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Morphological Characterization and Yield Evaluation of Sweetpotato Landraces for Genetic Recombination

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An investigation was initiated to evaluate the diversity that exists in sweetpotato landraces with the following objectives:, to identify parents that flowers profusely and are resistant to pests and diseases of ecological origin, to select landraces in terms of high root yield, processing quality and to build up reserve of breeding materials of native species that have nutritional and industrial potential for crop improvement program. The varieties used for the investigation were 15 Landraces collected within Abia State, Nigeria plus three collected outside Abia State (Kwara from Kwara state, Ex-Igbariam from Anambra State and Buttermilk from Nassarawa State). The national standard Check variety TIS87/0087 and orange fleshed variety UMUSPO/3 were used as reference varieties. Each accession was planted in a 3x3m plot at a planting distance of 1.0m x 0.3m. The Experimental Design was randomized Complete Block Design. Each block contained 18 plots. Replicated 3 times, plot size was 9m2 and separated from each other by a space of 1m. The planting material was 30cm long. Data were collected based on: total storage root yield, large storage root yield, small storage root yield, Total number of roots, Number of large roots and Number of small roots, root flesh color and other root characteristics, pests and diseases severity score and flowering habit. Data collected on root weight and root number were subjected to Analysis of variance and Means separation was done using standard Error of means, above ground morphological characteristics were described using the sweetpotato descriptor manual. List of morphological characteristics and character states were based on sweetpotato descriptor manual code character, while morphological character analysis was based on the mathematics of information theory which allows simultaneous analysis of both quantitative and qualitative data. The result indicated that all accessions collected from Abia State were similar in morphological traits with TIS87/0087 and were duplicates of TIS87/0087. They are the same and one accession. The three accessions Kwara, Buttermilk and Ex-Igbariam from Kwara State, Nasarawa States and Anambra State were high yielding. Kwara with 29.8t/ha, Buttermilk with 19.6t/ha and Ex-Igbariam with 16.9t/ha of large roots respectively. The flesh color of Kwara is intermediate orange and flowers profusely, Buttermilk with cream flesh does not flower at all while Ex-Igbariam with yellow flesh color flowers profusely. These accessions after adaptive studies could be registered for release to farmers in the other parts the country and could be included in the germplasm for yield improvement. They have good shape easy for processing, resistant to major field pests and diseases of sweetpoato.

Keywords: Sweetpotato, landraces, profuse flowering, morphological, characterization, genetic recombination.

INTRODUCTION

Landraces can make a significant contribution to the diet of the people or as varieties in the farming system of the people or as progenitors in a breeding program for the farmer preferred traits (Human and Asmat, 1999). In sweetpotato growing States in Nigeria, sweetpotato farmers depend on the landraces for survival. Sweetpotato is an important security food for poor resource farmers. It is planted and harvested piecemeal for home consumption and as such regarded as security crop. The maturity period is between four and five months when compared with cassava, yam and cocoyam which take 8 to 12 months to mature. Sweetpotato can be boiled and eaten in some cases without salt or even eaten with

