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Full Length Research

Variability in the yield and character association in Nigerian sweet potato (*Ipomoea batatas* (L.) Lam) genotypes

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The aim of the study was to determine the variability among 15 sweet potato genotypes and identify traits which are positively and significantly correlated with fresh tuber yield and also identify genotypes with high yield for the environment. A land area of 19m x 45m was laid out in a randomized complete block design with four replications. Vine length (cm), number of functional leaves per plant, leaf area per plant (cm^2), number of branches per plant, tuber length (cm), circumference of tubers (cm), fresh tuber yield (t/ha), number of marketable tubers and non- marketable tubers per plot, weight of top growth, number of cracks and holes per tuber were studied. Significant differences ($P \leq 0.05$) were observed among the sweet potato genotypes for all the characters. UM/11/015 was superior over all the other sweet potato genotypes in three important characters, namely circumference of tubers, fresh tuber yield (t/ha) and number of marketable tubers per plot, followed by Solo 2 in two, namely tuber length and number of non-marketable tubers per plot.TIS 87/0087 was the next superior genotype for number of marketable tubers per plot and fresh tuber yield. The study showed that tuber length, circumference of tubers, number of marketable tubers and number of non-marketable tubers were significantly and positively correlated with fresh tuber yield ($p < 0.01$). However, number of branches per plant and vine length were negatively correlated with number of leaves, circumference of tubers, tuber length, and number of marketable and non-marketable tubers. Based on these findings, tuber length, circumference of tubers, number of marketable and non-marketable tubers are important traits that should be considered for selection in sweet potato. The high yielding genotypes showed weak resistance to holes and cracks in tubers. Therefore, UM/11/015, TIS 87//0087 and Solo 2 could be recommended for Uyo agro-ecology while UM/11/015 and Solo 2 could be advanced to the pre-released trials in the area. Four sweet potato genotypes, EA/11/025, CIP 420068, UMUSPO/3 and Butter milk which were generally vegetative and unproductive types could be eliminated from the list of sweet potato of Uyo environment.

Keywords: sweet potato, variability, yield components, character association

Introduction

Sweet potato (*Ipomoea batatas*) belongs to the morning glory family Convolvulaceae (Woolfe, 1992) and is widely grown important staple in most parts of Nigeria (Njoku et al., 2009). Sweet potato is the world's most important food crops after wheat, rice, maize, potato, barley and cassava (Gundadhur, 2012), with an estimated 300 million metric tons grown on 19 million hectares of land (Laurie et al., 2013). It is grown for its large starchy, sweet tasting tuberous roots (Nwankwo and Bassey, 2014). The young leaves and shoots are used as food condiments and for preparation of local soups, porridge yam, plantain, cocoyam, rice and beans. The leaves are also used for wrapping “ekpangnkukwo”, a delicacy popular among the Ibibios and Efiks (Antiaobong and Bassey, 2009). Nutritionally, sweet potato has a higher protein content than other tuber crops, such as cassava and yam. Protein content varies from 1-2.5%. Carotenes, precursors of vitamin A production are also present in yellow varieties (Mukhtar et al., 2010). Sweet potato can be reconstituted into edible forms such as foofoo or blended with carbohydrate flour source especially wheat, for baking bread, cakes and other confectionery (Woolfe, 1992).

It has a short gestation period of about four months and matures before the onset of dry season when planted between April and June (Nwankwo et al., 2012). It is a drought resistant and hardy crop and can grow on marginal areas, thus contributing to food security (Mukherjee, 2010); like cassava only the non-edible part is used for planting material and so does not compete for human food (Antiaobong and Bassey, 2009).

Estimated yields of sweet potato in farmers’ plots in Nigeria are relatively low, 2.6 tonnes per hectare compared with average in Africa (9.6t/ha), China (22.0 t/ha) and the world (15.9t/ha). Estimated yield on research stations range between 40-70t/ha for improved varieties in four to five months under good management (Tewe et al., 2001). The lowering yields per unit area could be attributed to inappropriate management and persistent use of unproductive local types and inability to access the improved varieties (Karanja et al., 2013). Correlation analysis is of great use to plant breeders for selection and breeding genotypes with high yield potentials. Therefore, improvement of one character in field experiments results in simultaneous improvement of all the positively correlated characters (Nnungu and Uguru, 2014). Selection of suitable genotypes from existing ones could be an important aspect of improvement of sweet potato, especially, if their physiological characters and yield components correlate with tuber yield (Gargi et al., 2013). Therefore, the purpose of the study was to determine variability among 15 sweet potato genotypes and identify traits which are positively and significantly associated with yield and also identify genotypes with high yield potential vis-a-vis the national checks for the environment.

