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Morpho-Agronomic Characterization and Evaluation of In-Country Sweet Potato Accessions in Southeastern Nigeria

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Abstract

The experiment was conducted in 2010 and 2011 to evaluate and characterize fifteen in-country sweet potato accessions for root characteristics and root yield, plant habits, ground cover, severity of root damage by *Cylas puncticollis* and *Meloidogyne incognita* and identify duplications. Significant differences ($P<0.05$) were observed for number of roots per plot, salable roots per plot, unsalable roots per plot and root yield. The highest number of roots per plot, salable roots and root tuber yield were given by E_{10}, followed by B_{21} while the lowest came from E_{17}. The result indicated B_{26} as highly susceptible to *C. puncticollis*, E_3, E_{11}, E_6, E_{27} and TIS 87/0087 were resistant, while B_6, E_5, B_2, E_{17}, B_{21}, E_{14}, E_7, B_{23} and E_{10} were highly resistant to the pest. Seven accessions (E_5, B_6, B_2, E_{14}, E_7, B_{23} and E_{10}) were highly resistant, five accessions (E_3, B_{26}, E_{11}, E_2 and TIS 87/0087) showed moderate resistance while B_2, E_6 and E_{17} were highly susceptible to root knot disease. Ground cover of less than 50% was identified with B_{21} (erect type), the semi-erect types (E_5, E_6, and B_{23}) had ground cover of 50-75%, while the spreading types (B_6, B_2, E_{11}, E_{17}, E_{14} and E_7) had 76-90% ground cover. The extremely spreading types (E_3, B_{26} and E_{27}) had more than 90% ground cover. Six accessions (E_5, E_3, E_6, E_{14}, B_{23} and E_{10}) had white skin, seven (B_6, B_{26}, B_2, E_{27}, E_{17}, E_7 and TIS 87/0087) were pale pink while two (E_{11} and B_{12}) were pink. The root flesh of one accession (B_6) was white, three yellow, while the remaining eleven accessions were creamy, and E_{27} and TIS 87/0087 were duplicates.

Keywords: characterization, evaluation, sweet potato accessions, root characteristics, *Cylas puncticollis*, *Meloidogyne incognita*

1. Introduction

Sweet potato (*Ipomoea batatas* (L) Lam) is an important food crop in the tropical and sub-tropical countries and belongs to the family *convolvulaceae* (Gill, 1988). It is cultivated in more than 100 countries (Woolfe, 1992). The area under sweet potato cultivation in Nigeria is estimated at about 200,000-300,000 hectares annually (Enwezor et al., 1989). Nigeria is the third largest producer in the world with China leading, followed by Uganda (FAO, 2004). Sweet potato ranks seventh among the world food crops, third in value of production and fifth in caloric contribution to human diet (Bouwkamp, 1985).

Small holder farmers have developed more interest for sweet potato production in Nigeria. This is so because sweet potato has a short gestation period of about four months and tolerates wide ecology. Once fully established, it suppresses weeds and reduces the overhead cost of production compared to cassava and yam (Chukwu, 2001; Antiaobong & Bassey, 2008). It has high photosynthetic efficiency (Kapinga et al., 1997), and high yield per unit area and also serves as a bridge between periods of food shortages (Bouwkamp, 1985). The non-edible parts (vines) are used for planting material and so do not compete for human food, in addition to the fact that they are easy to transport to the field (Antiaobong & Bassey, 2008).

Sweet potato blends with rice, cowpea and plantain in Nigerian diets. It is also becoming popular as a substitute to yam and *garri* (Chukwu, 2001). It can be reconstituted into *fofoo* or blended with other carbohydrate flour sources, such as wheat (*Triticum aestivum*) and cassava (*Manihot esculenta*) for baking bread, biscuits and other confectioneries (Woolfe, 1992). The leaves are rich in protein and the orange flesh varieties contain high β-carotene and are very important in combating vitamin A deficiency especially in children (Korieocha et al., 2009).

