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Assessment of Four Sweet Potato (*Ipomoea batatas* L.) Varieties for Adapatibility and Productivity in Iwo, Osun State

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Authors' contributions

This work was carried out in collaboration between both authors. Author VIE designed the study, analyzed the data and managed the literature searches. Author OOO collected the data. Both authors read and approved the final manuscript.

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ABSTRACT

Vitamin A deficiency is prevalent especially in sub-Saharan Africa because most available food contains negligible amounts of beta-carotene which fail to meet the physiological requirements resulting in the impairment by high rates of infection. However, introducing orange-fleshed sweet potato cultivar with high ß –carotene will help eradicate the problem of vitamin A deficiency, malnutrition and food insecurity in Iwo, Nigeria. Aim: Therefore, the primary goal of this project is to enhance food security and smallholder farmers' income including women and young people in Iwo by introducing orange-fleshed sweet potato with high nutritional values. The varieties used were: Mother's delight (V1), King J (V2), Iwo I (V3) and Iwo II (V4). The field experiment was conducted at the Teaching and Research Farm of Bowen University, Iwo, Osun State from July to October 2017. Data were taken on leaf length, leaf breadth, petiole length, plant height and tuber yield (kg). V4 had the highest number of tubers per row (17) although, it was not statistically different ($P<0.05$) from V1 which gave the lowest number of tubers per row (14.25). V2 had the most extended petiole length of 32.06cm, and it was statistically different ($P<0.01$) from the remaining three potato varieties under evaluation. V3 was the highest yielding variety with a tuber yield of

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2.93kg, but it was not statistically different (P<0.05) from V1 which had the lowest tuber yield (2.05kg). V1 (an orange-fleshed variety) had the relatively lowest number of tubers per row but gave tuber yields (2.05kg) comparable with the highest yielding variety (V3 = 2.93kg), which is a locally cultivated and adapted variety. It can be concluded that the introduced ranges were similar in performance to the adapted landraces. It is recommended that the introduced varieties (specifically V1, the orange-fleshed potato) be adopted by the farmers for cultivation as the performance of both introduced varieties was significantly compared with the landraces cultivated by Iwo farmers.

Keywords: Horticulture; introduction; food security; eradication; productivity.

1. INTRODUCTION

Sweet potato (*Ipomoea batatas* [L.] Lam.) is a dicotyledonous plant from the family Convolvulaceae that grows in tropical and subtropical areas and even in some temperate zones of the developing world [1]. In developing countries, sweet potato ranks fifth economically after rice, wheat, maize, and cassava, sixth in dry matter production, seventh in digestible energy production, and ninth in protein production [2, 3]. World production is about 131 million tonnes yr-1, on approximately 9 million ha with mean estimated yields of 13.7 tonnes ha-1 [4]. China is the world's leading producer of sweet potato, accounting for about 80% of the total production worldwide. Nigeria is the most abundant sweet potato producer in Africa and second to China in world production [5].

Sweet potato flourishes in temperature ranges of 15°C to 35°C; with an optimum of 24°C [6]. The crop requires an annual rainfall of 750–1000 mm, with a minimum of 500 mm in the growing season [1]. This horticultural crop grows well in fertile, high organic matter, well-drained, light, and medium textured soils with a pH range of 4.5-7.0 [7, 1]. Heavy and poor textured, poorly drained soils that have frequent water-logging and poor soil aeration impede the growth of storage roots, reducing their size and yield. Waterlogging in early growth stages hinders the establishment of roots, and in later growth stages cause decay of the storage roots [1]. Sandy loam soils that are light and well-drained are the best for growing sweet potato. A well-drained sandy loam is preferred, and heavy clay soils should be avoided as they can retard root development, resulting in growth cracks and poor root shape. Lighter soils are more easily washed from the roots at harvest time. The crop is very sensitive to aluminium toxicity, which occurs at pH below 4.5, and may lead to the death of the crop within six weeks [8]. Nitrogen deficiency, phosphorus deficiency, potassium deficiency, magnesium deficiency, boron deficiency, iron deficiency, acid soils, aluminium toxicity, and salinity are the primary nutritional disorders of sweet potato [8].