MATERIALS AND METHODS

A study was conducted at the Teaching and Research Farm of the University of Uyo, Nigeria in 2013 and 2014 cropping seasons. The area lies within latitude 4^o33^1 and 5^o33^1 north and longitude 7^o55^1 and 8^o25^1 east of the Greenwich meridian. A land area of 19m x 45m was laid out in a randomized complete block design with four replications. There were 15 plots per block and each plot measured $12m^2$. The treatments were fifteen sweet potato genotypes, obtained from the National Root Crops Research Institute, Umudike, Abia State, Nigeria, namely NRSP/12/060, TIS86/0356, UMUSPO/2, EA/11/025, TIS8164, UM/11/015, Kwara, CIP 420068, TIS 87/0087, UM/11/22, SOLO2, UMUSPO/3, UM/11/022, UMUSPO/1 and Butter milk. Two genotypes TIS87/0087 and TIS8164 were included as national checks.

The land was mechanically ploughed, harrowed and ridged 1m apart. Sweet potato vines were cut 30cm long with seven nodes. The vine cuttings were sown 30cm intra-row and 100cm inter-row on the crest of ridges, and 10cm below the soil surface, giving 36 plants per plot and 2880 plants in the entire experimental farm, equivalent to 55,555 plants per hectare. Planting was done on 14th June, 2013 and 14th June, 2014. Fertilizer (NPK: 15:15:15) was applied 400kg//ha 4 weeks after planting (WAP), immediately after first weeding (Nwankwo et al., 2012). Manual weeding was done two times by hand hoeing at 3 and 6 WAP.

Five plants per plot were randomly selected and tagged for data collection. Growth characters studied were vine length (cm), leaf area per plant (cm^2), number of leaves per plant and number of branches per plant. Data were taken at 3 weeks intervals for a maximum of 18 weeks after planting. Sweet potato tubers were harvested 18 weeks after planting and the following yield components such as tuber length (cm), circumference of tubers (cm) and fresh tuber yield (t/ha) were estimated. The number of marketable and non-marketable tubers per plot and number of holes and cracks were also recorded.Analysis of variance was conducted on all the characters and the means separated with the Duncan Multiple Range Test (DMRT) at 5% probability level. Pearson Product Moment Correlation analysis was conducted to determine character association among the sweet potato genotypes.

RESULTS

Significant differences ($p < 0.05$) were observed among the sweet potato genotypes for number of leaves per plant for all the months and years under study. The highest number of leaves per plant was produced by TIS8164, followed by TIS87/0087, UM/11/022 and TIS86/0356 in that order, while the lowest was found in Solo 2 (Table 1). Variability for number branches per plant ($p < 0.05$) was observed .CIP420068 produced the highest number of branches per plant, followed by EA/11/025, NRSP/12/060 and Butter milk in that order, while the lowest was observed with Solo 2 (Table 2). However, no significant differences were observed between CIP 420068 and EA/11/025 and between NRSP/12/060 and Butter milk for the character. The sweet potato genotypes showed significant differences

Table 1: Number of leaves per plant as influenced by sweet potato genotypes in Uyo, Nigeria