Several constraints limit sweet potato production world wide, notably low yield and losses due to insect pests especially the sweet potato weevils (*Cylas* spp.) and diseases (Chaltant et al., 1996). Others include, use of unimproved varieties and insufficient planting materials at the beginning of the cropping season (Njoku et al., 2009). Tewe et al. (2001) reported yield losses of up to 80% attributed to *Cylas puncticollis*, while Onwueme, (1978) reported 75% crop loss due to the insect pest alone. Yields are still low in farmers' fields (8t/ha) (Njoku et al., 2009). Decrease in quality salable roots has also been attributed to root tuber cracks caused by root knot nematodes (*Meloidogyne* spp). Due to the outcry for reduction and/or banning of the use of chemical insecticides, there is the need to develop resistant clones. Resistant and high yielding sweet potato clones have been developed at the National Root Crops Research Institute (NRCRI), Umudike and International Institute of Tropical Agriculture (IITA), Ibadan, both in Nigeria and distributed to farmers for multi-location trials in Nigeria (Kumar & Peter, 2000).

The aim of this study was to characterize and evaluate 15 in-country sweet potato accessions for root characteristics and yield, skin and flesh colours, plant habits and ground cover, resistances to *Cylas puncticollis* and root knot disease and eliminate duplications.

2. Materials and Methods

The experiment was conducted in 2010 and 2011 farming seasons at the Experimental Farm of the National Root Crops Research Institute, Umudike, Nigeria (Longitude 07°34'E and Latitude 05°29'N and located at an altitude of 122 m above sea level). The purpose of the study was to evaluate and characterize fifteen in-country sweet potato accessions for yield, based on salable and unsalable root tubers, tuber characteristics (skin colour, root flesh colour), and determine severity of damage by *Cylas puncticollis* and root knot nematode and determine plant habits and duplication among the accessions. The sweet potato accessions were obtained from Ebonyi State and Benue States both in Nigeria. Nine accessions were obtained from Ebonyi State, namely E_3, E_5, E_6, E_{11}, E_{17}, E_{21}, E_7, E_{14} and E_{10}, while five accessions were obtained from Benue State, namely B_6, B_{26}, B_2, B_{21} and B_{23} and TIS 87/0087 used as a check was obtained from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. The soil of the experimental site is classified as sandy loam ultisol. Rainfall is bimodal with an annual average of 2076.8 mm and the area falls within the tropical rainforest zone of Nigeria (Njoku et al., 2009). The land, previously cultivated with yam and left fallow for two years was disc ploughed, harrowed and ridged 1m apart for the experiment.

The experiment occupied a land area of 15m x 9m and was laid out in a randomized complete block design with three replications. Vine cuttings of 30cm with seven nodes were obtained from healthy stem portions and sown 30cm along the crest of the ridges with about three nodes buried in the soil. Each plot contained 30 plants, giving 1440 plants in the entire experimental farm. Each plot received a "blanket" application of NPK 15:15:15 fertilizer at 400 kg/ha after hoe weeding 4 weeks after planting (WAP). Selective removal of *Panicum maximum* by hand pulling was done at 8 WAP.

Records were taken at 16 WAP (Ezulike et al., 2001) on number of roots per plot, Salable (>100 g) and unsalable roots (<100 g) (Levett, 1993), dry matter content of tubers, severity of damage by *Cylas puncticollis* and nematodes (Stathers et al., 2003). The sweet potato accessions were harvested plot by plot and the number of root tubers attacked by *C. puncticollis* and *M. incognita* counted and their percentages determined as:

$$\frac{Number\ of\ damaged\ sweet\ potato\ root\ tubers\ per\ plot}{Total\ number\ of\ sweet\ potato\ root\ tubers\ per\ plot} \times \frac{100}{1}$$

Then, the severity of damage was indicated for each accession using a five point (1-5), where:

1 = 0%: no observable damage of sweet potato tubers by weevils (*C. puncticollis*) or *M. incognita.*

2 = 1%-25% sweet potato root tubers attacked by *C. puncticollis* or *M. incognita*, indicating very little damage.

3 = 26%-50% sweet potato root tubers attacked by *C. puncticollis* or *M. incognita*, indicating moderate damage.

