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Yield Evaluation and Assessment of Growth of Five Different Varieties of Sweet Potato (*Ipomoea batatas* (L.) Lam)

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Authors' contributions

This work was carried out in collaboration between all authors. Author PAA designed the study, performed the statistical analysis, wrote the protocol and first draft of the manuscript. Author SOO managed the analyses of the study. Author AMA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Sweet potato production is on the increase worldwide, especially in the countries within the tropics. However, yields from many varieties are limited. The experiment was carried out to evaluate growth and yield of different sweet potato varieties.
The field experiment was laid out in Randomized Complete Block Design with five treatments replicated four times. The experiment was located along Parry Road, University of Ibadan Longitude $3^{\circ}45'$E and Latitude $7^{\circ}27'$N with elevation of 200-300 m above sea level. Five different varieties of sweet potato were used as treatments namely; Ex-igbaraiam, Benue, Akinima, TIS87/0087 and Eruwa. Soil samples were taken prior to planting for both physical and chemical analysis. Plant growth and yield parameters determined include vine length, number of leaves, total biomass, number of tubers and weight of tubers. Data were subjected to statistical analysis using GENSTAT

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3rd edition software package. Total biomass was in order of TIS 87/0087 >Akinima> Benue >Eruwa> Ex-igbaraiam. Sweet potato tubers were significantly difference (p=0.05) with TIS 87/0087(1.72 t/ha) and Benue (1.66 t/ha) had the highest yields followed by Ex-igbaraiam (1.07 t/ha) and least by Eruwa (0.81 t/ha) and Akinima (0.77 t/ha). Yield to total biomass ratio (a measure of conversion of biomass to yield) was in order of TIS 87/0087>Akinima>Benue > Eruwa >Ex-igbaraiam. TIS 87/0087 and Benue with highest yields are better options for farmers for optimum yield production compared to other varieties.

Keywords: Yield; growth; varieties and sweet potato.

1. INTRODUCTION

Sweet potato (*Ipomoea batatas*) belongs to the family convolvulaceae or the morning glory family and genus Ipomoea. It is the fifth most important food in terms of fresh weight, one of the three most important root crops in the world, and it is ranked seventh in the world production after wheat, rice, maize, potato, barley and cassava [1]. Sweet potato (*Ipomoea batatas)* is the only crop of economic importance as food in the entire family convolvulaceae [2]. It is herbaceous and has trailing or twining stems and vines (1-5 m long) that produce root or tuber. The crop is grown mainly for its thick, edible roots which range in shape from spherical to nearly cylindrical [2,3]. A lot of variability exists among the 3000 varieties which can be seen in the skin color, flesh color, shape of tubers, vegetative characters, depth of rooting and time of maturity [4].

Sweet potato is high in carbohydrate, vitamins A and can produce more edible energy per hectare per day than wheat, rice or cassava [1]. The green leaves of the plant are also consumed by human and animals [1]. Recently, more focus has been placed on the orange fleshed sweet potato (OFSP) cultivars that are rich in beta-carotene, unlike the white-fleshed varieties. In several sub-Saharan African countries, efforts are being made to promote its spread so as to combat the high level of vitamin A deficiency. Thus, it becomes imperative that qualitative research be conducted to access different sweet potato yields. Poor sweet potato productivity in Sub-Saharan Africa has been traced to poor soil fertility status [5].

Another factor contributing to a decline in food production in upland farming systems, especially in Nigeria, has often been attributed to farmer's inability to replenish nutrients lost in continuous cultivation [6]. This may partly be due to the intense farming pressure on land in order to meet the food demand of the ever-growing population, consequently leading to soil degradation [7].

Due to the high cost of procuring fertilizers by peasant farmers in rural communities for improving crop yield coupled with the challenge of slow rate of mineralization of organic soil amendments, comparing coping potential of commonly grown sweet potato cultivars on degraded soils is evident. Hence, on-farm studies were conducted to evaluate the growth and yield performance of five [5] sweet potato cultivars.