Sweet potato genotype	**WEEKS AFTER PLANTING**											
	3		6		9		12		15		18	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
NRSP/12/060	6.8^{ab}	7.1^{ab}	22.6^{c}	22.3^{c}	43.2^{d}	43.0^{d}	71.0^{d}	71.1^{d}	80.0^{c}	80.2^{c}	79.5^{d}	79.4^{d}
TIS 86/0356	8.0^{a}	8.3^{a}	36.3^{b}	36.6^{b}	68.0^{a}	67.3^{a}	80.9^{c}	81.2^{c}	96.6^{b}	96.3^{b}	86.0^{c}	85.3^{c}
UMUSPO/2	6.4^{b}	6.3^{b}	23.0^{c}	22.6^{c}	41.8^{d}	42.1^{d}	71.9^{d}	72.1^{d}	80.7^{c}	81.3^{c}	78.1^{d}	78.4^{d}
EA/11/025	3.7^{c}	3.9^{c}	19.2^{c}	18.7^{c}	34.6^{c}	33.1^{e}	64.0^{e}	63.1^{e}	70.8^{d}	71.0^{d}	65.1^{c}	65.3^{e}
TIS 8164	9.6^{a}	9.8^{a}	48.4^{a}	48.1^{a}	71.0^{a}	70.4^{a}	110.4^{a}	110.2^{a}	120.2^{a}	120.6^{a}	112.2^{a}	112.6^{a}
UM/11/015	5.6^{b}	5.3^{b}	22.2^{c}	21.1^{c}	33.6^{e}	33.6^{e}	59.0^{ef}	58.2^{ef}	62.2^{de}	62.7^{de}	79.0^{d}	78.4^{d}
Kwara	4.2^{c}	3.9^{c}	11.8^{d}	11.3^{d}	18.4^{g}	18.7^{g}	42.8^{a}	43.9^{g}	56.5^{e}	56.3^{e}	67.7^{e}	67.5^{e}
CIP 420068	5.0^{b}	5.7^{b}	18.7^{c}	18.3^{c}	31.8^{ef}	31.1^{ef}	55.0^{f}	54.0^{f}	66.7^{d}	66.3^{d}	75.6^{d}	75.3^{d}
TIS 87/0087	9.4^{a}	9.3^{a}	45.2^{ab}	44.5^{ab}	69.2^{a}	68.7^{a}	90.8^{b}	91.2^{b}	118.1^{a}	118.6^{a}	98.7^{b}	98.6^{b}
EA/11/022	8.6^{a}	8.8^{a}	40.7^{b}	40.1^{b}	61.7^{b}	60.1^{b}	83.0^{c}	82.2^{c}	99.4^{b}	99.9^{b}	83.3^{c}	83.6^{c}
Solo 2	4.1^{c}	3.9^{c}	10.2^{b}	10.5^{b}	29.2^{f}	28.6^{f}	40.9^{g}	41.0^{g}	52.2^{e}	52.6^{e}	60.6^{f}	60.8^{f}
UMUSPO/3	6.9^{b}	6.7^{b}	16.2^{cd}	16.5^{cd}	26.9^{f}	27.4^{f}	43.2^{g}	43.6^{g}	58.1^{c}	58.3^{c}	67.6^{e}	67.2^{e}
UM/11/022	9.6^{a}	9.0^{a}	42.0^{b}	41.3^{b}	58.2^{c}	57.8^{c}	92.4^{b}	92.6^{b}	116.2^{a}	116.3^{a}	98.1^{b}	98.3^{b}
UMUSPO/1	7.2^{ab}	7.2^{ab}	22.0^{c}	21.3^{c}	41.5^{d}	40.0^{d}	75.3^{d}	75.5^{d}	83.8^{c}	83.7^{c}	68.5^{e}	68.4^{e}
Butter milk	6.4^{b}	6.3^{b}	17.6^{c}	17.1^{c}	30.1^{f}	29.8^{f}	38.2^{g}	38.5^{g}	52.6^{e}	52.6^{e}	69.1^{e}	69.4^{e}

* Values with the same letter(s) are not significantly different ($p < 0.05$)

($p < 0.05$) for leaf area per plant and vine length throughout the period of study. The largest leaf area per plant was produced by TIS 87/0087, followed by TIS 8164, TIS 86/0356 and UM/11/022 in that order, while the smallest leaf area per plant was noticed for Solo 2 (Table 3). The longest vines were produced by UMUSPO/2, followed by EA//11//025, EA/11/022 and TIS 87/0087 in that order, while the shortest vines were given by UMUSPO/1. No significant difference was observed for vine length between UMUSPO/2 and EA/11/025 (Table 4).

The sweet potato genotypes were significantly different ($p < 0.05$) for all the yield and yield components, marketable and non-marketable tubers per plot and number of holes and cracks per tuber (Table 5). The largest number of marketable root tubers per plot was produced by UM/11/015, followed by TIS 87/0087, Solo 2 and EA/11/022 in that order, while UM/11/022 and UMUSPO/2 yielded the least numbers. The results showed that UM/11/015, TIS 87/0087 and Solo 2 were not significantly different ($p < 0.05$) in marketable root tubers per plot. Similarly, the highest non-marketable tubers were produced by TIS 86/0356, followed by TIS 87/0087, TIS 8164 and UMUSPO/1 in that order, while the lowest non-marketable tubers were recorded for Solo 2. However, no significant differences for non-marketable tubers per plot were observed among the genotypes TIS 86/0356, TIS 87/0087, TIS 8164 and UMUSPO/1 even though their means differed. The longest tubers were produced by Solo 2, followed by EA/11/22, UM/11/022 and UM/11/015 in that order, while the shortest tubers were given by TIS 8164. Significant differences ($p< 0.05$) were not observed on tuber length among Solo 2, EA/11/022 and UM/11/022. The largest circumference of tubers was produced by UM/11/015 followed by Solo 2, NRSP/12/060 and TIS 87/0087, while the smallest tubers were produced by TIS 86/0356. However, no significant difference was observed for tuber circumference between Solo 2 and NRSP/12/060.The genotype UM/11/015 was identified with the highest fresh tuber yield of 22.7t/ha, followed by TIS 87/0087 (21.7t/ha), Solo 2 (20.6t/ha) and TIS 8164 (20.3t/ha), while the lowest fresh tuber yield of 8.6t/ha was produced by