4 = 51%-75% sweet potato root tubers attacked by *C. puncticollis* or *M. incognita*, indicating considerable damage.

5 = 76%-100% sweet potato root tubers attacked by *C. puncticollis* or *M. incognita*, indicating severe damage.

Similarly, skin colours and root flesh colours were determined using colour chart. The plant habits and ground cover of each sweet potato accession were determined using 1-5 point scale by visual method, where 1 = 1%-25%

ground cover; 2 = 26%-49% (<50%) ground cover; 3 = 50%-75% ground cover; 4 = 76%-90% ground cover while 5 = 91%-100% ground cover (>90%).

Dry matter content was determined within 24 hours of harvesting. Fresh root tubers of each accession were sliced into pieces and 100g was dried in an oven at 80 °C for 24 hours until a constant mass was achieved and percentage dry weight determined as

$$\frac{Final\ weight}{Initial\ weight} \times \frac{100}{1}.$$

Duplication in accessions was determined by comparing the data obtained for the study, accessions with identical entries were regarded as duplications. The metric characters were subjected to analysis of variance and their means separated with the Least Significance Difference (LSD), using the procedure described by Wahua (1999). The yield and dry matter contents of the accessions for 2010 and 2011 were compared, using the t-test of paired observation (Wahua, 1999).

3. Results and Discussion

3.1 Plant Habits and Ground Cover

The sweet potato accessions had different growth habits (Table 1). Four accessions were extremely spreading (ES) types, namely E_3, B_{26}, E_{27} and E_{10}; six accessions were spreading types, namely B_6, B_2, E_{11}, E_{17}, E_{14} and E_7, while three were semi-erect, namely E_5, E_6 and B_{23}. However, only two accessions (B_{21} and TIS87/0087) were erect. The erect type had ground cover of less than 50%, the semi-erect 50-75%, the spreading type 76-90%, while the extremely spreading type had ground cover of more than 90%. Antiaobong and Bassey (2008) and Korieocha (2009) observed variability in several growth habits in sweet potato and reported that growth habit has a direct effect on the growth and yield of companion crops, soil characteristics, weeds control and may also aid in the selection of sweet potato in cropping systems. Similarly, IITA (1982) noted that spreading cowpea varieties have the abilities of spreading rapidly over the soil surface and intercepts all the available light, thus preventing and suppressing weeds, thus providing suitable soil environment for proper root development, especially when planted as a sole crop. Nangju et al. (1978) considered the spreading types more suitable for intercropping, since they have greater potential of utilizing available sunlight under cereal canopy than the erect and semi-erect types. However, the erect and semi-erect types may be preferred in crop mixtures if the companion crops are dwarf and shade tolerant.

3.2 Skin and Root Flesh Colours of Sweet Potato

Different skin and root flesh colours were observed among the sweet potato accessions (Table 1). Six accessions had white skin (E_5, E_3, E_6, E_{14}, B_{23} and E_{10}), seven were pale pink (B_6, B_{26}, B_2, E_{27}, E_{17}, E_7 and TIS 87/0087), while two were pink (E_{11} and B_{21}). Similarly, the root flesh colour of eleven accessions was creamy and this constituted the predominant flesh colour among the accessions. However, one accession was white, while three were yellow flesh types. Rees et al. (2001) reported that the colour characteristic of sweet potato roots constitutes an important factor in the choice of sweet potato by consumers, and could be used as genetic marker in predicting yield and culinary attributes of the roots. According to Rees et al. (2001), some farmers in Tanzania prefer white skin, yellow flesh tubers; others prefer white skin and orange flesh, while others prefer red skin and yellow flesh, red skin and white flesh and white skin and white flesh.