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sauce. It could be fried, boiled and pounded into fufu or ground together with or without cassava and toasted into garri. With the commercial value addition of sweetpotato, the roots could be used for bread making, biscuits, processed into starch, doughnuts, chinchin and other food products (Islam *et al.,* 2002). This makes the crop an important crop. In sweetpotato growing states, the crop has been used for income generation and for home consumption. As a result, many indigenous landraces exists (IBPGR, 1999). Landraces are adapted to their local areas and have developed resistance to local pests and diseases. Landraces gained recognition from farmers as a result of their good qualities as such could be used for genetic recombination (Wolfang *et al.,* 2008). It is based on this reason that some States in Nigeria such as Benue and Ebonyi States had been explored and found to grow a wide range of sweetpotato varieties which have been clonally selected by farmers from different sources such as the introduction or by chance seedlings. The landraces from these two States had been collected and characterized (Nwankwo, 2013). *Kapinga et al.,* (1995) noted that some of these landraces have superior agronomic characteristics which could qualify them for official recommendation and release as varieties. Mills *et al.,* (2009) reported that the landraces also contain valuable sources of resistance to important diseases and pests, capable of adapting to environments where the sweetpotato is grown, and desirable characteristics such as high dry matter content which is associated with culinary qualities preferred by consumers. Kays (1985) also pointed out that landraces could be a source of resistance or immunity to sweetpotato virus disease (SPVD) which is caused by a sweetpotato feathery mottle virus (SPFMV) and sweetpotato chlorotic stunt virus (SPCSV) that has been a hindrance to sweetpotato cultivation and improvement. The sweetpotato breeding program can be described as a multistage process with a continuous flow of germplasm from both national and international landraces, introductions of clones from various breeding programs across the globe and local breeding lines (Pandey *et al.,* 1986).

Low *et al.,* (2006) observed that gene pools are improved by hybridization and selection, and their best fractions are further advanced to form populations. The superior families from each germplasm pool or population are combined to form high yielding experimental varieties. Multi-location trials play an important role in the sweetpotato development program. Superior varieties are selected for two main purposes merely to use within the sweetpotato breeding program and to distribution of national programs for eventual use by farmers (Rees *et al.,* 2003). According to Odedode, 2004) a vital goal in breeding and agronomic research is to provide reliable guidance for selecting the best genotypes for planting in future years and at new sites. This will enable the prediction of yield as precisely as possible based on limited experimental data (Ludvik *et al.,* 2002). The investigation was initiated to evaluate the diversity that exists in sweetpotato landraces and to conserve them for future usage, to identify parents that flowers and are resistant to pests and diseases of ecological origin, to select landraces in terms of high large tuberous root yield for commercial purposes and processing quality. To finally build up a reserve of breeding materials of native species that has nutritional and industrial potential for crop improvement program.

MATERIALS AND METHODS

The varieties used were 15 Landraces collected within Abia State plus three collected outside Abia State (Kwara from Kwara state, Ex-Igbariam from Anambra State and Buttermilk from Nassarawa State). Abia State is divided into three Agricultural zones| Abia North, Abia Central and Abia South.

Accession collection

Eighteen accessions were collected by farmers in those agricultural zones. Farmers were at the collection sites instructed to write the local name for the accessions or the curators' name. The accessions were established and multiplied in the nursery.

Accession evaluation

Field experiments of the accessions were conducted in 2013 and 2014 all in the Eastern experimental field of National Root Crops Research Institute, Umudike. The soils at the site of the evaluation were well drained deep ultisoil with a mean annual rainfall of 1500mm and mean sunshine of 4.5 hours per day. The first and second trial of the accessions involved screening the accessions for yield and diseases such as SPVD and fungus disease like Leaf spots. In the second trial of the accessions, morphological characterization of the accessions was included. The national standard Check variety TIS87/0087 and orange fleshed variety UMUSPO/3 were used as reference varieties. Each accession was planted in a 3x3m plot at a planting distance of 1.0m x 0.3m. The Experimental Design was randomized Complete Block Design. Each block contained 18 plots, replicated 3 times. Plot size was 9m2 and separated from each other by a space of 1m. The planting material was 30cm long. Vine cuttings from a symptomless terminal portion of mother vines were planted on ridges with two thirds of the cuttings stick into the soil. A virus susceptible variety UMUSPO/3 was included in the trial as a check and a source of inoculum. However, healthy planting material of all the clones except the spreader susceptible variety was used for planting the trial. Virus symptoms on the above ground vegetative growth were scored at 2 and 4 months after planting, and root weevil was scored at harvest on a scale of 1 to 5. Where 1= no symptoms, 2= symptom mild, 3=symptom moderate, 4= symptom severe and 5= symptom very severe. The experimental field was manually kept weed-free until harvested 120 days after planting. Fertilizer was NPK 15:15:15 using side application. Data were collected based on: total storage root yield, large storage root yield, small storage root yield, Total number of roots, Number of large roots and Number of small roots, root flesh color and other root characteristics, pests and diseases severity score. Data collected were subjected to Analysis of variance and Means separation was done using standard Error of means. At harvest fresh storage root weight was measured in kilogram and converted to tonnes per hectare, the number of storage root per plant per hectare, root dry matter yield, root skin color, flesh color were compared using a color chart, the above ground morphological characteristics were described using the sweetpotato descriptor manual. List of morphological characteristics and character states were based on sweetpotato descriptor manual code character, while morphological character analysis was based on the mathematics of information theory which allows simultaneous analysis of both quantitative and qualitative data (Nwankwo, 2013). This method simultaneously group vegetative traits that have corresponding biological similarity together in the ranks. Any character or state that is not in alliance with the column character is discriminatory. At a glance at the table duplicate accessions can easily be detected out.

