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Evaluation of the performance of improved sweet potato (*Ipomoea batatas* L. LAM) varieties in Bayelsa State, Nigeria

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This study was conducted using randomized complete block design with three replications each in two locations (Amassoma Wilberforce Island and Yenagoa, Bayelsa State) to evaluate the performance of improved sweet potato varieties (Ex-Igbariam, TIS 8164, 199004-2 and TIS 87/0087 including Kukunduku local) from March to June 2010. There were significant differences among varieties at both locations and across locations but locations and location x variety interaction were non-significant for sweet potato root yields. Ex-Igbariam and TIS 87/0087 had higher fresh root yields of 7.39 and 4.17 t ha^{-1}, respectively, than others across locations. Regarding trailing characteristic (soil surface cover), too, varieties were significantly different at both locations and across locations but location and location x variety interaction were non-significant with Ex-Igbariam and TIS 87/0087 having best soil surface cover, and consequently, best weed suppressants. There was incidence of diseases but that of insects was low. For fresh root phenotypic characteristics, Ex-Igbariam and 199004-2 had yellow flesh, indicative of the presence of vitamin A precursor. Since Ex-Igbariam, TIS 87/0087 and a few others showed real promise in yield and carotene content, carrying out a multi-locational trial would, hopefully, enable selection of high - yielding varieties for commercial production to improve farmers' yields and income in the different agro-ecological zones of Bayelsa State.

Key words: *Ipomoea batatas* L. Lam, improved variety, yield, Nigeria.

INTRODUCTION

Sweet potato (*Ipomoea batatas L. Lam*), the only member of the genus Ipomoea whose roots are edible, is one of the world's most important food crops because of its high yield, nutritive value and capacity to tolerate marginal environmental conditions (Hahn, 1977; Date and Eronico, 1987). It contains about 70, 1.5, 0.5, 25 and 1 water, fat, carbohydrate, fibre and ash, respectively (Martins and Leonard, 1955). Of the carbohydrates, 3-4.5% is sugar and the remainder mostly starch while 0.2 and 0.5% of the ash are calcium and phosphorus, respectively. Also, it contains carotene and fair quantities of ascorbic acid and B vitamins.

Regarding utilization, sweet potato cultivation is for human consumption (Hahn, 1977; Horton, 1988; Nwokocha and Okwowulu 1996; Tewe et al., 2000; Odebode, 2004: Odebode et al., 2008), livestock feed (Tewe and Ologhobo, 1983; Scott and Wall, 1992; Woolfe, 1992; Asuquo et al 1992; Asuquo and Anuebunwa, 1993; Okoroji et al., 1996; Onwubuemeli et al., 1996; Okposen et al., 1996; Ojeniyi and Tewe, 2003), industrial processing to make alcohol and starch (Martins and Leonard, 1955; Prain et al., 1997) including confectioneries (Obieri et al., 2004; Igbokwe et al., 2005; Uzoka et al., 2005; Odebode, 2004; Odebode et al., 2008). The green leaves

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could be consumed by humans and animals (Okposen et al., 1996) including fish (Madugba et al., 2005) while the whole plant is a natural weed suppressant (Udealor et al., 1993; Nnawuchi et al., 2001; Melifonwu and Ikeorgu, 2003; Ajagu et al., 2005). Also, potato root intake is medicinal in combating blindness and diabetes in humans (Low et al., 1996; Carey et al., 1999).

Its large starchy sweet-tasting roots are an important root vegetable (Purseglove, 1992; Woolfe, 1992) and, sometimes, the young leaves and shoots are eaten fresh. Although the leaves and shoots are edible, the starchy tuberous roots are by far the most important product. In some tropical areas, they are a staple food crop.

In West African countries (Guinea, Sierra Leone and Liberia) as well as in Northeastern Uganda and East Africa, the consumption of young leaves and vine tips of sweet potato as a vegetable is common. In 1990, FAO reported sweet potato leaves and shoots as good source of vitamins A, C and B2 (riboflavin) (FAO, 1990). However, sweet potato varieties with dark orange flesh have more beta carotene than those with light coloured flesh and their increased cultivation is being encouraged in Africa where vitamin A deficiency is a serious health problem (Hagenimana et al., 1999b).

