants sampled from each plot and their petiole measured using measuring tape. The tubers were harvested at 21WAP after taking record of the number of plant stands in each plot and yield parameters such as Mean weight of tubers, tuber length, tuber girth, mean number of tubers per plant, dry matter content and total tuber yield were observed. Multiple correlation coefficients were determined by correlating Total tuber yield with relative growth, vine length, mean tuber weight, tuber length, tuber girth, petiole length, number of tubers per plant, leaf area, leaf area index and dry matter content. All these were then correlated with one another using the Genstat Discovery Edition Version 3 software.

Path coefficient analysis was used to analyse five parameters that showed variation. The dependent variable was the Total tuber yield while the independent variables were tuber length, vine length, leaf area index and mean weight of tubers. The correlation coefficients were partitioned into direct and indirect effects by solving simultaneously the following equations by Dewey and Lu (1959).

$P_1 + r_{12}P_2 + r_{13}P_3 + r_{14}P_4 = r_{15}$ ....(1)

$r_{12}P_1 + P_2 + r_{23}P_3 + r_{24}P_4 = r_{25}$ ....(2)

$r_{13}P_1 + r_{23}P_2 + P_3 + r_{34}P_4 = r_{35}$ ....(3)

$r_{14}P_1 + r_{24}P_2 + r_{34}P_3 + P_4 = r_{45}$ ....(4)

where P_1 to P_4 = Path coefficients
r_{12} to r_{45} = Correlation coefficients
1 = Mean tuber length
2 = Mean vine length
3 = Leaf area index
4 = Mean tuber weight
5 = Total tuber yield

The residual effect (R_X) was estimated by the formula:

$$R_X = 1 - \sqrt{P_1 r_{15} + P_2 r_{25} + \ldots P_4 r_{45}}$$

RESULTS AND DISCUSSION:

CORRELATION ANALYSIS: Table 1 shows the correlation matrix involving Ten (10) attributes and Total tuber yield of sweet potato clones. Total tuber yield was positively and significantly correlated with mean tuber weight, tuber length, tuber girth, petiole length, mean number of tubers per plant, leaf area and leaf area index, which indicates that these are major yield components in the sweet potato. A similar observation was reported by Hahn and Hozyo (1984). Engida *et al.*, (2006) observed that tuber girth, tuber length and mean tuber weight greatly influence the total yield in the sweet potato.

. Total tuber yield and vine length were positively but non- significantly correlated while total tuber yield and dry matter content were negatively correlated and significant.Harper (1983) reported that during the growth of crop plants, substantial morphological changes occur, which influence the accumulation or distribution of the total dry matter among the major organs. Vines, which are major plant organs in the sweet potato, tend to compete with other parts of the plant for dry matter accumulation. This might explain the relationship between vine length and the total tuber yield which was positive but not significant in this study. However, total tuber yield and relative growth rate were negatively but non-significantly correlated at 5%level of probability.

The relative growth rate was positively and significantly correlated with vine length, tuber length, tuber girth, mean number of tuber per plant, leaf area and leaf index, as has also been reported by Harper (1983). Relative growth rate influences dry matter production and accumulation for the bulking of tuberous root including their number, size and weight as seen in this study. Relative growth rate was positively but non- significantly correlated with mean tuber weight and petiole length at 5% level of probability. However, Relative growth rate was negatively but non- significantly correlated with dry matter content as shown in Table 1.This indicates the presence of compensatory relationship between these components. A similar observation has been reported by Engida *et al.,* (2006). Somassundaram and Sandthoshmithra (2008) reported that dry matter partitioning was explained on the basic idea that the source potential is the more limiting factor in the initial phase and the sink capacity is more important after the formation of the storage roots.

Vine length was positively and significantly ($p< 0.05$) correlated with mean tuber weight, tuber length, tuber girth, leaf area and leaf area index. The relationship between vine length and petiole length, mean number of tubers per plant and dry matter content was positive but non- significant at 5% level of probability as shown in table 1. Mean tuber weight was negatively but non- significantly ($p< 0.05$) correlated with tuber length. Mean tuber weight was positively and significantly correlated with tuber girth and mean number of tubers per plant. Mean tuber weight was positively but non- significantly correlated with petiole length, leaf area, leaf area index and dry matter content at 5% level of probability as shown in Table 1.