RESULTS AND DISCUSSION

The result of the number of roots and weight of the root yields are presented in Table 1.

Table 1: Combined mean Total number, saleable roots and Total weight of total roots and saleable roots of the accessions in 2013 and 2014

Accession name	Total number of roots (t/ha)	Number of large roots (t/ha)	large number of roots	% number of small roots	Total root weight (t/ha)	Weight of large roots (t/ha)	% weight of large roots
Okorie, A	47.0	28.7	61.0	39.0	14.0	8.6	61.4
Chidi, C	92.3	59.3	64.2	35.8	17.0	11.8	69.4
Edozie, E	45.0	30.7	68.2	31.8	15.8	12.0	75.9
Madu, O	44.0	28.3	64.3	35.7	15.7	12.0	76.4
Okeiyi, A	59.7	39.3	65.8	34.2	11.3	8.5	75.2
Nwakanma, T	48.0	34.0	70.8	29.2	16.2	8.2	24.4
Johnny, J	43.0	36.0	83.7	16.3	17.1	11.2	65.4
Sussan, O	35.0	30.0	85.7	14.3	16.3	9.0	55.2
Uzondu, A	46.0	37.0	80.4	19.6	18.2	12.3	67.6
Oluchi, F	36.0	28.0	77.7	22.3	19.1	13.3	69.6
Udokanma, K	45.0	40.0	81.8	11.2	17.2	13.6	79.1
Nwagbara, N	47.0	39.0	83.0	17.0	16.8	11.0	65.5
Nnabuihe, N	50.0	42.0	84.0	16.0	18.4	12.7	69.0
Kwara	72.0	65.0	90.2	9.8	35.7	29.8	83.5
Buttermilk	57.0	52.0	87.7	12.3	23.6	19.6	83.1
Ex-igbariam	33.0	27.0	81.8	18.2	18.8	16.7	88.8
UMUSPO/3	11.3	6.7	59.2	40.8	1.1	0.9	81.8
TIS87/0087	60.3	38.0	63.0	37.0	17.9	13.9	77.6
Sig. level	P<0.05	P<0.05		==	P<0.05	P<0.05	==

Table 2: Foliar morphological characterization of 18 sweetpotato accessions collected from Abia State and other states