Right now, sweet potatoes are useful in Africa to combat a widespread vitamin A deficiency that results in blindness and even death for 250,000 - 500,000 African children yearly. About two - thirds of the children developing xerophthatmia, the blindness - inducing disease resulting from lack of vitamin A, die within a year of losing their sight (Low et al., 1996; Carey et al., 1999; Bourke and Vlassak, 2004). Though for long it has been a staple food of the continent's diet, the African sweet potato contains white flesh which has no beta carotene (a precursor to vitamin A) unlike its sweeter, yellow-orange fleshed relative.

Although researchers long believed that African states would reject the coloured variety, an International Potato Centre (CIP) project conducted in Eastern and Southern Africa over the past ten years has identified a yellow-orange variety palatable to Africans (Woolfe, 1992). The researchers complemented their findings with the development of a nutritional education programme that has been successful in motivating African mothers to accept new varieties of sweet potato. Now researchers intend to focus their efforts on developing a more productive crop and expanding the reach of their education programme (Wardle et al., 1991).

Globally, sweet potato is a very important food crop and ranked fourth in terms of consumption as the world's most important. FAO (2004) reported that approximately 129,536,275 million tons were produced in more than 100 countries and Asia as the world's largest sweet potato - producing region with 114 million tons annually as the leading supplier of sweet potatoes. However, nearly half of the sweet potatoes in Asia are for animal feed with the remainder primarily for human consumption either as fresh or processed products. In contrast, African farmers produce only about 12 million tons of sweet potatoes annually but most of the crop is for human consumption. Also, they indicated the world potato hectarage in 2004 as 9074459 ha comprising 4874180, 945000, 602000 and 500,000 ha from China, Nigeria, Uganda and Tanzania, respectively. However, the major obstacles to sweet potato growth in the tropics are insects and diseases such as the sweet potato weevils and viral diseases.

In China, recent research by CIP personnel has shown that sweet potato yield could increase by as much as 30 - 40% without additional fertilizer, pesticide or genetic improvement (Prain et al., 1997). In a five year project in the province of Anhui and Shandong, using a procedure that eliminates viral diseases from planting materials, scientists had virus-free cuttings that developed into healthy plants. Extending this to all of China's sweet potato-growing regions, benefits exceeding USD$1.5 billion could be realized and would considerably reduce the country's reliance on cereal imports for livestock feed. In Kwara State, sweet potato enjoys the high cultural status of yams (*Dioscorea* sp.) in Southern Nigeria celebrating with feasts and cultural dances. Although Nigeria produces only 0.2% (about 0.26 million tons per year on 20 - 25 thousand ha) of the world total (Horton, 1988), there are indications of the crop turning into a life saver and foreign exchange earner for Nigeria. It has a 4-month growth cycle and its cultivation could be two to three times with supplementary irrigation.

On-shelf technology from National Root Crops Research Institute, Umudike, Nwokocha and Okwowulu (1996) reported mean total yields of 8.41, 15.18 and 11.16 t ha^{-1} in 1993 including 9.15, 14.32 and 19.85 t ha^{-1} in 1995 for improved varieties TIS 8441, 87/0087 and 8164, respectively. Later, Ojeniyi and Tewe (2003) indicated that the International Institute of Tropical Agriculture (IITA), Ibadan and the National Root Crops Research Institute (NRCRI), Umudike had reported high agronomic yield potential of sweet potato as a food security crop in Nigeria but the high potential was yet to be converted into increased output under the present cropping system.

However, one of the reasons identified for the failure to achieve increased sweet potato production in Nigeria was the bad agronomic system of cultivation. Also, the devastating pests notably *Cylas* sp. (sweet potato weevil), viruses and rots need control. After harvest, up to 80-100% of the roots could be lost within one to two weeks and so effective storage methods are necessary. The dark/brown discoloration of the sweet potato flour on or after reconstitution needs elimination.