In developing countries like most of Africa countries, people are traditionally dependent upon cereals and cassava and are unaware of the nutritional value of sweet potatoes. Currently, farmers in Iwo only grow white and yellow-fleshed varieties, which are low in vitamin A. This is consistent with the work of [9] who reported that most sweet potatoes cultivars presently used by sweet potato growers, especially the white and yellow-fleshed cultivar, have less or no beta-carotene a pre-vitamin A, they are also poorly adapted with low tuber yield and less micronutrient. In the same vein, [10] also stated that the African sweet potato varieties characteristically possess relatively high storage root dry matter content, and are somewhat dry or mealy textured when cooked. In contrary, many sweet potato varieties introduced from outside the region [11] typically have relatively low storage root dry matter content and are moist textured when cooked. Moreover, orange-fleshed, low dry matter varieties usually possess a robust carrot- or squash-like flavour that is quite distinct from the 'mild' flavour typical of the African varieties.

Vitamin A deficiency is especially prevalent in sub-Saharan Africa because most available foods contain negligible amounts of ß–carotene (a precursor of vitamin A). [12] classified sub-Saharan Africa as having the highest rates of vitamin A deficiency in children aged between 1 and 5 years. Pregnant and lactating women also add to this statistic. Vitamin A deficiency is suspect in increasing the risk of death from childhood illnesses like diarrhoea and 34-64% of childhood blindness in Nigeria is predominantly a result of vitamin A deficiency among other things [13]. Vitamin supplementation is a low-cost intervention. Orange-fleshed sweet potato cultivars are an excellent source of ß–carotene and can help enhance food security and improve farmer's income and wellbeing. [14] posited that the consumption of orange-fleshed sweet potato varieties could help in the alleviation of vitamin A deficiency. Consumption of 100g of sweet potato can provide enough ß–carotene to meet the suggested daily vitamin A requirement for infants and young children [15]. This is an amount that an orange-fleshed sweet potato supplies [15].

Sweet potato is considered as one of the major sources of food, animal feed and industrial raw materials. It has a significant contribution as an energy supplement and phytochemical source of nutrition. It provides powerful nutrients and thereby good health to those who eat it and possesses anti-carcinogenic and cardiovascular disease preventing properties [16]. Thus, several authors have reported on the benefits and prospects of the consumption of orange-fleshed sweet potatoes in Nigeria, but no research has been carried out on the introduction, adaptability and benefits of this varieties in Osun State. Promoting the introduction of orange-fleshed sweet potato will help boost the income of farmers in Iwo and enhance vitamin A and other nutrients in the daily diet of the population which can result in improved well-being and physical development of the population, especially children and pregnant women. In so doing, the problem of vitamin A deficiency can be mitigated across the country due to its technical feasibility and cost-effectiveness.

The work aims to enhance agriculture and food security in Iwo by introducing orange-fleshed sweet potatoes. Orange-fleshed sweet potatoes are an excellent source of vitamin A and could be grown in Iwo to reduce malnutrition in the area. The specific objectives are to (1) Evaluate the adaptability of orange-fleshed sweet potato in Iwo and (2) Assess four potato varieties for their yield and related components.

2. MATERIALS AND METHODS

2.1 Experimental Location and Plant Material

The experiment was carried out at the Teaching and Research Farm of Bowen University, Iwo, Osun State (Latitude and Longitude $7^{o}62^{'}$ N and $4^{o}19^{'}$ E, respectively).

Four varieties of sweet potato [two introduced varieties called Mother’s delight and King J (V1 and V2, respectively) and two landraces Iwo I and Iwo II (V3 and V4, respectively) were used for this evaluation. V1 is the orange-fleshed sweet potato with high beta-carotene content. The two introduced varieties were obtained from a Commercial Agricultural Center located in Abuja. This Commercial Agricultural Center sell the vine of sweet potato to promote the production of orange fleshed sweet potato across the country

2.2 Experimental Design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replicates. The total plot size was 33m x 10m with each replication having a plot size of 11m x 2m. The intra and inter row spacing was 30 cm and 90 cm, respectively. Rows of each variety were separated by a 1m boundary and replications were separated by 2m boundaries. The vines of each variety were planted in triplicate rows containing 6 plants each, thus a total of 18 plants for each block. The sweet potato cuttings measuring at least 30cm in length and having 3-4 nodes were planted on top of the ridges with cuttings facing the right-side up.