Accession name	Plant type	Predominant vine colour	Secondary vine colour	Vine tip pubsence	Mature leaf shape	Leaf lobe type	Leaf lobe number	Shape of central leaf lobe	Mature leaf colour	Immature leaf colour	Flower habit
Okorie, A	7	1	0	0	4	0	1	2	2	2	3
Chidi, C	7	1	0	0	4	0	1	2	2	2	3
Edozie, E	7	1	0	0	4	0	1	2	2	2	3
Madu, O	7	1	0	0	4	0	1	2	2	2	3
Okeiyi, A	7	1	0	0	4	0	1	2	2	2	3
Nwakanma, T	7	1	0	0	4	0	1	2	2	2	3
Johnny, J	7	1	0	0	4	0	1	2	2	2	3
Sussan, O	7	1	0	0	4	0	1	2	2	2	3
Uzondu, A	7	1	0	0	4	0	1	2	2	2	3
Oluchi, F	7	1	0	0	4	0	1	2	2	2	3
Udokanma, K	7	1	0	0	4	0	1	2	2	2	3
Nwagbara, N	7	1	0	0	4	0	1	2	2	2	3
Nnabuihe, N	7	1	0	0	4	0	1	2	2	2	3
Buttermilk	7	1	0	0	4	0	1	1	2	8	5
Ex-igbariam	9	1	5	5	4	0	1	1	2	5	3
Kwara	5	1	4	3	6	7	5	5	2	8	3
UMUSPO/3	7	6	4	0	4	0	1	2	3	3	3
TIS87/0087	7	1	0	0	4	0	1	2	2	2	3

Note: *Foliar morphological characterization of 18 sweetpotato accessions*

Plant type 7= semi-erect, 9- extremely spreading,
Predominant vine colour 1=green, 6= purple, **Secondary vine colour** 0= no additional colour., 4= mainly purple, 5= mix green and purple, **Vine tip pubsence**, 0= no Vine tip pubsence, **Mature leaf shape**, 4 = entire, **Leaf lobe type**, 0 =entire ie not divide, 7= divided, **Leaf lobe number**, 1= not divided, 5= divided, **Mature leaf colour**, 2 = green, **Immature leaf colour** 2=green, 8= purple, 3= purple under surface, 5= green purple at the edge. **flower habit** 3= flowers. 5= non flowering.

Number of roots

The results indicated significant (P<0.05) variation in the number of roots produced by the accessions. Total number of roots ranged from 11.3 (UMUSPO/3) to 92.3 numbers of tuberous roots (Chidi.C), while the number of large tuberous roots ranged from 6.7 (UMUSPO/3) to 39.3 (Chidi.C). However, the percentage large number of tuberous roots indicated that Kwara had the highest percentage (92.2%) of large roots when compared with the reference materials (TIS87/0087) and UMUSPO/3 which had 63.0% and 59.2% respectively. This was followed by the accession Buttermilk with 87.7% of large tuberous roots. The two accessions had low percentage of small roots (11.2% and 9.8%, respectively), which indicated that they are adaptable to the soils of Umudike, Southeastern Nigeria. Farmers are more interested in the number of roots per stand and per plot than in the weight of roots and a high percentage number of large roots will be appreciated since it will command higher market price and ease for food processing. Accessions with a high percentage number of large roots is an indication that the accession adapted well to the soil of that locality.

Fresh root weight

Significant (P<0.05) variability existed in the fresh root weight of the accessions. Total fresh root weight ranged from 1.1t/ha (UMUSPO/3) to as high as 35.7t/ha (Kwara). This was followed by Buttermilk which gave 23.6t/ha of fresh root weight. The weight of large root ranged from 0.9t/ha of fresh weight from UMUSPO/3 to 29.8t/ha fresh root weight from Kwara and 19.6t/ha from Buttermilk. Fresh weight is the weight of starch or carbohydrate together with water content. Large roots are the marketable roots. Its fresh root weight contributes to the sale of the roots when the weight is measured in scales as in advance countries or in Supermarkets. The farmer is not only interested for his own consumption, he also sales to gain income. Large roots (more than 100g) are for commercial purposes and for consumption. Large tuberous roots are easy for processing for food while small tuberous roots (less than 100g) are for livestock (such as pigs, cattle, sheep and goats) feed. Accessions with high percentage of marketable /large tuberous roots should be selected for adaptive studies in other ecologies and for registration and distribution to farmers for both local consumption and for commercial production. Accessions with the heavy weight of tuberous roots could be selected and maintained in the germplasm for yield improvement.

