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Growth and Principal Component Analysis of Some Selected Sweet Potato Genotypes Grown in Southeast Nigeria

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Abstract
A field experiment was conducted at the National Root Crops Research Institute Umudike to determine the growth and path analysis (PCA) of some selected sweet potato genotypes in south-east Nigeria. The sweet potato genotypes (*Centennial, Umuspo* 3 (Mother's Delight), TIS 8164, *Ex-Igbariam*, TIS 87/0087, *Umuspo* 1(King J), *Solomon* 2) were fitted into a randomized complete block design (RCBD) with four replications. Principal component analysis revealed that PC1, PC2, and PC3 with eigenvector value loads above unity accounted for the cumulative variance of 84.10 %, indicating the degree of influence the associated growth parameters had on fresh storage root yield of sweet potato in both cropping seasons. In PC1, Leaf area ratio (LAR) and Specific leaf area (SLA) with the vector loading of 0.44605 and 0.39781 (2014) and 0.38409 and 0.36831 (2015), cropping seasons accounted for 47.54% variability among the genotype. PC2 with the same plant character also gave the highest vector load in the 2015 cropping season. In PC4, except for the relative growth rate (2014) and leaf area ratio, specific leaf area, and net assimilation rate (2015), the other principal components influenced the tuber root yield of sweet potatoes. In PC4 CGR, LAR, SLA, TDW, NAR 2014 CGR, RGR, and TDW 2015 influenced the tuber root yield of sweet potato. The results further suggested that the improvement of sweet potato could be achieved through these characteristics that have a positive magnitude effect on tuber root yield. Umuspo 1 (King J) gave the highest tuber yield among other sweet potato genotypes and therefore can be recommended for farmers.
Keywords: Sweet potato, growth analysis, principal component analysis, and fresh storage root yield

Introduction

The identification of growth physiological indices such as leaf area index (LAI), total dry weight (TDW) and leaf dry weight (LDW), growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR), leaf area duration (LAD), among others in analysis of factors affecting growth and yield of crops is of great importance and demands close evaluation to enhance crop performance and environmental efficiency (Gardner *et al*., 1985; De Sclaux *et al*., 2000; Anzoua *et al*., 2010). According to Bouwkamp and Hassam, (1988) leaf area and photosynthetic rate (source potential of the crop) and storage root number and weight (assimilate sinks of the crop) are positively correlated and vary widely amongst sweet potato cultivars depending on the environment and their genetic make-up. Furthermore, Bhagsari and Ashley (1990) stressed the importance of photosynthate translocation rate between source and sink to storage root yield.

The path coefficient analysis, which is a standardized partial regression coefficient, indicates the causes of mutual relationships between characters and permits the separation of correlation coefficients into components of direct and indirect effects, hence serving as a veritable instrument in crop selection by elucidating information through direct and indirect pathways leading to the complex plant character following the procedures of Dewey and Lu (1959) in their studies on crested wheatgrass (Triticum aestivum), Gravois and McNew (1993) on rice (Oryza sativa) and (Board et al. 1997) on soybean (Glycine max).

Therefore, the objectives of this work were to assess the growth analysis and also identify yield traits in crop plants that could serve as good yield components among the selected sweet potato genotypes. The path coefficient technique was developed by Wright (1921). To determine the degree of correlation between various yield-contributing attributes and their direct and indirect effects on tuber yield, the current study was conducted (Prabha *et al*., 2016). field experiment was carried out in 2016 and 2017
cropping seasons at National Root Crops Research

Materials and Methods

Experimental Site

A field experiment was conducted in the 2014 and 2015 cropping seasons, seven sweet potato genotypes were assessed under rain-fed conditions at National Root Crops Research Institute, Umudike, Abia State, Nigeria. Umudike is situated in the humid tropics of southeastern Nigeria. Umudike is located on 07°0331E and 05°0291N, at an elevation of 122 m above sea level. In the cropping seasons, annual mean rainfall, maximum temperature, and relative humidity (0900 hours) were 209.2 mm, 31.0 ºC, and 80.6 %, respectively(2014) and 206.2 mm, 30.5 ºC, and 78.6 %, respectively (2015). In both cropping seasons, composite soil samples were randomly collected at 0-20 cm depth. The samples which were air-dried ground and sieved through a 2mm mesh for physicochemical analysis in the laboratory using standard procedures. The soil type is a sandy loam.