2.3 Data Collection

Six (6) plants in the middle row of the triplicate rows were harvested and data were collected on leaf length, leaf breadth, plant height, petiole length, internodal length and yield (kg).

- Vine length- The length of two most vigorous vines were taken using a measuring tape. The length was taken from the base of the plant vine to the tip of the vine. The vines were straightened so as to get accurate reading.
- Petiole length- This was taken by measuring the stalk of the leaf from the base of the leaf, to the point of attachment to the stem.
- Leaf length- The length was measured from the tip of the leaf to the base or bottom of the leaf.
- Leaf breadth- This was the measurement of the width of the leaf. The widest part of the bottom was measured from side to side.
- Internodal length- This was obtained by measuring the distance between the nodes of the vines.

- Plant height- This was measured with a carpenters measuring tape, done by putting the tape on the ground and elongating the tape to check the height without straightening of the vine.
- Fresh weight of the tubers harvested were taken with a weighing balance.

Other parameters collected were: general outline of the leaf, leaf lobe type, mature leaf size, Storage root shape, predominant skin colour, and root flesh colour, Storage roots surface defects, distribution of secondary flesh colour and cooked taste.

2.4 Statistical Analysis

The data collected were subjected to an analysis of variance to determine the differences among treatments. Means separation was performed by Turkey's test. Data collected were subjected to analysis of variance to ascertain the differences amongst traits and varieties used. Means separation was performed by DMRT' test. Broad Heritability and Pearson correlation were also determined.

3. RESULTS

3.1 Predominant Vine Colour

The predominant vine colour could be either Green, Green with few purple spots, Green with many purple spots, Green with many dark purple spots, Mostly purple, Mostly dark purple, Totally purple, Totally dark purple. The results obtained from this study (Fig. 1) are as follows:

> The predominant vine colour of variety 1 was Purple.
> The predominant vine colour of variety 2 was Green.
> The predominant vine colour of variety 3 was Green with few purple.
> The predominant vine colour of variety 4 was Green with plenty purple.

3.2 Leaf Morphology

The general outline of the leaves was measured visually and they revealed the following morphological characteristics:

> Introduced variety 1 was Cordate
> Introduced variety 2 was Lobed
> Local variety 1 was Triangular
> Local variety 2 was Lobed

3.3 Leaf Lobe Type

The leaf lobe type of each variety are presented as follows:

> Leaf lobe type for introduced variety 1 was of no lateral lobes (0) while that of introduced variety was Deep (7). Very slight (teeth) (1) was recorded in Local 1 while moderate (5) type was observed with Local 2

3.4 Mature Leaf Size

This is the length from the basal lobes to the tip of the leaves which could be Small (<8 cm), medium (8-15 cm), large (16-25 cm), very large (> 25 cm). The following size was recorded in each of the four varieties:

> Mature leaf size for variety 1 was Medium (11)
> Mature leaf size for variety 2 was Medium (11)
> Mature leaf size for variety 3 was Medium (10)
> Mature leaf size for variety 4 was Medium (8)

3.5 Storage Root Shape

This is the storage root outline shown in a longitudinal section, it could be Round (almost a circular outline), Round elliptic (a circular outline with acute ends), Elliptic (symmetrical outline), Ovate (outline resembling the longitudinal section of an egg), Obovate (inversely ovate outline), Oblong (almost rectangular outline with sides nearly parallel an corners rounded), Long oblong (oblong outline), Long elliptic (elliptic outline), Long irregular or curved. The different shape measured visually are as follows:

> The storage root shape of variety 1 was Round eliptic, those of varieties 2, 3 and 4 were long oblong, long eliptic and long irregular, respectively.

3.6 Predominant Skin Colour of Sweet Potato Tubers

The colour of the tuber was orange in variety 1, pink in variety 2 and 4 and cream in variety 3. Fig. 2 shows the different colors of the tubers.