Cylas sp., the most economically important field pest which devastates the root tubers of sweet potato has been a major constraint in production. *Acraea acerata* is a pest reported for the first time at Umudike in 1985 and population dynamics of *A. acerata* showed it as mainly a dry season pest occurring mainly from mid-November to mid-December (Anioke et al., 1987). However, the incidence of pests is, generally, low due to prolonged rainy season which is inimical to the development of insect pests (Anioke et al., 1990). Also, they reported TIS 81/647 as having the highest percentage of *Cylas* sp. damage on its tuber but TIS 2498 and TIS 87/0087 were found to be tolerant to the weevil *A. acerata* Hew damage on foliage. In addition, they reported the incidence of young instars of *Zonocerus variegatus* which caused serious damage to leaves. In 1991, NRCRI reported TIS 87/0087 as having good growth habit and tolerance to virus and *Cylas* sp. when harvested at four months. Based on the fact that sweet potato creeps, it is a natural weed suppressant, and given the right plant density and appropriate varieties, can develop a thick cover fast (Nwokocha, 1992). However, it has been observed that a mixture of Alachlor (Lasso) and Cloramben mixed at the rates of 1.92 and 2.88 kg ai/ha, respectively, has served in NRCRI, Umudike as an effective pre-emergence herbicide (Nwokocha, 1992).

Since sweet potato is important in Bayelsa State, it features in the farming system with growing interest. Usually, farmers cultivate local varieties which are not only low-yielding and less nutritive but, also, susceptible to diseases including insects and, some late-maturing, making evaluation of improved varieties for cultivation necessary.

The objective of this study, therefore, was to evaluate the performance of improved sweet potato varieties that would enable selection of high-yielding ones for commercial production to improve farmers' yields and income in Bayelsa State, Nigeria.

MATERIALS AND METHODS

A field experiment was conducted from March to June 2010 at two locations (Amassoma and Yenagoa, Bayelsa State) both in the Niger Delta humid tropics with bimodal rainfall pattern. The experiment was conducted on a two-year fallow land previously cultivated with maize (*Zea mays*). Four improved varieties (Ex-Igbariam, TIS 8164, 199004-2 and TIS 87/0087) from National Root Crops Research Institute (NRCRI) Umudike and a locally grown variety Kukunduku (control from Amassoma) in a randomized complete block design with three replications. After taking pre-cropping soil samples for analysis and land preparation without liming since smallholder farmers usually do not apply lime, planting of sweet potato was with four node vines plots at 100 x 30 cm spacing giving a population density of 33,333 plants per hectare. Weeding was at 4 and 8 weeks after planting (W.A.P) and basal application of 100 kg/ha NPK 20:10:10 fertilizer after the first weeding. A total of 5 treatments were used and these were replicated thrice. Plot size was 5 x 4 m. The treatments are: T_1- Ex-Igbariam; T_2- TIS 8164; T_3- 199004-2; T_4- TIS 87/0087; T_5- Kukunduku local (control).

All these potato varieties are, however, phenotypically viny and trailing varieties. Sweet potato fresh root yield was determined in tonnes per hectare including soil surface cover (trailing characteristic) on a scale of 1-5 with 1 as very good, 2 good, 3 average, 4 bad and 5 very bad.

Insect and disease incidence was on a scale of 0-5 with 0 as absent and 5 high as well as fresh root phenotypic characteristics (skin and flesh colour).

Statistical analysis obtained

The data obtained were subjected to analysis of variance (ANOVA) according to procedures of Statistical Analysis System (SAS 1999) and split plot arrangement (combined analysis) by Gomez and Gomez (1984). Differences between means were determined using least significant difference (LSD) statistic ($p \leq 0.05$).

RESULTS

Chemical and physical properties of soil at the experimental sites

The soil was clay, acidic (low pH) as well as low in organic matter and total nitrogen including essential nutrients (Table 1).