Kapinga et al. (1997) reported that the yellow or white root flesh were the most preferred by consumers. Rees et al. (2001) noted that consumers tend to prefer attractive root skin and flesh colours. Some traders preferred to sell yellow flesh roots, while others preferred white flesh roots. However, mixed skin and root colours were more preferred by consumers. Takahata et al. (1993) reported that carotenoid of orange flesh types were highly vitamin A active and almost exclusively β-carotene, yet most consumers prefer varieties with white or pale yellow flesh which contain very little carotene. According to Oyunga et al. (2001), increasing the consumption of the orange-flesh sweet potato roots and food could provide a significant proportion of the required dietary vitamin A intake. In general, vitamin A intake is often inadequate in children because of the seasonality of foods, early abandonment of exclusive feeding, high morbidity levels and the practice of not giving vitamin A-rich foods to young children (McGuire, 1993). Foods such as dairy and meat products containing pre-formed vitamin A are often too expensive for the majority of people in tropical and sub-tropical Africa. Plant foods which contain concentrated pro—vitamin A carotenoids can make a tremendous contribution to improved human health in these areas. The challenge however is to increase awareness, availability of carotene rich types, utilization and consumer acceptance (Oyunga et al., 2001).

Table 1. Skin colour, flesh colour and severity of weevil attack and root cracks, plant habit and ground cover of sweet Potato accessions in Southeastern Nigeria

Cultivars	Skin colour	Root flesh colour	Pest (*Cylas puncticollis* severity	Severity of root cracks	Plant habit	Ground cover
E5	White	Cream	1	1	SE	3: 50-57%
B6	Pale pink	White	1	1	S	4: 76-90%
E3	White	Cream	2	2	ES	5: >90%
B26	Pale pink	Cream	5	2	ES	5: >90%
B2	Pale pink	Yellow	1	5	S	4: 76-90%
E11	Pink	Yellow	2	2	S	4: 76-90%
E6	White	Cream	2	4	SE	3: 50-75%
E27	Pale pink	Cream	2	2	ES	5: >90%
E17	Pale pink	Yellow	1	5	S	4: 76-90%
B21	Pink	Cream	1	1	E	2: <50%
E14	White	Cream	1	1	S	4: 76-90%
E7	Pale pink	Cream	1	1	S	4: 76-90%
B23	White	Cream	1	1	SE	3: 50-75%
E10	White	Cream	1	1	ES	5: >90%
TIS87/0087	Pale pink	Cream	2	2	E	3: <50%

Weevil and root crack severity rating scale 1-5, where:

1 = 0%: no observable damage of sweet potato tubers by weevils (*C. puncticollis*) or *M. incognita;* 2 = 1%-25% sweet potato root tubers attacked by *C. puncticollis* or *M. incognita*, indicating very little damage; 3 = 26%-50% sweet potato root tubers attacked by *C. puncticollis* or *M. incognita*, indicating moderate damage; 4 = 51%-75% sweet potato root tubers attacked by *C. puncticollis* or *M. incognita*, indicating considerable damage and 5 = 76%-100% sweet potato root tubers attacked by *C. puncticollis* or *M. incognita*, indicating severe damage. S = spreading; ES = Extremely spreading; E = Erect; SE = Semi-erect.

3.3 Severity of Damage by Pests (Cylas puncticollis)

The result as presented in Table 1 indicated that the accession B_{26} had the highest attack of *C. puncticollis*, followed by E_3, E_{11}, E_6 and E_{27}. Other accessions however, showed no apparent attack by the pest and may carry resistance genes. Ezulike et al. (2001) reported that resistance of the crop significantly influences the degree of damage by the pest and suggested the use of resistant types in *Cylas* prone areas. Similarly, the accessions B_6, E_{17}, B_{21}, E_{14}, E_7, B_{23} and E_{10} were tolerant to the pest. The accession B_{26} which was highly susceptible to the pest could be eliminated from the recommended list for the area. Resistance of the accessions to pest based on root flesh colour or skin colour could not be established using the data generated for this study but Tewe et al. (2001) noted that the orange flesh clones were more susceptible to pests than the white flesh clones. Ngeve (2001) noted that since root yields and related characters were highly correlated with weevil damage, selection of accessions should be based on resistances to pest attack.