Table 2: Number of Branches per plant as influenced by sweet potato genotypes in Uyo, Nigeria

Sweet potato genotype	**WEEKS AFTER PLANTING**											
	3		6		9		12		15		18	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
NRSP/12/060	1.2^{c}	1.2^{c}	3.6^{bc}	3.6^{bc}	8.9^{b}	8.9^{b}	14.8^{ab}	14.9^{ab}	18.2^{c}	18.1^{c}	21.6^{b}	21.5^{b}
TIS 86/0356	0.8^{e}	0.6^{e}	1.7^{d}	1.8^{d}	4.6^{de}	4.5^{de}	7.6^{c}	7.6^{c}	10.6^{d}	10.7^{d}	12.3^{cd}	12.3^{cd}
UMUSPO/2	0.0^{f}	0.0^{f}	0.0^{f}	0.0^{f}	2.6^{e}	2.5^{e}	6.3^{cd}	6.2^{cd}	8.2^{d}	8.2^{d}	11.3^{d}	11.2^{d}
EA/11/025	1.7^{b}	1.7^{b}	5.8^{b}	5.6^{b}	10.4^{b}	10.5^{b}	17.4^{a}	17.4^{a}	21.5^{a}	21.6^{a}	26.2^{a}	26.1^{a}
TIS 8164	0.8^{e}	0.9^{e}	2.4^{c}	2.3^{c}	6.2^{cd}	6.3^{cd}	8.6^{c}	8.6^{c}	11.4^{d}	11.3^{d}	13.6^{c}	13.7^{c}
UM/11/015	0.0^{f}	0.0^{f}	0.0^{f}	0.0^{f}	4.3^{de}	4.3^{de}	7.5^{c}	7.4^{c}	9.8^{d}	9.8^{d}	11.5^{d}	11.6^{d}
Kwara	0.0^{f}	0.0^{f}	0.0^{f}	0.0^{f}	4.5^{de}	4.5^{de}	6.6^{cd}	6.5^{cd}	8.0^{d}	8.1^{d}	9.8^{d}	9.7^{d}
CIP 420068	2.0^{a}	2.1^{a}	8.6^{a}	8.3^{a}	15.2^{a}	15.3^{a}	18.3^{a}	18.4^{a}	24.4^{a}	24.3^{a}	29.6^{a}	29.6^{a}
TIS 87/0087	0.8^{e}	0.8^{e}	2.6^{c}	2.5^{c}	6.4^{cd}	6.3^{cd}	8.3^{c}	8.3^{c}	13.2^{cd}	13.1^{cd}	16.6^{c}	16.7^{c}
EA/11/022	0.0^{f}	0.0^{f}	0.3^{e}	0.1^{e}	2.7^{e}	2.6^{e}	4.6^{d}	4.6^{d}	8.6^{d}	8.7^{d}	11.3^{d}	11.2^{d}
Solo 2	0.0^{f}	0.0^{f}	0.0^{f}	0.0^{f}	0.3^{g}	0.3^{g}	1.3^{e}	1.3^{e}	3.2^{f}	3.1^{f}	6.2^{e}	6.2^{e}
UMUSPO/3	0.0^{f}	0.0^{f}	0.2^{e}	0.3^{e}	3.0^{e}	3.2^{e}	4.1^{d}	5.1^{d}	5.8^{e}	6.3^{e}	7.4^{e}	9.8d^{e}
UM/11/022	0.0^{f}	0.0^{f}	0.6^{e}	0.7e	1.3^{f}	1.2^{f}	3.8^{e}	3.7^{e}	7.3^{e}	7.3^{e}	9.6^{de}	9.5^{de}
UMUSPO/1	0.0^{f}	0.0^{f}	1.2^{d}	1.2^{d}	4.2^{de}	4.2^{de}	8.6^{c}	8.5^{c}	15.6^{c}	15.6^{c}	18.3^{bc}	18.4^{bc}
Butter milk	0.0^{f}	0.0^{f}	0.5^{e}	0.6^{e}	7.5^{bc}	7.6^{bc}	13.3^{b}	13.4^{b}	17.7^{c}	17.6^{c}	20.5^{b}	20.6^{b}

* Values with the same letter(s) are not significantly different ($p < 0.05$)

UM/11/022.