Sweet potato fresh root yields

The results obtained show that the treatments (varieties) were significantly different at Amassoma and Yenagoa locations. In Amassoma location, TIS 8164, 199004-2, TIS 87/0087 and Kukunduku local were not significantly different but were significantly different from Ex-Igbariam which had the highest fresh root yield (12.81 t ha^{-1}) followed by TIS 87/0087, TIS 8164, 199004-2 and Kukunduku local which had 7.48, 7.01, 5.99 and 5.67 t ha^{-1}, respectively (Table 2). Although the trend was the same at Yenagoa, mean fresh root yields were higher at Amassoma.

In a combined analysis using split plot arrangement with locations as main plot and treatment sub plot, the results obtained (Table 3) show means for fresh root yields of the sweet potato varieties across locations as 7.39, 4.19, 3.93, 3.28 and 3.09 t ha^{-1} for Ex-Igbariam, TIS 87/0087, TIS 8164, 199004-2 and Kukunduku local, respectively, still, with the same trend.

Soil surface cover (trailing characteristics)

In Table 4, there are means for the soil surface cover (trailing characteristic) and the results obtained at Amassoma and Yenagoa locations showed that treatments (varieties) were significantly different. In Amassoma, TIS 87/0087 had the highest (best soil surface cover) followed by Kukunduku local, TIS 8164, Ex-Igbariam and 199004-2 with 4.3, 3.8, 3.3 and 2.7, respectively, whereas at Yenagoa, TIS 87/0087 and Kukunduku local were highest and non-significantly different but significantly different from TIS 8164, Ex-Igbariam and 199004-2 which had 3.8, 3.3 and 2.6, respectively. In a combined analysis using split plot

Table 1. Soil characteristics of Amassoma, Wilberforce Island and Yenagoa locations.

Parameter		Amassoma, W. Island	Yenagoa
Organic matter (%)		1.81	1.9
pH*		4.8	4.32
Mechanical	Sand	23	25
Analysis (%)	Silt	31	34
	Clay	46	41
Soil texture		Clay soil	Clay soil
Total N (%)		0.07	0.09
Available P (mg/kg)		78.1	86.6
CEC (cmo1/kg)		2.0	2.02
	Ca	1.16	1.41
Exchangeable	Mg	10.0	12.0
Bases (cmo1/kg)	K	47.0	48.0
Base saturation		42	51

*pH in 1:10 distiled water.

Table 2. Mean fresh root yields (t ha^{-1}) of sweet potato varieties at Amassoma, Wilberforce Island and Yenagoa.

Treatment	Amassoma, W. Island	Yenagoa
Ex-Igbariam	12.81	11.81
TIS 8164	7.01	6.08
199004 - Z	5.99	4.96
TIS 87/0087	7.48	6.44
Kukunduku local	5.67	4.64
LSD .05	2.31	2.44

Table 3. Mean fresh root yields (t ha^{-1}) of sweet potato varieties across locations.

Treatment	Fresh root yields
Ex-Igbariam	7.39
TIS 8164	3.93
199004 - Z	3.28
TIS 87/0087	4.19
Kukunduku local	3.09
LSD .05	1.61

Table 4. Mean soil surface cover* of sweet potato varieties at Amassoma, Wilberforce Island and Yenagoa locations.

Treatments	Amassoma	Yenagoa
Ex-Igbariam	3.5	3.1
TIS 8164	3.8	3.8
199004 - Z	2.7	2.6
TIS 87/0087	4.9	4.3
Kukunduku local	4.3	4.3
LSD 0.05	0.42	0.42

*Indicates soil surface cover (1-5) 1 as very good, 2 as good, 3 average, 4 bad and 5 very bad.

Table 5. Mean soil surface cover* of sweet potato varieties across locations (Amassoma, Wilberforce Island and Yenagoa) in Bayelsa State.