Three of the accessions (Kwara with 83.5%, Buttermilk with 83.1% and Ex- Igbariam with 88.8%) produced a high percentage of commercial/large roots more than the reference varieties (UMUSPO/3 with 81.8% and TIS87/0087 with 77.6%) (Table 1). The high number of storage roots with heavy weight could be an indicator of sink/bulking capacity in sweetpotato. High yielding accessions generally have a higher harvest index than lower yielding ones. Harvest index indicated high efficiency in storage root formation relative to their biological yield. Accessions with high harvest index will increase root yield per unit area. Accessions with a high percentage number of roots and high percentage root weight should be selected for registration and release to farmers for commercial sweetpotato production. They should be conserved and maintained in the germplasm for sweetpotato crop improvement.

Sixteen principal characteristics (11 foliar and 5 root morphological characteristics) were analyzed using the mathematics of information theory. Each column is a character while each row is a state or an accession. Where the code (figure) change is a variation in the above or below the character. The foliar morphological characters of the accessions from Okorie to Nnabuihe. N were the same and started discriminating from Buttermilk to TIS87/0087 (Table 2). From the result, it was observed that all the accessions collected from Abia States have a similar biological ranking with TIS87/0087, and may be regarded as duplicate of TIS87/0087. These accessions are quite distinct from Kwara, Ex-Igbariam and Buttermilk. The characterization enable an easy and quick discrimination between accessions. The characters discriminated upon are generally highly heritable, can be easily seen by the eye and are equally expressed in all environments (IBPGR, 1999). However, IBPGR (1999) reported that many of the 'evaluation traits' are those that are susceptible to environmental differences but are generally useful in crop improvement and may involve complex biochemical or molecular characterization. These include yield, agronomic performance, stress susceptibility, biochemical and cytological traits. The result also indicated that all the accessions flowered (Score 3) except buttermilk (score 5) throughout the two cropping seasons (Table 2). The accessions that flowered could be selected for genetic improvement of the sweetpotato crop while those that did not flower could be treated to flower by grafting or girdling.

The result of the assessment of the sweetpotato root flesh and skin color is presented in table 3.

Table 3: Assessment of the sweetpotato root flesh and skin colour of the 18 sweetpotato accessions collected from Abia State

Accession name	Predominant skin colour	Secondary skin colour	Predominant flesh colour	Secondary flesh colour	Root shape	Pest	Diseases	
						Root weevil	SPVD	Leaf spot
Okorie, A	6	6	2	2	5	1	1	1
Chidi, C	6	6	2	2	5	1	1	1
Edozie, E	6	6	2	2	5	1	1	1
Madu, O	6	6	2	2	5	1	1	1
Okeiyi, A	6	6	2	2	5	1	1	1
Nwakanma, T	6	6	2	2	5	1	1	1
Johnny, J	6	6	2	2	5	1	1	1
Sussan, O	6	6	2	2	5	1	1	1
Uzondu, A	6	6	2	2	5	1	1	1
Oluchi, F	6	6	2	2	5	1	1	1
Udokanma, K	6	6	2	2	5	1	1	1
Nwagbara, N	6	6	2	2	5	1	1	1
Nnabuihe, N	6	6	2	2	5	1	1	1
Kwara	3	0	7	3	2	1	1	1
Buttermilk	1	0	2	8	3	1	1	1
Ex-igbariam	2	0	4	8	8	1	1	2
UMUSPO/3	4	4	8	4	2	2	3	1
TIS87/0087	6	6	2	2	5	1	1	1

Note: *Assessment of the sweetpotato root flesh and skin colour*

skin colour 1 =white, 2=cream, 3= 0range, 6=purple, **Secondary skin colour**, 6 =no secondary skin colour, 0= mixed with orange, 4= predominant orange, **Predominant flesh colour** 2 = cream, 4 =yellow, 7=mixed orange, 8=orange, **Secondary flesh colour**, 2= cream, 3=orange, 4= yellow, 8 yellow, **Root shape**, 5= obvate, 3 =round, 8= enlongate, 2= oblong
Disease score: Where 1= no symptoms, 2= symptom mild, 3=symptom moderate, 4= symptom severe and 5= symptom very severe. SPVD = Sweetpotato virus diseases