However, significant differences were not observed among the genotypes UM/11//095, TIS 87/0087, Solo 2 and TIS 8164 for fresh tuber yield (t/ha). The results further showed that the four genotypes, EA/11/025, CIP 420068, UMUSPO/3 and Butter milk were generally vegetative and unproductive types throughout the period of study (Table 5). Six sweet potato genotypes that produced tuber yields higher than the world average of 15.9t/ha include,UM/11/015(22.7t/ha), TIS 87/0087(21.7t/ha), Solo 2(20.6t/ha), TIS 8164(20.3t/ha), EA/11/022(16.8t/ha) and NRSP/12/060, (16.4t/ha).

Relation between yield and some yield related characters were observed among the genotypes tested. Accordingly, high yield showed a positive and significant association ($p< 0.01$) for tuber length, circumference of tubers, number of marketable and non-marketable tubers per plot and number of cracks per tuber. However, number of branches per plant, and vine length were negatively correlated with fresh tuber yield in sweet potato. Similarly, no correlation was evident between fresh tuber yield, top growth, number of leaves per plant, number of holes per tuber and leaf area per plant. Also, there was correlation between number of cracks per tuber and number of holes per tuber in the study. (Table 6)

DISCUSSION

Significant differences ($p < 0.05$) in morphological characters and yield were observed among the 15 sweet potato genotypes.UM/11/015 was superior over all the other sweet potato genotypes, including the two national checks (TIS 87/0087 and TIS 8164) in three important characters, namely, circumference of tubers, fresh tuber yield (t/ha) and number of marketable tubers, followed by Solo 2 in two characters, tuber length, and non-marketable

Table 3: Leaf Area Per Plant as influenced by Sweet Potato genotypes in Uyo, Nigeria

Sweet potato genotypes	**WEEKS AFTER PLANTING**											
	3		6		9		12		15		18	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
NRSP/12/060	465.0^{d}	464.2^{d}	1498.2^{e}	1496.7^{e}	2995.9^{d}	2997.1^{d}	5025.8^{f}	5026.7^{f}	5133.9^{e}	5133.6^{e}	4614.1^{e}	4613.9^{e}
TIS 86/0356	436.1^{e}	435.7^{e}	2512.8^{b}	2514.4^{b}	4796.8^{a}	4798.4^{a}	5902.4^{c}	5901.6^{c}	6434.3^{c}	6433.8^{c}	5337.2^{c}	5336.3^{c}
UMUSPO/2	537.2^{a}	538.0^{a}	1516.9^{e}	1516.6^{e}	2936.7^{d}	2936.4^{d}	5103.7^{e}	5104.6^{e}	5156.2^{e}	5154.4^{e}	4556.9^{f}	4556.6^{f}
EA/11/025	256.9^{h}	257.0^{h}	1328.8^{f}	1329.1^{c}	2396.9^{f}	2396.4^{f}	4646.9^{h}	4647.9^{h}	5048.7^{f}	5049.5^{f}	4410.8^{g}	4411.0^{g}
TIS 8164	495.2^{c}	494.0^{c}	2438.3^{bc}	2438.6^{bc}	3881.0^{bc}	3880.4^{bc}	6365.7^{b}	6366.2^{b}	6728.6^{b}	6729.4^{b}	6034.9^{b}	6035.3^{b}
UM/11/015	237.4^{i}	236.3^{i}	1195.7^{g}	1196.3^{g}	1961.4^{g}	1960.8^{g}	3558.2^{j}	3558.3^{j}	3775.1^{h}	3774.5^{h}	4605.9^{e}	4606.0^{e}
Kwara	153.6^{i}	153.2^{j}	478.4^{k}	477.9^{k}	1550.8^{j}	1551.6^{j}	2159.6^{m}	2159.0^{m}	2640.1^{k}	2639.3^{k}	2930.6^{l}	2930.1^{l}
CIP 420068	230.5^{ai}	230.5^{i}	879.8^{ij}	880.4^{ij}	1546.2^{j}	1545.6^{j}	2764.8^{k}	2765.8^{k}	3392.2^{i}	3391.9^{i}	3718.9^{i}	3719.8^{i}
TIS 87/0087	528.4^{b}	528.4^{b}	2997.9^{a}	2999.7^{a}	4715.8^{b}	4716.9^{b}	6443.9^{a}	6444.1^{a}	7769.7^{a}	7769.4^{a}	6139.6^{a}	6139.1^{a}
EA/11/022	494.1^{c}	493.3^{c}	2374.0^{c}	2373.7^{c}	3742.2^{c}	3741.2^{c}	5404.0^{d}	5404.6^{d}	6353.2^{d}	6353.6^{d}	5109.8d^{e}	5109.6^{de}
Solo 2	132.7^{aj}	133.3^{j}	394.2^{k}	393.7^{k}	1161.2^{i}	1160.0^{i}	1892.2^{n}	1891.3^{n}	2382.2^{i}	2382.7^{l}	2598.7^{m}	2598.5^{m}
UMUSPO/3	258.2^{h}	257.2^{h}	686.0^{j}	685.5^{j}	1214.6^{k}	1213.2^{k}	2267.2^{lm}	2266.7^{lm}	3070.1^{i}	3070.6^{i}	3408.9^{k}	3408.3^{k}
UM/11/022	363.6^{f}	363.5^{f}	1812.6^{d}	1813.4^{d}	2607.1^{e}	2607.3^{e}	4870.4^{g}	4870.7^{g}	6335.8^{j}	6336.0^{j}	5182.8^{d}	5182.3^{d}
UMUSPO/1	288.9^{g}	283.6^{g}	916.2^{i}	915.0^{i}	1736.7^{h}	1736.0^{h}	3707.4^{i}	3708.5^{i}	4365.9^{g}	4366.6^{g}	3528.9^{j}	3529.7^{j}
Butter milk	360.1^{f}	360.4^{f}	1017.9^{h}	1018.4^{h}	1643.^{gi}	1643.4^{i}	2294.4^{i}	2294.6^{l}	3094.1^{j}	3093.4^{j}	3951.8^{h}	3951.6^{h}