Treatments	Soil surface cover
Ex-Igbariam	1.92
TIS 8164	2.28
199004 - Z	1.58
TIS 87/0087	2.58
Kukunduku local	2.58
LSD .05	0.27

arrangement, locations and location x varieties interaction were non-significant while there were significant differences among varieties for this characteristic across locations (Table 5).

Insect and disease incidence

The results obtained (Table 6) showed no incidence of diseases but that of insects was low.

Fresh root phenotypic characteristics (skin and flesh colours)

Among the sweet potato varieties involved (Table 7), visual observation of fresh root cuttings showed that Ex-Igbariam and 199004-2 had yellow flesh indicative of the presence of vitamin A precursor (carotene).

Table 6. Incidence of diseases and insects* on sweet potato varieties at Amassoma, Wilberforce Island and Yenagoa locations.

Treatment	Amassoma		Yenagoa	
	Disease	Insect	Disease	Insect
Ex-Igbariam	0	1	0	1
TIS 8164	0	1	0	1
199004 - Z	0	1	0	1
TIS 87/0087	0	1	0	1
Kukunduku local	0	1	0	1

*Incidence of diseases and insects with 0 as absent and 5 high.

Table 7. Fresh root phenotypic characteristics of sweet potato varieties at Amassoma, Wilberforce Island and Yenagoa locations.

Treatment	Amassoma, W. Island		Yenagoa	
	Skin colour	Flesh colour	Skin colour	Flesh colour
Ex-Igbariam	Orange	Yellow	Orange	Yellow
TIS 8164	Light pink	White	Light pink	White
199004 - Z	Pink	Yellow	Pink	Yellow
TIS 87/0087	Light orange	Cream	Light orange	Cream
Kukunduku local	Pink	White	Pink	White

DISCUSSION

Considering that the tolerable pH level for sweet potato growth and performance is 6.7 - 8, the pH level of 4.8 appeared low. This was expected because most soils in the state are acid and, traditionally, farmers do not apply lime. The basis for using these varieties is because they are early maturing and high yielding.

Except for slightly lower fresh root yields, the trend was the same in Yenagoa. In a combined analysis using split plot arrangement, locations and location x variety interaction were non-significant but varieties were significantly different with the same trend when compared with the results of Nwokocha and Okwowulu (1996) who reported mean total yields of 8.41, 15.18 and 11.16 t ha^{-1} in 1993 including 9.15, 14.32 and 19.85 t $ha-^{1}$ in 1995 for improved varieties TIS 8441, 87/0087 and 8164, respectively, the results obtained with Ex-Igbariam having fresh root yield (12.81 and 11.81 t ha^{-1} at Amassoma and Yenagoa, respectively) would be regarded acceptable under our experimental conditions of low pH. Therefore, selection of an improved variety for increased yield and commercial production appears feasible.

The observations obtained for soil surface cover (trailing characteristic) showed, therefore, that TIS 87/0087 and Kukunduku local provided better soil surface cover and suppressed weeds best indicating that selection of a good weed suppressant is feasible.

Since there was no incidence of diseases and that of insect was low because only a few grasshoppers and dragon flies were observed, the results were similar to those of Anioke et al. (1990) who reported, generally, low incidence of pests because of rainy season which is inimical to the development of insects.

Due to the fact that visual observation of fresh root cuttings showed that Ex-Igbariam and 199004-2 had yellow flesh, the results were similar to the reports of other scientists (Wolfe, 1992; Hegenimana et al., 1999) who indicated that sweet potato varieties with dark orange flesh have more beta carotene than those with light coloured flesh and their increased cultivation is being encouraged in Africa where vitamin A deficiency is a serious health problem.

Conclusion

Generally, the study shows that the improved varieties are higher in root yields with Ex-Igbariam, TIS 87/0087 and few others showing real promise in yield and carotene content. It is, therefore, recommended that carrying out a multi-locational trial would, hopefully, enable selection of high-yielding varieties for commercial production to improve farmers' yields and income in the different agro-ecological zones of Bayelsa State.

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