2. MATERIALS AND METHODS

The experimental plot was located along Parry Road, University of Ibadan Longitude $3^0 45'$E and Latitude $7^\circ 27'$N with elevation of 200-300m above sea level, Ibadan is in the southwestern zone of Nigeria which falls under the humid tropical zone and Surface soil samples (0 – 15 cm) were randomly collected prior to the commencement of the experiment. The soil samples were air-dried sieved to pass through a 2-mm mesh prior to analysis. Particle size as determined by hydrometer method [8], while soil pH was determined in a 1:1 soil to water suspension using a pH meter. Organic carbon was determined by wet oxidation method [9]. While total Nitrogen was done by Macro-kjeldahl method and available P by Bray-1 method [10]. Exchange bases were extracted with neutral IM NH4OAc at a soil solution ratio of 1:10 and measured by flame photometry. Magnesium was determined with an atomic absorption spectrophotometer. Exchange acidity was determined by titration method [11]. Soil analysis of the experimental site was taken for analysis in the laboratory. Two seasons prevail – the wet and dry season. The wet season extends from April to October and the dry season from November to March. The experimental plot occupied a land area of 162 m^2. Using the

RCBD, the plot was divided into four replicates. There were fifteen plants per variety per replicate making a plant population of 300 plants in all. Five sweet potato varieties (Ex-igbaraiam, Benue, Akinima, TIS87/0087 and Eruwa) were planted and vine cuttings were obtained from the Department of Agronomy, University of Ibadan. The vines were cut into 25 cm lengths and planted 30 cm apart on heaps on 5th of May 2012. Weeding was done manually and data on the length of main vine, number of branches and number of leaves were taken four weeks after planting and yield parameter after harvesting. All data collected were subjected to analysis of variance (ANOVA) using GENSTAT 3rd edition software package. Means were separated using Duncan Multiple Range Test (DMRT) at 5% level of probability.

Yield parameters such as weight of harvested tubers and total biomass (on fresh weight basis) were determined on the field by weighing the tubers and all agronomic components of the sweet potato varieties, respectively. Furthermore, the harvest index and percentage yield production for each sweet potato variety were determined using the follow equation:

$$HI = \frac{TW}{TBW}$$

Where HI = harvest index, TW = weight of harvested tuber, TBW = weight of total biomass.

$$\%YP = \frac{MY}{TM} \times 100$$

Where %YP = percentage yield production, MY = mounds with yield, TM = total mounds planted to sweet potato.

3. RESULTS

3.1 Soil Physical and Chemical Properties of Experimental Site

Table 1 presents the results of the soil physical and chemical properties of the study site. The soils of the experimental site were slightly acidic, the soil had a pH value of 5.7. The org. C content was 26.04 g/kg, while the Total Nitrogen, available phosphorus and potassium contents were 2.69 g/kg, 17.71 mg/kg and 0.49 cmol/kg, respectively. The site had a bulk density and saturated hydraulic conductivity values of 1.39 g/cm^3 and 1.38 cm/hr, respectively.

Table 1. Soil properties of degraded soils planted to sweet potato varieties

Parameter	Value
pH (H_2O)	5.7
Organic carbon (g/kg)	26.04
Total nitrogen (g/kg)	2.69
Available phosphorus (mg/kg)	17.71
K (cmol/kg)	0.49
Ca (cmol/kg)	9.81
Mg (cmol/kg)	0.77
Na (cmol/kg)	0.65
Mn (mg/kg)	166
Cu (mg/kg)	0.59
Fe (mg/kg)	94.1
Zn (mg/kg)	3.48
Bulk density (Mg m^{-3})	1.39
Saturated hydraulic conductivity (cm hr)	1.38
Particle size distribution (g/ kg^{-1})	
Sand	872
Silt	55
Clay	73
Textural class	Loamy sand

3.2 Number of Leaves, Vine Length and Vine Branches

Fig. 1 depicts the number of leaves of sweet potato varieties grown on the soil. Number of leaves was found to be highest at 10 WAP with significant ($p \le 0.05$) variations among the varieties. Benue had the highest number followed by Ex-Igbaraiam, Eruwa and TIS 87/0087, and least by Akinima.