Experimental Materials Design and Agronomic Maintenance

Seven (7) sweet potato genotypes (*Ex-Igbariam*, *Solomon* 2, TIS 8164, *Umuspo* 1, TIS 87/0087, *Umuspo* 3, *Centennial)* obtained from NRCRI were evaluated in an experiment in a randomized complete block design (RCBD) with four replications. The dimension of the entire experimental area was 50 m × 25 m while each experimental plot size was 6 m × 5 m. The experimental site was plowed, harrowed, thinned, and one-meter ridges made with a disc-ridge. Planting was down on the crest of the ridges using one 20 cm vine per stand at a distance of 30 cm by 100 cm to give a plant population of 33,333 plants/ha (Collins, 1995). Weeding was carried out, four weeks after planting (WAP) and 8 weeks after planting (WAP). Fertilizer (NPK 15:15:15) was applied at the rate of 400 kg per hectare at 4WAP immediately after the second weeding. Harvesting was done at 16 WAP from the net plots. Also, randomly, four sweet potato plants were selected from the net plots, partitioned into various plant fractions (leaf, vine, and storage root tuber) oven-drying until a constant weight was obtained, and weighed with the aid of a sensitive electronic scale. Dry matter data obtained were subjected to several biometric growth analyses.

Leaf area ratio (LAR), which is the ratio between leaf area (LA) and total plant dry matter (W), [LAR = LA / W (cm^2 g)] (Radford, 1967). Specific leaf area (SLA), is the measure of the leaf area (LA) of the plant to leaf dry matter (LDM), [SLA = LA / LDM (cm^2 g)] (Kvet *et al*., 1971).

Crop Growth Rate (CGR) = $W_2 – W_1$ / P ($T_2 – T_1$) (Watson, 1952),where, W1, W2 = Biomass yield at harvest at times T1 and T2 and, P = Ground area on which W1 and W2 have been estimated.

Relative Growth Rate (RGR) = $W_2 – W_1$ / W_1 ($T_2 – T_1$) (Radford, 1967), where, W_2, W_1 = Biomass yield at harvest at times T1 and T2 and, P = Ground area on which W1 and W2 have been estimated.

Net assimilation rate (NAR) = ($W_2 – W_1$ / $T_2 – T_1$) * (Loge A_2 - Loge A_1) / ($A_2 – A_1$)],Where, W1, W2 = Biomass yield at harvest at times T1 and T2.

Dry matter included oven-dried leaves, stems, and roots of sampled plants at 70 ºC until constant plant weight was achieved. Principal component analysis (PCA), which allows for good visualization of the differences among the individuals and identifies possible groups (Aremu *et al*., 2007) was estimated and used to evaluate the traits contributing to the genotypic variation among the sweet potato genotypes. All collected data were subjected to analysis of variance (ANOVA) using the Genstat Discovery Edition 4.23 software (Genstat, 2003) while PCA was performed using statistical analysis system (SAS) for Microsoft Windows, release 6.12 (1997) in line with PRINCOMP procedure. Least significant differences (LSD) at a 5 % level of probability were used to detect differences between treatment means following the procedure outlined by Obi (2002). Weeding was carried out at four weeks after planting (4WAP) supplemented by rouging at 8WAP. Fertilizer (NPK 15:15:15) was applied at the rate of 400 kg per hectare at 4WAP immediately after the first weeding. Nine agronomic data were measured on a plot basis, including stand count at harvest, number of marketable (roots > 100 g) roots, number of unmarketable roots (roots15 cm taken from the proximal to the distal end of roots using a tread, and a meter rule), medium root length (length 10-15 cm) and smallest root length (length < 10 cm), widest root girth (girth >15 cm taken from the widest part of the roots using a tread and a meter rule.), medium root girth (root girth 10 – 15 cm)Institute located in Umudike (coordinates: 07° 33′E; 05° 29′N; 122 m a.s.l.). Umudike is situated in the humid tropics of southeast Nigeria. The experimental site experienced a total annual precipitation of 1,901.80 and 2,526.84 mm, average daily air temperature range of 30.5–34.0°C and 30.0–34.0°C as well as average daily solar radiation hours of 5.36 and 5.70 in 2016 and 2017 cropping seasons, respectively.

Results and Discussion

Significant ($P<0.05$) variation was obtained in the fresh root yield of sweet potato in both seasons (Table 1). Umuspo 1 gave the highest root yield in the 2014 and 2015 cropping seasons, closely followed by the TIS 87/0087 genotype. The root yield of Umuspo 1 was higher by 93.26 and 87.6 % compared to the lowest-yielding genotype (Centennial) in the 2014 and 2015 cropping seasons, respectively. This report is in line with Wariboko and Ogidi (2014) who indicated that higher root yield in sweet potatoes could be due to the genetic makeup of the variety as well as its positive exposure to growth resources.