Skin and flesh colour

Results in Table 3 showed variation in the skin or peel colour and variations in flesh colour. Although, consumers prefer a skin colour that is white to pink. The skin colour of sweetpotato roots do not add to the taste of the root. The white or cream skin colour only appeals to the eye. Ex-Igbariam, buttermilk and Kwara have skin colours ranging from white to cream. This suggested additional reasons why these varieties are popular with farmers. Sweetpotato varieties that have yellow to orange flesh colour are of higher nutritional value than white or cream fleshed colour. This is because of the appreciable amount of beta-carotene content it have which is the precursor for vitamin A necessary for clear eyesight and improving the health of children under five years of age and good for pregnant and lactating mothers (Low *et al.,* 2006). Cream fleshed varieties could be used in other food processing such as boiling and eating, roasting, garri-making and other value additions (Mills

et al., 2009). Smooth shapes are preferred to cracks, rough and wrinkled because of the ease in processing, especially during peeling and washing of the roots.

Pests and diseases

There were no severity of attack of pests and diseases on the crops in the first and second year except the mild attack of root weevil pest on the root of UMUSPO/3 (Score 2), may be as a result of time of harvest and mild infection of leafspot on Ex-Igbariam (Table 3). Conditions favoring the infection of these diseases such as high humidity should be avoided. Therefore, planting during heavy rains under shades should be completely avoided. However, the variety UMUSPO/3 was moderately infected by the sweetpotato virus disease (SPVD) (Score 3). Since most of the accessions do not show any virus symptoms, it indicated that the accessions are resistant to field sweetpotato virus diseases.

CONCLUSION

The three accessions Kwara, Buttermilk and Ex-Igbariam from Kwara State, Nasarawa States and Anambra State are high yielding with 29.8t/ha, Buttermilk with 19.6t/ha and Ex-Igbariam with 16.9t/ha of large roots respectively. These accessions also have a high percentage number of large roots of 90.2%, 87.7% and 81.8% for Kwara, Buttermilk and Ex-Igbariam respectively, than the two reference varieties (UMUSPO/3 with 59.2% and TIS87/0087 with 63.0%) and a high percentage of fresh root weight (Kwara with 83.5%, Buttermilk with 83.1% and Ex- Igbariam with 88.8%) while the two reference varieties had 81.8% and 77.6% of large fresh root weight for UMUSPO/3 and TIS87/0087 respectively. Accessions with a high percentage number of roots and high percentage root weight should be selected for registration and release to farmers for commercial sweetpotato production. They should be conserved and maintained in the germplasm for sweetpotato crop improvement.

It was also observed that all accessions collected from Abia State were similar in foliar and morphological traits with TIS87/0087 and were duplicate of TIS87/0087. They are the same and one accession. This also showed that Abia State has no long history of Sweetpotato cultivation in Nigeria. This was evident by the fact that no other accession was found or introduced from other States by farmers themselves, except the one and only variety across the State which was introduced by IITA in Ibadan Oyo State, Nigeria in the 1980s.

The flesh color of Kwara is intermediate orange and flowers profusely; Buttermilk with cream flesh does not flower at all while Ex-Igbariam with yellow flesh color flowers profusely. These accessions after adaptive studies could be registered for release to farmers in the other parts the country and could be included in the germplasm for yield improvement. They have good shape, resistant to major field pests and diseases. The flesh color of Kwara and Ex - Igbariam are of high nutritive value. They contained appreciative amount of beta-carotene, precursor for Vitamin A for eyesight which is required for young children under five years and a good food for lactating mothers and pregnant women (Low *et al.,* 2006).

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