Fig. 2 illustrates the vine length of sweet potato varieties grown. The results shows significant ($p \le 0.05$) differences in the vine length among sweet potato varieties at 10 WAP. Benue had the highest vine length followed by TIS 87/0087, Ex-Igbaraiam, Eruwa and Akinima respectively.

3.3 Yield Indicators

Yield components of sweet potato varieties grown are presented in Table 2.

3.3.1 <u>Total biomass</u>

Total biomass which was determined on fresh weight basis by weighing the plant biomass of sweet potato plants showed significant ($p \le 0.05$) differences among the sweet potato varieties. TIS 87/0087 had the highest total biomass of 26000 kg ha^{-1}, followed by Akinima, Benue, Eruwa and Ex-Igbaraiam.

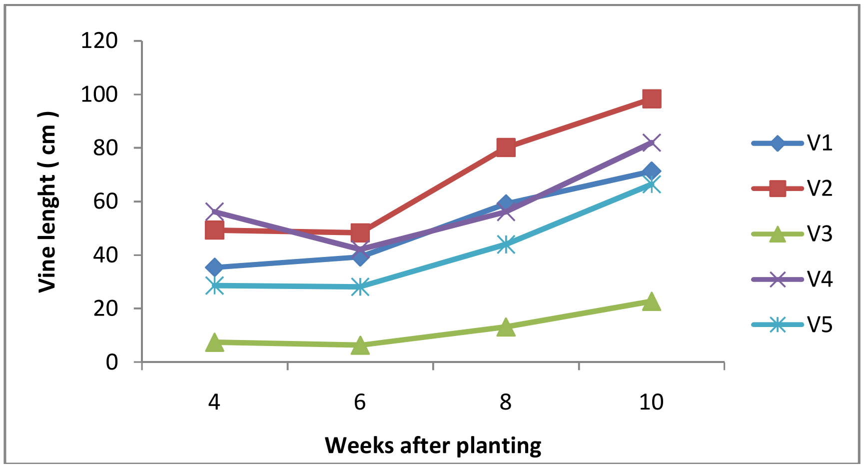

Fig. 1. Showing the vine length (cm) for different varieties of sweet potato
V1= Ex-igbaraiam, V2 = Benue, V3= Akinima, V4= TIS 87/0087, V5= Eruwa

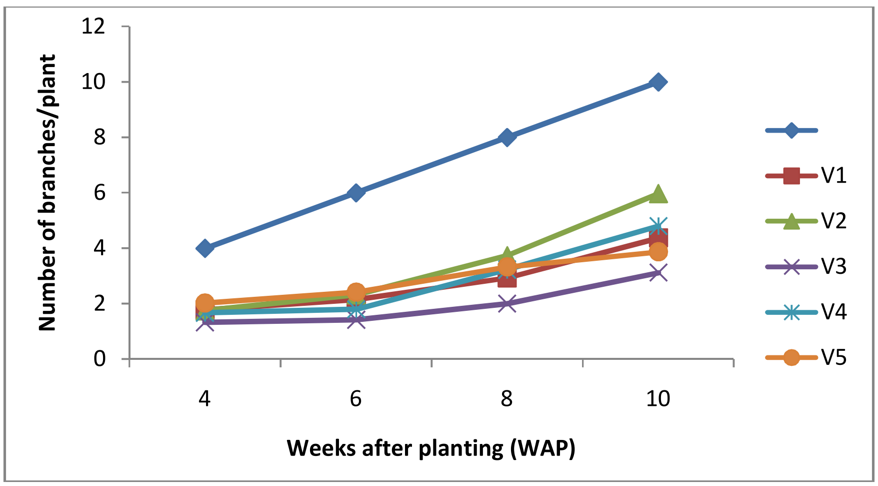

Fig. 2. Showing the number of branches for different varieties of sweet potato
V1= Ex-igbaraiam, V2 = Benue, V3= Akinima, V4= TIS 87/0087, V5= Eruwa