* Values with the same letter(s) are not significantly different ($p < 0.05$)

tubers. Similarly, TIS 87/0087 was superior over other genotypes, except UM/11/015 for number of marketable tubers per plot and fresh tuber yield (t/ha). In terms of fresh tuber yield (t/ha) and number of marketable tubers, UM/11/015 ranked first, followed by TIS 87/0087 and Solo 2, in that order.

The results showed that the top yielding sweet potato genotypes were more vulnerable to root cracks and holes in the field and there was association between number of holes per tuber and number of cracks per tuber suggesting breeding for horizontal resistance in sweet potato. Differences in fresh tuber yield due to genetic constitution among sweet potato genotypes have been reported (Nechunchezhiyan et al., 2007). Based on these unique attributes, UM/11/015, TIS 87/0087 and Solo 2 could be recommended for cultivation in Uyo agro-ecology. According to Alam et al., (1998), only genotype(s) with superior yields in relation to local or natural checks in a tested environment over time should be selected for a given environment. For advancement to pre-release trials, only UM/11/015 and Solo 2 satisfied the selection criteria of securing higher yields. Rees et al. (2001) considered a variety or genotype having early bulking and maturing when it is capable of producing reasonable yield in tested environment(s). Ragassa et al. (2015) suggested improvement of sweet potato genotypes by crossing with superior ones in a given environment. Genotypes with tuber yields below 20t/ha could be crossed with the top yielders.

Four genotypes: EA/11/025, CIP 420068, UMUSPO/3 and Butter milk were generally vegetative and unproductive types and none of

Table 4: Vine Length (cm) as influenced by sweet potato genotypes in Uyo, Nigeria