Tuber length was positively and significantly correlated with tuber girth, petiole length, mean number of tubers per plant, leaf area and leaf area index at 5% level of probability. Tuber length was negatively but non- significantly correlated with dry matter content (Table 1). Tuber girth was positively and significantly ($p< 0.05$) correlated with petiole length, mean number of tubers per plant, leaf area and leaf area index. The relationship between tuber girth and dry matter content was negative but non-significant as shown in Table 1.

The correlation between petiole length and mean number of tubers per plant and dry matter content was positive but non – significant, indicating that there is a variation in the growth pattern of these plant parts. Bouwkamp (1983) reported that in the sweet potato, competition between different parts of the plant for the available assimilates continues for a long period of time, and that the growth rate of each part of the plant provides a measure for their competitive ability as sink.

Petiole length was positively and significantly correlated with mean number of tubers per plant, leaf area and leaf area index at 5% level of probability. The correlation between petiole length and mean number of tubers per plant and dry matter content was positive but non – significant, indicating that there is a variation in the growth pattern of these plant parts. Bouwkamp (1983) reported that in the sweet potato, competition between different parts of the plant for the available assimilates continues for a long period of time, and that the growth rate of each part of the plant provides a measure for their competitive ability as sink. However, mean number of tubers per plant was positively and significantly correlated with leaf area and leaf area index but was negatively and non-significantly correlated with dry matter content at 5% level of probability as shown in Table 1.

Leaf area was positively and significantly correlated with leaf area index. Leaf area was positively but non- significantly correlated with dry matter content ($p< 0.05$). Leaf area index was positively but non- significantly correlated with dry matter content at 5% level of probability as shown in Table 1.Leaf area, leaf area index, mean number of tubers per plant, petiole length and tuber girth were positively and significantly correlated with tuber length, indicating the existence of a linear relationship between these attributes, as reported by Harper (1983).

Table 1: Correlation matrix involving Ten (10) Attributes and Total tuber yield in Sweet potato

%	Tuber yield	RGR	Vine length	Mean Tuber weight	Tuber length	Tuber Girth	Petiole Length	Number of Tubers per Pant	Leaf Area	Leaf Area Index	Dry Matter
Tuber yield	1.00	-0.093	0.201	0.265*	0.464*	0.745*	0.577*	0.551*	0.378*	0.350*	-0.208
RGR		1.00	0.269*	0.183	0.514*	0.449*	0.068	0.465*	0.853*	0.873*	-0.022
Vine length			1.00	0.441*	0.320*	0.208*	0.046	0.183	0.386*	0.390*	0.154
Mean Tuber weight				1.00	-0.013	0.483*	0.176	0.702*	0.002	0.013	0.141
Tuber Length					1.00	0.443*	0.405*	0.413*	0.557*	0.543*	-0.058
Tuber girth						1.00	0.602*	0.629*	0.448*	0.422*	-0.066
Petiole Length							1.00	0.469*	0.288*	0.250*	0.037
Number of tubers per plant								1.00	0.372*	0.353*	-0.012
Leaf Area									1.00	0.986*	0.187
Leaf Area Index										1.00	0.195
Dry matter %											1.00

* Significant at 5% level of probability

PATH ANALYSIS: Table 2 andFigure 1 show the direct and indirect pathways of association between total tuber yield and four attributes in Sweet potato. Mean tuber weight exerted the highest (102.2%) direct influence on total tuber yield followed by tuber length (84.27%), leaf area index (34.57%), while vine length exerted the least direct contribution (19.67%) to total tuber yield.