3.4 Root Crack Infection by Moloidogyne Incognita

The accessions B_2 and B_{17} had the severest damage by nematodes disease caused by *Meloidogyne incognita*, hence they were regarded highly susceptible to the disease, followed by E_6 with moderate damage. Very little damage was recorded for E_{11} and TIS 87/0087. The other accessions, namely: E_5, B_6, E_3, B_{26}, E_{27}, B_{21}, E_{14}, E_7, B_{23} and E_{10} had no apparent damages by root cracks and are said to be highly resistant to the disease. Tewe et al. (2001) reported that losses from root knot nematodes range between 20-30% in Nigeria and suggested the use of resistant accessions. Nwauzor et al. (2006) reported that the disease invades sweet potato roots in the region of tissue differentiation and infection in the primary roots cause galling of the roots. Secondary roots are deformed and tubers may crack due to nematode and suggested that resistant clones to root knot nematode be bred and released to farmers in this area.

3.5 Root Tuber Characteristics and Yield

The result as presented in Table 2 shows the yield of sweet potato accessions in 2010 and 2011 and the highest root yield per plot and salable root was produced by E_{10}, followed by B_{21}, while the lowest number of salable roots was obtained from E_{17}. Significant differences ($P<0.05$) were observed for number of root per plot, salable roots per hectare and unsalable roots per plot. However, no significant differences were observed for dry matter contents and unsalable root yield (tonnes/ha) of the sweet potato accessions. The accessions, B_{21} and E_{10} had the highest dry matter contents and salable roots and these are important factors for selection of sweet potato and serve as indicators of adaptability of the crop to local conditions (Antiaobong & Bassey, 2008). Yield is an important factor which determines farmers' choice of sweet potato varieties (Njoku et al., 2009). Sweet potato has several industrial uses, for adhesives, textile, paper, flour (confectionery), alcohol production as well as energy source for batteries, all dependent on dry matter yield. Carey et al. (1997) considered dry matter content of sweet potato as determining the acceptability of accessions for large scale production and use for baking, flour production and in fortification of yam, cassava and other root crops. The high yielding types could be used in breeding programmes to upgrade the yield and dry matter contents of other accessions. The two accessions (B_{21} and E_{10}) were also found to be highly resistant to *Cylas puncticollis* and root knot nematode disease which affect sweet potato production in Southeastern Nigeria and could be incorporated into breeding programmes for the production of hybrid varieties in the cropping system of the area.

The result in Table 3 shows comparison of yield and dry matter content of sweet potato accessions for 2010 and 2011 cropping seasons. The t-test for yield and dry matter content indicated no significant year effect on yield and dry matter content of the accessions.

Table 2. Number of storage roots per plot, number of salable roots per plot, number of unsalable roots per plot, storage root yields (t/ha), salable root yield (t/ha), unsalable root yield (t/ha) and dry matter content of sweet potato accessions in Umudike, Southeastern Nigeria