Only the first three principal component axes (PC1, PC2, and PC3) in the principal component analysis (PCA) had eigenvalues up to unity (Table 2), indicating cumulative variance of 90.97 and 98.49 % in 2014 and 2015, respectively. Principal components one (PC1) and two (PC2), with eigenvalues of 3.083 and 1.914 (2014) and 3.803 and 1.751 (2015) contributed 47.54 and 23.92 % (2014) and 54.86 and 25.02 % (2015) of the total variability observed among the seven sweet potato genotypes.

In PC1, the characters that accounted for most of the 47.54 % observed variability among the sweet potato genotypes were leaf area ratio and specific leaf area with vector loading of 0.44605 and 0.39781 (2014) and 0.38409 and 0.36831 (2015), cropping seasons. PC2 also gave the highest vector load from the same plant characters in the 2015 cropping season. In PC4, expect of relative growth rate (2014) and leaf area ratio, specific leaf area, and net assimilation rate (2015), the other principal components influenced tuber root yield of sweet potato. The results of Komaki and Katayama (1999) in their earlier studies on root crops corroborated our findings, which indicated that principal components such as specific leaf area, total dry weight of the plant, leaf area ratio, and net assimilation rate could serve as useful indices during breeding and selection in root crops improvement. Similar results were obtained by Suganthi and Murugan (2007) on legumes.

Conclusion

PCA technique aimed to identify plant traits that contribute most to the observed variation within a group of genotypes. There was a positive relationship with the plant growth analysis which influenced the tuber yield of sweet potato. Umuspo 1 and TIS 87/0087 sweet potato genotypes produced the highest fresh root yield relative to the other genotypes; farmers in the agroecological zone of the study area can be encouraged to plant them.

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Table 1: Yield (t/ha) of seven sweet potato genotypes grown under degraded ultisol in the 2014 and 2015 cropping seasons

Sweet potato genotypes	Ex-Igbariam	Solomon 2	TIS 8164	Umuspo 1	TIS 87/0087	Umuspo 3	Centennial	S.e.d	L.S.D (0.05)
2014	10.2	16.5	18.6	31.2	27.4	5.1	2.10	3.77	7.92
2015	9.45	15.52	16.13	28.73	25.01	5.94	3.55	3.633	7.633

Table 2: Eigen-vector value, total variance, and cumulative variance for seven sweet potato genotypes in the 2014 and 2015 cropping seasons

Variables	Principal components (PC) of genotypes			
	PC1	PC2	PC3	PC4
2014				
FSR YLD (t ha^{-1})	-0.34271	0.19067	0.49063	0.44007
CGR	-0.45906	0.17825	-0.04469	0.12467
RGR	-0.21481	0.40355	-0.58245	-0.35213
LAR (8WAP)	0.44605	0.25487	-0.19113	0.31736
SLA (8WAP)	0.39781	0.28144	-0.26348	0.52988
TDW (8WAP)	-0.41720	0.15412	-0.35628	0.16914
NAR	-0.29430	-0.43829	-0.30756	0.50664
Eigen-value	3.083	1.914	1.011	0.550
Percentage variation	47.54	23.92	12.64	6.87
Cumulative variance (%)	47.54	71.46	84.10	90.97
2015				
FSR YLD	0.21385	0.23172	0.80501	0.49667
CGR	-0.43558	0.38576	-0.00437	0.05699
RGR	-0.42824	0.36497	-0.08743	0.08461
LAR (8WAP)	0.38409	0.47881	-0.02523	-0.25418
SLA (8WAP)	0.36831	0.48466	-0.01261	-0.44886
TDW (8WAP)	-0.43527	0.38001	0.00947	0.02197
NAR	-0.32941	-0.23609	0.58601	-0.69018
Eigen-value	3.803	1.751	1.018	0.284
Percentage variation	54.86	25.02	14.55	4.06
Cumulative variance (%)	54.86	79.88	94.43	98.49

FSR YLD = Fresh storage root yield (t ha^{-1}), CGR = Crop growth rate (g m^{-2} d^{-1}), RGR = Relative growth rate (g g^{-1} d^{-1}), NAR = Net assimilation rate (g m^{-2} d^{-1}), LAR 8 WAP = Leaf area ratio (g m^{-2}), SLA 8 WAP = Specific leaf area (g cm^{-2}), TDW 8 WAP = Total dry weight (g).