Vine length exerted the highest indirect effect via tuber length (68.37%) followed by Leaf area index (60.66%) via tuber length, Tuber length via Leaf area index (14.16%), Leaf area index via vine length (4.01%), Tuber length via vine length (2.48%), Leaf area index via Mean tuber weight (1.01%), Vine length via leaf area index (0.86%), Tuber length via mean tuber weight (0.76%) with the least positive indirect contribution coming from Mean tuber weight via leaf area index as shown in table2, figure 1. Path coefficient also reveals that the indirect contribution of Mean tuber weight via Tuber length (-0.19%), Mean tuber weight via Vine length (-1.26%) and Vine length via Mean tuber weight (-13.77) were all negative as shown (Table 2 and Figure 1).Results of the path analysis revealed that the mean tuber weight exerted the highest positive direct influence on yield, followed by tuber length. Engida *et al*., (2006) and Islam *et al.,* (2002) reported that tuber girth, tuber length and mean tuber weight greatly influence total tuber yield in the sweet potato. The direct contribution of leaf area index and vine length on total tuber yield were observed to be low. Ajala *et al.*, (1997) reported that leaf area index favours horizontal root growth which leads to increase tuber length. The vertical root growth is limited. This might explain why leaf area index exerted a low influence on total tuber yield as observed in this study.

Although vine length recorded a low positive direct influence on total tuber yield, it exerted the highest indirect positive effect via tuber length.

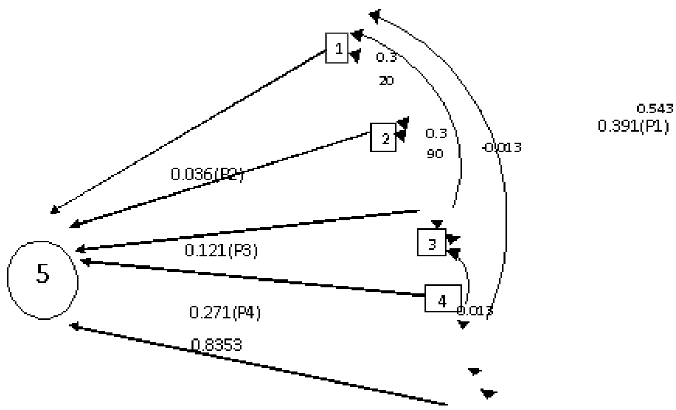

Figure 1: Path diagram showing the direct and indirect effects of four Attributes on Total yield
1 = mean tuber length
2 = mean vine length
3 = leaf area index
4 = mean tuber weight
5 = total tuber yield

Table 2: Path analysis showing the Direct and Indirect effects of four (4) attributes on Total Tuber Yield in Sweet Potato

Pathway of Association	Direct Path Coefficient (P)	%	Indirect Path Coefficient (P x r)	%	Correlation Coefficient (r)
1. Tuber length					
(a) Direct (P1)	0.391	84.27			
(b) Indirect via					
Vine length (r12P3)			0.01152	2.48	
LAI (r13P3)			0.06570	14.16	
Mean tuber weight (r14P4)			-0.00352	0.76	
(c) Total effect					0.464
2. Vine length					
(a) Direct effect (P2)	0.036	19.67			
(b) Indirect via					
Tuber length (r12P1)			0.21512	68.37	
LAI (r23P3)			0.04719	0.86	
Mean tuber weight (r24P4)			-0.02520	-13.77	
(c) Total effect					0.183
3. LAI					

(a) Direct effect (P3)	0.121	34.57			
(b) Indirect via					
Tuber length (r13P1)			0.21231	60.66	
Vine length (r23P2)			0.01404	4.01	
Mean tuber weight (r34P4)			0.00352	1.01	
(c) Total effect					0.350
4. Mean tuber weight					
(a) Direct effect (P4)	0.271	102.26			
(b) Indirect via					
Tuber length (r14P1)			-0.00508	-0.19	
Vine length (r24P2)			-0.00335	-1.26	
LAI (r34P3)			0.00157	0.59	
(c) Total effect					0.265
Residual (R)	0.8353				

CONCLUSION

The correlation analysis showed that leaf area, leaf area index, mean numbers of tuber per plant, petiole length, tuber girth, tuber length and mean tuber weight are major components that influence yield in the sweet potato.The path analysis study revealed that mean tuber weight and tuber length exerted a high direct positive influence on total tuber yield. In selecting for improved yield in the sweet potato, therefore, mean tuber weight and tuber length should be considered as major yield indices.

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