Sweet potato genotype	WEEKS AFTER PLANTING											
	3		6		9		12		15		18	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
NRSP/12/060	38.2^{d}	38.7^{de}	143.9^{d}	144.7^{d}	253.8^{c}	253.6^{c}	319.0^{c}	319.3^{c}	388.9^{c}	389.6^{c}	399.0^{b}	399.5^{b}
TIS 86/0356	34.0^{e}	33.7^{de}	79.8^{g}	80.9^{g}	161.0^{ef}	160.2^{ef}	214.6^{d}	214.0^{d}	273.8^{e}	273.0^{e}	281.6^{c}	218.3^{c}
UMUSPO/2	36.9^{de}	36.7^{c}	144.2^{d}	143.4^{d}	218.6^{d}	219.0^{d}	382.4^{b}	382.8^{b}	469.2^{a}	469.6^{a}	472.6^{a}	472.3^{a}
EA/11/025	64.4^{b}	64.6^{b}	171.8^{e}	172.6^{e}	259.2^{c}	258.8^{c}	405.8^{a}	405.2^{a}	445.9^{ab}	444.6^{ab}	451.2^{a}	451.6^{a}
TIS 8164	27.9^{t}	27.7^{f}	97.1^{b}	96.4^{fg}	148.0^{f}	147.6^{f}	185.2^{e}	185.7^{e}	202.9^{f}	202.7^{f}	219.3^{e}	219.5^{e}
UM/11/015	27.0^{t}	27.2^{f}	92.8^{f}	92.6^{f}	172.8^{e}	173.5^{e}	205.3^{d}	205.7^{d}	230.2^{e}	230.6^{e}	238.2^{d}	238.6^{d}
Kwara	26.8^{e}	26.9^{e}	81.9^{g}	81.7^{g}	151.6^{f}	151.2^{f}	213.8^{d}	213.3^{d}	244.3^{e}	244.6^{e}	258.2^{d}	258.7^{d}
CIP 420068	35.8^{de}	36.0^{de}	164.2^{c}	163.5^{c}	255.3^{c}	255.8^{c}	329.6^{c}	329.1^{c}	350.0^{d}	350.1^{d}	366.4^{c}	366.8^{c}
TIS 87/0087	72.8^{a}	72.4^{a}	207.8^{b}	207.6^{b}	320.2^{a}	320.6^{a}	381.4^{b}	381.1^{b}	399.2^{c}	399.5^{c}	416.7^{b}	416.3^{b}
EA/11/022	73.6^{a}	73.7^{a}	163.1^{c}	163.4^{c}	321.1^{a}	321.3^{a}	416.8^{a}	417.1^{a}	425.8^{b}	425.3^{b}	438.9^{ab}	438.3^{ab}
Solo 2	39.6^{d}	39.2^{d}	147.2^{d}	147.7^{d}	213.2^{d}	213.6^{d}	335.0^{c}	335.3^{c}	391.8^{c}	391.6^{c}	412.8^{b}	412.4^{b}
UMUSPO/3	24.8^{g}	24.6^{g}	60.2^{i}	60.5^{i}	107.4^{g}	107.1^{g}	298.1^{c}	298.4^{c}	354.6^{d}	354.3^{d}	319.2^{d}	319.7^{d}
UM/11/022	69.1^{ab}	69.4^{ab}	232.3^{a}	232.7^{a}	273.6^{b}	272.3^{b}	300.0^{c}	300.3^{c}	390.1^{c}	390.4^{c}	415.6^{b}	415.2^{b}
UMUSPO/1	20.2^{h}	20.5^{h}	70.1^{h}	70.5^{h}	104.0^{g}	103.7^{g}	144.6^{f}	144.4^{f}	174.0^{g}	174.3^{g}	188.4^{f}	188.6^{f}
Butter milk	55.7^{c}	55.5^{c}	157.1^{c}	157.3^{c}	292.4^{b}	292.7^{b}	311.2^{c}	311.7^{c}	389.2^{c}	389.6^{c}	393.7^{f}	393.2^{b}

* Values with the same letter(s) are not significantly different ($p < 0.05$)

them produced fresh tubers at 18 months after planting. Rees et al. (2001) suggested that late maturers cannot fit into cropping systems and therefore should be eliminated from sweet potato list for the environment and advancement to the next selection trials. However, Kathabwalika et al., (2013) suggested cultivation of the genotypes as forage for ruminants. It was however surprising that TIS 86/0356 which produced the highest fresh tuber yield over TIS 87/0087 in Owerri (Okorie et al., 2012) was rated 7th yield producer in Uyo, indicating a possible environmental effect on genotypes. Correlation analysis indicated association between fresh tuber yield and four characters, namely: tuber length, circumference of tubers, number of marketable and non-marketable tubers and suggests that improvement of those characters will simultaneously result in the improvement fresh tuber yield in sweet potato. The result agrees with Alam et al. (1998) that fresh tuber yield correlates with tuber width, tubers per plant and fresh tuber weight in sweet potato.

CONCLUSION

Three genotypes, UM/11/015, TIS 87/0087 and Solo 2 which produced highest yields, with no significant differences among them could be recommended for cultivation in Uyo environment. Since TIS 87/0087 is a variety and national check, UM/11/015 and Solo 2 could be advanced to the pre-release trials in the agro-ecology. The four genotypes, which were highly vegetative and unproductive, (EA/11/025, CIP 420068,

Table 5: Tuber Length (cm) per plant, Circumference of Tubers (cm), Number of Marketable tubers per plot, Numberof nonmarketable tubers per plot, Fresh Tuber Yield (t/ha), Weight of Top Growth (kg) and Number of Cracks and Holes per tuber in Uyo, Nigeria