All the farmers who was given the tubers to boil and rate the taste of the boiled sweet potato, testified that the orange fleshed sweet potato tubers (V1) were excellent in taste compared to other varieties.

3.7 Descriptive Analysis of the Traits

The overall averages with their respective standard deviations for each phenotypic trait are presented in Table 1. These averages range from 2.51 to 22.76. The highest (22.76 cm) was obtained for plant height and the lowest for yield (2.51kg). Similarly, the highest standard deviation 7.37 was recorded with the highest mean and the lowest standard deviation with internode length even though the lowest mean was not associated with this trait. This indicates that the data for internodal length are well grouped together compared to yield.

Table 1. Means and standard deviation of characters

Characters	Mean	Std. deviation
Leaf Length	11.24	2.89
Leaf Breadth	8.84	2.24
Plant Height	22.76	7.37
Petiole Length	11.76	4.06
Internodal Length	3.53	0.86
Number of Tubers	15.50	3.41
Yield	2.51	0.886

3.4 Analysis of Variance of the Seven Traits

No significant differences were recorded for leaf breadth, internodal length, number of tubers and yield amongst the four varieties (Table 2). The lowest and the highest were 7.58cm and 10.74 cm, 3.28cm and 4.16 cm, 14.25 and 17.00k, 2.05kg and 2.58 kg, respectively. There were significantly differences amongst varieties for leaf length, petiole length and plant height. The lowest leaf length was observed with V1 followed by V4 while the highest was observed with the local variety V3. The longest petiole was recorded with V3 (15.43 cm) and the lowest observed with V4 (8.93 cm). V2 had the highest plant length of 32.06cm and it was statistically different ($P<0.01$) from the remaining three sweet potato varieties with V1 the lowest (17.28 cm) under evaluation. V1 (an orange fleshed variety) had the lowest number of tubers per row but gave tuber yields comparable with the highest yielding variety (V3), which is a locally cultivated and adapted variety.

3.5 Relationship between Seven Traits Measured

Table 3 is the summary of correlation coefficient among traits studied. Total yield was positively

Fig. 1. Picture showing the different colours of the vines, V1, V2, V3 and V4

Fig. 2. Picture showing the different varieties of tubers harvested V1, V2,V3 and V4 after 5 months of experiments

Table 2. ANOVA of phenotypic traits measured

Variety	Leaf length (cm)	Leaf breadth (cm)	Petiole length (cm)	Internodal length (cm)	Plant height (cm)	Number of tubers	Yield (kg)
V1	8.60b	7.94a	9.39b	3.30a	17.28b	14.25 a	2.050a
V2	12.98a	9.08a	13.30ab	3.28a	32.06a	14.50a	2.58a
V3	13.77a	10.74a	15.43a	3.37a	23.07b	16.25a	2.90a
V4	9.63b	7.58a	8.93b	4.16a	18.64b	17.00a	2.50a

but not significantly correlated with leaf length (r = 0.415), leaf breadth (r = 0.307), plant height (r =0.397), petiole length (r = 0.275) and internodal length (r = 0.330), and significantly and positively correlated with number of tubers (r = 0.602, P < 0.05). Number of tubers was positively correlated with leaf length (r =0.129), leaf breadth (r = 0.150), plant height (r = 0.316) and internodal length (r = 0.283), but was negatively correlated with petiole length (r = -0.028). Highly and significantly positive correlation coefficient values were also recorded among leaf length and leaf breadth (r =0.887, P<0.01), leaf breadth and petiole length (r =0.835), leaf length and petiole length (r =0.862, P<0.01). Significantly positive correlation coefficient value was observed between leaf length and plant height (r =0.612, P<0.05).

3.6 Broad Heritability

The highest heritability was observed in leaf breadth (0.80) followed by leaf length, internodal length (0.73) and plant height (0.69), thus they are the most heritable traits while the lowest were recorded in Yield (0.21) and petiole length. The heritability was low for yield when compared to the vegetative traits.