	Accession	Total storage root no per plot		Salable roots number/plot		Unsalable roots plot		Total roots storage yield (t/ha)		Salable root yield (t/ha)		Unsalable root yield (t/ha)		Dry matter contents (%)	
		2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
1	E5	31.9^{de}	31.5^{cd}	16.8^{cd}	16.9^{d}	15.1^{e}	14.9	14.3^{g}	14.7^{e}	13.3^{e}	13.7^{f}	1.0	1.0	35.5	35.7
2	B6	40.5^{f}	40.9^{e}	26.6^{f}	26.8^{f}	13.9^{de}	14.1	16.0^{h}	16.8^{f}	15.2^{f}	16.0^{g}	0.8	0.8	32.6	32.6
3	E3	27.4^{d}	26.0^{c}	14.6^{c}	13.4^{c}	12.8^{de}	12.6	6.0^{c}	6.2^{c}	5.6^{c}	5.9^{c}	0.4	0.4	32.4	32.6
4	B26	29.1^{d}	29.7^{c}	20.2^{e}	20.7^{e}	8.9^{c}	9.0	7.7^{de}	7.9^{cd}	6.9^{cd}	7.1^{d}	0.8	0.8	32.6	32.6
5	B2	34.0^{e}	34.0^{d}	21.8^{e}	21.6^{e}	12.2^{d}	12.4	10.3^{e}	10.9^{d}	9.8^{d}	10.4^{e}	0.5	0.5	32.4	32.4
6	E11	37.5^{ef}	37.1^{d}	25.9^{f}	25.0^{f}	11.9^{d}	12.1	11.9^{f}	11.7^{de}	10.9^{de}	10.7^{e}	1.0	1.0	36.1	36.3
7	E6	33.9^{e}	34.1^{d}	23.9^{ef}	24.1^{ef}	10.0^{d}	10.0	5.8^{c}	5.6^{c}	5.1^{c}	4.9^{c}	0.7	0.7	32.4	32.6
8	E27	35.8^{de}	36.2^{d}	20.8^{e}	21.2^{e}	15.0^{e}	15.0	6.7^{d}	6.7^{d}	6.3^{c}	6.3^{d}	0.4	0.4	29.3	29.3
9	E17	6.0^{a}	6.0^{a}	1.8^{a}	1.6^{a}	4.2^{a}	4.4	0.9^{a}	0.9^{a}	0.5^{a}	0.5^{a}	0.4	0.4	32.5	32.3
10	B21	58.8^{g}	59.2^{f}	43.2^{g}	43.4^{f}	15.6^{e}	15.8	10.9^{ef}	10.7^{d}	10.3^{de}	10.1^{e}	0.6	0.6	40.0	40.4
11	E14	16.8^{c}	16.0^{b}	13.9^{c}	13.5^{c}	2.9^{a}	2.5	9.0^{e}	9.2^{cd}	8.5^{d}	8.7^{de}	0.5	0.5	33.0	33.0
12	E7	12.5^{b}	12.9^{b}	5.7^{b}	5.7^{b}	6.8^{b}	7.2	3.0^{b}	3.0^{b}	2.4^{b}	2.4^{b}	0.6	0.6	36.0	36.0
13	B23	27.6^{d}	27.8^{c}	17.1^{d}	17.5^{d}	10.5^{d}	10.3	8.4^{de}	8.2^{cd}	7.7^{cd}	7.5^{d}	0.7	0.7	32.7	32.7
14	E10	86.0^{i}	86.6^{g}	64.9^{i}	65.1^{h}	21.2^{f}	21.5	16.0^{h}	16.0^{f}	15.4^{f}	15.4^{g}	0.6	0.6	36.9	36.9
15	TIS87/0087	61.2^{h}	61.6^{f}	45.5^{h}	45.9^{g}	15.7^{g}	15.7	10.2^{e}	10.6^{d}	9.5^{d}	9.9^{e}	0.7	0.7	35.2	35.6
	LSD (0.05)	3.14	3.15	2.18	2.19	1.22	1.22	1.02	1.02	1.07	1.07	NS	NS	NS	NS

Table 3. t-test comparison of sweet potato yields and dry matter content for 2010 and 2011

Plant attribute	t-cal (0.05)
Total root tuber numbers/plot	1.339 ^{NS}
Number of salable root tubers/plot	0.969 ^{NS}
Number of unsalable root tubers/plot	1.242 ^{NS}
Total root tuber yield (ions/ha)	0.973 ^{NS}
Salable root tubers (tons/ha)	0.919 ^{NS}
Unsalable root tubers (tons/ha)	0.0
Dry matter content	1.065^{NS}

Critical t (0.05) = 2.14

3.6 Duplicate Accessions in Collection

The accession E_{27} was identified as the duplicate accession of TIS 87/0087 in the sweet potato germplasm collection. Gill (1989) ordered for development and use of efficient screening techniques to eliminate duplication of accession in order to develop only few restrictive collections for public use.

4. Conclusion

The sweet potato accessions differed significantly for yield, number of salable and unsalable roots. They also showed differences in skin colour and root flesh colour, resistances to pest, such as *C. puncticollis* and root knot nematode disease. Evaluation and characterization of sweet potato accessions could be used to identify and select accessions with high root yields and resistances for incorporation into breeding programmes. Plant habits of the accession could determine their combination in cropping systems in Nigeria. The study showed that E_{27} was the duplicate accession of 87/0087 and this accession could be eliminated from the list recommended for the area.

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