Sweet potato genotype	Tuber (cm)	Length	Circumference of Tubers (cm)		No. of marketable tubers per plot		No. of non-marketable tubers/plot		Fresh tuber yield (t/ha)		Weight of Top Growth (kg)		Number of cracks per tuber		Number of holes per tuber	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
NRSP/12/060	16.2b	16.1b	22.3ab	22.3ab	15.0c	15.0c	12.0c	12.0c	16.4b	16.3b	3.90b	3.88b	2.56c	2.52c	0.00e	0.00e
TIS 86/0356	15.5b	15.6b	17.3	17.2c	14.7cd	14.6cd	16.4a	16.3a	15.8b	15.9b	3.80b	3.83b	0.00f	0.00f	1.30c	1.30c
UMUSPO/2	16.7b	16.6b	21.5b	21.6b	13.6d	13.6d	12.6b	12.6b	15.0b	15.1b	3.60b	3.56b	3.91b	3.93b	0.10d	0.12d
EA/11/025	X	X	X	X	X	X	X	X	X	X	1.33c	1.32c	X	X	X	X
TIS 8164	11.0c	11.1c	18.3c	18.2c	18.4bc	18.3bc	15.5a	15.4a	20.3a	20.1a	3.70b	3.71b	2.31c	2.30c	4.34a	4.66a
UM/11/015	16.9b	16.8b	26.1a	26.0a	24.6a	24.6a	12.1c	12.0c	22.7a	22.6a	4.20b	4.18b	3.48b	3.50b	2.33b	2.30b
Kwara	12.1c	12.1c	19.0bc	19.1bc	16.1c	16.0c	13.0b	13.0b	10.8	10.9c	3.75b	3.76b	0.14e	0.16e	0.53d	0.51d
CIP 420068	X	X	X	X	X	X	X	X	X	X	5.33ab	5.30ab	X	X	X	X
TIS 87/0087	14.8b	14.7b	21.7b	21.6b	24.1a	24.0a	16.0a	16.0a	21.5a	21.7a	3.11b	3.12b	4.14b	4.12b	2.81b	2.76b
EA/11/022	19.0a	19.1a	21.0b	20.9b	20.0b	20.1b	13.4b	13.3b	16.8b	16.7b	7.06a	7.04a	0.38e	0.36e	0.00e	0.00e
Solo 2	20.7a	20.7a	22.9ab	22.9ab	23.6a	23.6a	11.6c	11.6c	20.6a	20.6a	5.90a	5.92a	2.26c	2.24c	2.32b	2.30b
UMUSPO/3	X	X	X	X	X	X	X	X	X	X	1.10c	1.11c	X	X	X	X
UM/11/022	18.2a	18.3a	21.0b	21.1b	13.6d	13.4d	12.3bc	12.3bc	8.6d	8.6d	3.30b	3.31b	1.45d	1.48d	0.00e	0.00e
UMUSPO/1	15.9b	15.9b	20.9b	20.9b	20.1b	20.0b	15.3a	15.3a	11.2c	11.2c	4.61b	4.60b	5.33a	5.32a	4.15a	4.11a
Butter milk	X	X	X	X	X	X	X	X	X	X	7.20a	7.22a	X	X	X	X

* Values with the same letter(s) are not significantly different ($p < 0.05$)

Table 6: Correlation of growth characters, yield and yield components and root tuber cracks and holes in sweet potato

	NOBPP	LAPP	VL	NOLPP	TL	COT	NOMTPP	NONMTPP	FTY	NOCPR	NOHPR	WTG
NOBPP	1	.										
LAPP	.069	1										
VL	.144	.090	1									
NOLPP	-.096	.887**	-.103	1								
TL	-.560*	.219	-.031	.290	1							
COT	-.521*	.270	-.164	.361	.966**	1						
NOMTPP	-.504	.261	-.253	.347	.901**	.946**	1					
NONMTPP	-.472	.422	-.295	.514*	.886**	.921**	.900**	1				
FTY	-.470	.402	-.162	.448	.849**	.907**	.940**	.867**	1			
NOCPR	-.133	.090	-.246	.091	.436	.539*	.580*	.477	.555*	1		
NOHPR	-.183	-.019	-.456	.144	.302	.376	.571*	.397	.499	.612*	1	
WTG	.046	-.146	.073	-.096	.237	.158	.210	.100	.164	-.094	.207	1

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).
Number of branches per plant (NOBPP), Leaf area per plant (LAPP), Vine length (VL), Number of leaves per plant (NOLPP), Tuber length (TL), Circumference of tubers (COT), Number of marketable tubers per plot (NOMTPP), Number of non-marketable tubers per plot (NONMTP P), Fresh tuber yield (FTY), Number of cracks per root tuber (NOCPR), Number of holes per root tuber (NOHPR) and Weight of top growth (WTG).

UMUSPO/3 and Butter milk could be eliminated from sweet potato list of the environment. However, the high susceptibility to tuber cracks and holes among the high yielding genotypes suggest breeding for horizontal resistance by crossing them with the resistant ones. Sweet potato genotypes with yields below 20t/ha especially those resistant to cracks and holes could be crossed with UM/11/015, Solo 2 and TIS 87/0087 to improve their productive capacities for the environment. Breeding strategies for characters that correlate with fresh tuber yield, would improve yield in sweet potato.

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