4. DISCUSSION

The orange fleshed sweet potato variety introduced in Iwo but yet to be disseminated will definitely be adopted by farmers, thereby contributing to food security and boosting farmers' revenues in the locality. All the farmers who tasted the introduced orange fleshed sweet potato just liked it and would like to plant, this means that its adoption will not be an issue in the region. This is consistence with the study of [17] who reported Mafutha genotype scored well with the taste evaluation, confirming its status as the cultivar with a taste preferred by resource-poor farmers. They further stated that at all the localities the orange-fleshed genotypes were well accepted, despite it being a new crop.

The four varieties used in this study vary in shape, size, root storage, leaf length, leaf breadth, plant height, number of tubers, way to withstand abiotic and biotic resistance. This show the phenotypic and genotypic diversity amongst these varieties. The yields of the V2, V3 and V4 were not significantly different from the introduced orange fleshed sweet potato. This is an indication that the enrich vitamin A orange fleshed sweet potato is well adapted to the climate of Iwo and its surroundings and could be

Table 3. Correlation coefficient (r) among seven traits of the four sweet potato varieties by Pearson Correlation

	LL	LB	PH	PL	IL	NOT	Yield
LL	1						
LB	0.887**	1					
PH	0.612*	0.430	1				
PL	0.862**	0.835**	0.478	1			
IL	0.241	0372	0.074	0.214	1		
NOT	0.129	0.150	0.316	-0.028	0.283	1	
Yield	0.415	0.307	0.397	0.275	0.330	0.602*	1

***Correlation is significant at the 0.01 level (2-tailed)*
**Correlation is significant at the 0.05 level (2-tailed).*
LL= Leaf length, LB = Leaf breadth, PH = Plant height, PL = Petiole length, IL = Internodal length, NOT = Number of tubers,

well disseminated for its use and food security. It should also be noted that the marketable value of V1 was also excellent after harvest because they were not infested by insect pests and pathogens. Moreover, some big tubers surpassing the local varieties were harvested.

Table 4. Broad heritability

Variable	Heritability
LL	0.73
LB	0.80
PL	0.32
IL	0.73
PH	0.69
NOT	0.47
Yield	0.21

LL= Leaf length, LB = Leaf breadth, PH = Plant height, PL = Petiole length, IL = Internodal length, NOT = Number of tubers,

Phenotypic correlation analysis of sweet potato show evidence of strong genetic linkage between characters. These correlations among total yield, and yield components imply co-localization of genes for these traits especially with the number of tubers. Our results are consistent with those of [18] who suggested that the co-localization of quantitative trait loci for several traits is associated with a correlation in the phenotypic data, although, the current data are insufficient to establish, with certainty, the presence of co-localization genes. [19] reported negative correlation in apple (*Malus x domestica*), between flowering precocity and fruit yield as observed in study between number of tubers and petiole length. So, thus, selection and breeding for petiole length should not be a priority in sweet potato tuber improvement because of its indirect negative effect on the yield.

With high heritability obtained for LL, LB, IL and PH rapid selection especially mass selection in breeding program is possible while with low heritability in yield for instance families and progeny testing are more effective and efficient because our long-term goal is to develop high yield with new beta-carotene rich hybrids of orange-fleshed sweet potato that are resistant to damage by weevils and well adapted to the growing conditions in Iwo.

5. CONCLUSIONS

Variety 4 (a local variety) had a total number of 17 tubers but it was not statistically different (P<0.05) from the lowest yielding variety (V1) from which 14.25 tubers was harvested.

Although V1 resulted in the lowest number of tubers, it had yields comparable with the highest yielding variety (V3 – a local variety).

With high heritability obtained for LL, LB, IL and PH rapid selection in breeding program is possible while with low heritability in yield for instance families and progeny testing are more effective and efficient because our long-term goal is to develop high yield with new beta-carotene rich hybrids of orange-fleshed sweet potato that are resistant to damage by weevils and well adapted to the growing conditions in Iwo.

It is recommended that orange-fleshed potato varieties be adopted for cultivation by the local farmers. This can severely help mitigate food insecurity.

Further crop improvement of the introduced orange-fleshed potato variety can lead to even better tuber yields.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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