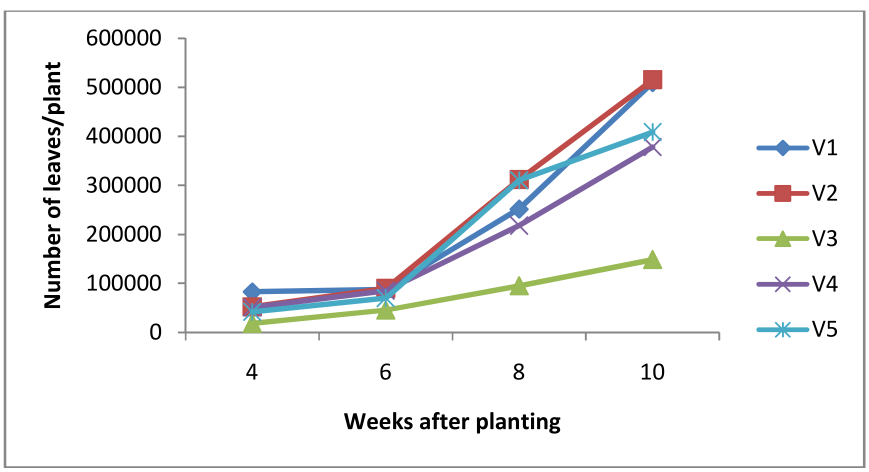

Fig. 3. Showing the number of leaves for different varieties of sweet potato
V1= Ex-igbaraiam, V2 = Benue, V3= Akinima, V4= TIS 87/0087, V5= Eruwa

V1= Ex-igbaraiam

V2 = Benue

V3= Akinima

V4= TIS 87/0087

V5= Eruwa

Plate 1. Different varieties of sweet potato tuber from the experiment

Table 2. Different sweet potato varieties yield parameters obtained

Varieties	Ex-igbaraiam	Benue	Akinima	TIS87/0087	Eruwa	CV
			Parameters			
TBM (kg/ha)	14,350ab	24,000a	24,250a	26,000a	22,250a	28.6
TW (kg/ha)	1075.5ab	1662.0a	771.0ab	1725.0a	810.8ab	19.8
HI	0.06c	0.11c	0.03c	0.06c	0.03c	9.7
PYP	62.5b	85a	72.5ab	80a	62.5b	75.2

Note: Means with the same letter(s) are not significantly different at p=0.05
TBM- Total biomass; TW – Tuber weight
HI- Harvest index
PYP- Percentage yield production

3.3.2 Tuber weight

There were significant (p≤0.05) differences in the weight of harvested sweet potato tubers among the varieties grown. TIS 87/0087 had the highest tuber weight of 1725.0 kg ha^{-1} followed by Ex-Igbaraiam, Benue, Eruwa and Akinima with the lowest yield.

3.3.3 Harvest index

Harvest index showed significant (p≤0.05) differences among the sweet potato varieties grown (Table 2). Benue had the highest harvest index of 0.11, followed by TIS 87/0087 and Ex-Igbaraiam, with a range of harvest index between 0.06 and 0.06, respectively and least by Akinima and Eruwa respectively.

3.3.4 Percentage yield production

This index of the yield potentials of sweet potato varieties grown on a degraded soil was found to vary significantly ($p \leq 0.05$) among the varieties grown. Benue had the highest percentage yield production of 85%, followed by TIS 87/0087, Akinima, Ex-Igbaraiam and Eruwa with a range of percentage yield production between 62.5% and 63.4%, respectively.

4. DISCUSSION

The data presented in (Table 1) show the values of physical and chemical properties of soil used for this trial. The soil belongs to the textural class of sandy loam with 70g/kg Coarse sand, 19.2 g/kg fine sand, 3.0g/kg silt and 7.8g/kg clay content according to the USDA Soil textural classification (Table 1).

The soil in the study area is characterized by high sand content (loamy sand), which is responsible for soil degradation rate (SDR) and vulnerability potential (Vp) value of 4/2. This is an indication that the farms were severely degraded with high vulnerability potential for further degradation. [12,13] reported that loamy sand lack adsorption capacity for basic plant nutrients and water. The soil pH value of the farms is low, indicating an acidic condition. [14] reported that optimum pH for most agricultural crops were between 6.0 and 7.0 and nutrients are readily available at pH of about 6.5. The low value of pH may be due to leaching which is a peculiar characteristic of a coarse textured soil (loamy sand). Low pH values could be due to the amount of materials removed at previous harvests, amount and type of fertilizer used to crop as reported by [15]. The SDR/Vp of 3/3 for soil pH showed that the soil was moderately degraded and moderately vulnerable to further degradation if conservation measures are not put in place.

[16] reported that continuous cropping of Alfisols, Ultisols and Oxisols in the tropics has resulted in a rapid decline in soil organic matter in the surface soil during the first few years following land clearing. The low level of nitrogen may be due to intensive farming carried out in the study area with significant nutrient mining impact. [17] reported that low levels of nitrogen in soils may be related to intense leaching and erosion due to rainfall. However, available phosphorus was low when compared with the critical range (8 to 12 mg kg^{-1}) reported for tropical soils [17] which could be attributed to continuous nutrient mining from continuous cropping in the previous years.

Soil physical assessment showed that the high bulk density values may be attributed to effects of seasonal erosion which leads to crusting and compaction [18].

The significant differences observed in the results of the various sweet potato parameters assessed in this study may be due to their genetic variations as opposed to the planting environment [19]. TIS 87/0087 with the highest yield has the capacity of consistently converting most of its photosynthetic products into carbohydrates stored in tuber in a degraded soil. TIS 87/0087 had the highest yielding variety across the farm while Akinima had the lowest yielding variety. The difference in tuber yield under the prevailing soil conditions could be attributed to the genetic variations among the varieties in partitioning photosynthates. Differences in yield due to the genetic make-up among varieties have also been reported in other sweet potato trials [20].

Eruwa and Akinima were among the three varieties with the lowest vine length whereas TIS 87/0087 was among the two varieties with the longest vine length, being second to Benue. This indicates that apart from tuber yield benefits obtained from TIS 87/0087 planted on a degraded soil, sweet potato vines could be used as forage to raise animals. Sweet potato vines have been included in livestock feed because it contains high protein and mineral contents that are needed for growth and development of ruminants [21,22,23]. From this study, it showed that some cultivars are good producer of vines on a poor soil while some cultivars could cope with degraded soils by producing high tuber yields. For example, Akinima was next to TIS 87/0087 in terms of total biomass, indicating that Akinima is able to convert most of its photosynthetic products into carbohydrates stored in various agronomic components of the plant.

Also, Benue and Ex-Igbaraiam had the highest number of leaves and vine length with reduced quantity of tubers indicating their poor ability to convert most of the photosynthetic products into carbohydrates and store them in the tubers [24]. On the other hand, the low tuber yield by Akinima may be attributed to its low number of leaves, which could have been responsible for its consistent low tuber yield. [25,21] explained that a genotype with large leaf area and number of leaves can easily trap sunlight for photosynthesis than those with small leaf area or number of leaves.

5. CONCLUSION

Low soil fertility could have been responsible for lower total biomass of sweet potato. However, cultivars of sweet potato responded differently to severely low soil fertility in terms of biomass and tuber yields. Akinima and Eruwa could not thrive well on a low fertile soil condition while TIS 87/0087 and Benue cultivars produced high vine length with high number of leaves, indicating that forage farmers could grow Benue and TIS 87/0087 purposely for feeding livestock animals.

However, TIS 87/0087 and Benue cultivars had highest tuber yield, indicating that farmers interested in sweet potato tubers could grow TIS 87/0087 and Benue cultivars on a slightly low soil for optimum tuber yield production compared to other varieties. However, further trials at other location should be conducted within the zone to confirm this study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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