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YIELD EVALUATION OF OPEN POLLINATED SWEET POTATO (*Ipomoea batatas* (L) Lam) GENOTYPES IN HUMID ENVIRONMENT OF UMUDIKE, NIGERIA

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Abstract

Field experiments were conducted in 2012 and 2013 cropping seasons to evaluate fourteen open pollinated sweet potato genotypes of the final stage of Uniform Yield Trial (UYT) for yield and yield related traits, root skin and flesh colours. The sweet potato genotypes were EA/11/031, EA/11/022, EA/11/014, EA/11/024, EA/11/026, EA/11/018, EA/11/030, EA/11/017, EA/11/003, EA/11/001, UM/11/002, EA/11/007, EA/11/005 and TIS87/087 as check. The sweet potato characters studied were plant count at harvest, total root tuber number, large root tuber number, small root tuber number, number of root tubers per plant, total root tuber yield (t/ha), large root tuber yield (t/ha) and small root tuber yield (t/ha), and root skin and flesh colours. Significant differences were observed for all the metric characters ($P \leq 0.05$). Ten genotypes produced total root tuber yields which were higher than the check variety and could be listed for Advanced Yield Trial, namely: EA/11/022, EA/11/002, EA/11/030, EA/11/018, EA/11/031, EA/11/026, EA/11/005, EA/11/017, EA/11/003 and EA/11/001. Four of them however gave root tuber yields greater than 11 t/ha and were classified as moderate yielding genotypes, namely: EA/11/022, EA/11/002, EA/11/030 and EA/11/018, although none was classified as high yielding genotypes (18 – 30 t/ha) at Umudike, Nigeria. Three genotypes namely: EA/11/007, EA/11/014and EA/11/024 recorded root tuber yield of less than 11 t/ha and could be eliminated from the list of sweet potato for advanced yield trial. All the moderate yielding genotypes however were the cream fleshed types which could be crossed with the β-carotene rich varieties for development of β-carotene – high yielding hybrid varieties for the environment.

Keywords: *Yield evaluation, sweet potato genotypes, uniform yield trial, yield, moderately yielding genotypes, advanced yield trial.*

Introduction

Sweet potato (*Ipomoea batatas*) is a dicotyledonous plant that belongs to the family *Convolvulaceae* (Tortoe, 2010). It is grown as a starchy food crop throughout the tropical, sub-tropical and frost-free temperate climate zones in the world (ICAR, 2007). Sweet potato is among the world's most important versatile and underutilized food crop grown generally for its storage roots (Tortoe, 2010) It is a short cycle crop which usually matures 3 – 4 months (Anyaegbunam *et al*., 2008), and may be grown two or three times in a year (Okonkwo, 2002). Sweet potato has high photosynthetic efficiency (Kapinga *et al*., 1997) and yields high amount of energy per unit area per unit time and is expected to bridge the food shortages and malnutrition (Nedunchezhiyan *et al*., 2012). The vine tips and leaves are used as vegetables. The vines form excellent source of green fodder for cattle (Nedunchezhiyan *et al*., 2012). The vines are also used for planting material and so do not compete with the root tubers for human food, in addition to the fact that they are easy to handle and transport to the field (Antiaobong and Bassey, 2008).

Sweet potato is cultivated in more than 100 countries (Woolfe, 1992). It is the seventh among all food crops worldwide from the point of view of total production, thirteenth in value of production and fifth in caloric contribution to human diet (Bouwkamp, 1985, Tortoe, 2010). Among the tuber crops grown in the world, sweet potato ranks second after cassava (Ray and Ravi, 2005). China accounts for the highest sweet potato production in the world, followed by Uganda and Nigeria (FAO, 2004) in that order. The area under sweet potato production in Nigeria is estimated at about 204.7 million hectares of land with 2.516 million metric tonnes of sweet potato in 2005 and 3.462 million metric tonnes in 2006 (Srinivas, 2009, Anyaegbunam *et al*., 2008). These increases were attributed to improved technological inputs, international and national research efforts (Anyaegbunam *et al*., 2011). The crop can be considered very important in promoting nutritional security particularly in agriculturally backward areas (Srinivas, 2009) with poor soils.

Sweet potato blends with rice, cowpeas and plantain in Nigeria diets. It may be boiled or steamed, fried or roasted and eaten with sauce. It is also becoming a substitute to yam and garri (Chukwu, 2001; Antiaobong and Bassey, 2009). It can be reconstituted into fufu or blended with other carbohydrate flour sources such as wheat (*Triticum aestivum*) and cassava (*Manihot esculenta*) for baking bread, biscuits and other confectioneries (Nwankwo *et al*., 2012). The leaves which are used in cooking soup and stew are rich in protein (27%), starch (8%), sugar (4%) and ash (10%). Smaller roots, peels and leaves constitute excellent food to livestock (Anyaegbunam *et al*., 2008). The orange fleshed sweet potato are naturally biofortified food of *Beta* carotene (Ezeocha, *et al.*, 2010) and is important in combating vitamin A deficiency in children (Korieocha *et al*., 2009). The comparative short duration with its innate power for tremendous dry matter production has enabled sweet potato to rank as the foremost root crop in respect to calorie value. It has the potential as a feedstock for bio-ethanol production (Nedunchezhiyan *et al*., 2012).

Sweet potato is nutritious, with the exception of protein and niacin, it provides over 90% of the nutrient per calorie required for most people. It brings more income to farmers than any other root crop; both the roots, leaves and tender vines have economic and nutritional values (Antiaobong and Bassey, 2009).

Yields vary greatly according to cultivars, local climatic conditions and cultural techniques (Antiaobong, 2007). Reported average yields are 4 t/ha (Chinaka, 1983) and 13t/ha (Horton, 1988). A survey in Nigeria shows a decreasing yield from the south east zone with average root tuber yields of 7t/ha to 3.5t/ha in the north-east zone (Ezulike *et al*., 2001). Generally, yields in farmer's plots are low (Njoku *et al*., 2009) due to the use of local genotypes, yields could be increased with improved varieties (Nwankwo, *et al*., 2012). Evaluation of open pollinated newly developed clones at the last stage of uniform yield trial could reveal some promising or interesting genotypes with high root yields and other desirable agronomic traits for farmers in southeastern Nigeria. Promising clones would be selected after further yield evaluations in different ecological zones in Nigeria (Bassey, 2012). Therefore, the objective of this study was to evaluate and identify sweet potato genotypes with high root yields and attractive root flesh colour for further breeding and selection in Umudike, Nigeria.

Materials and Methods

Field experiments were conducted in 2012 and 2013 cropping season at the western farm of the National Root Crops Research Institute, Umudike, Nigeria. Umudike is located at longitude 07° 34'E and Latitude 05° 29'N with a mean altitude of 122m above sea level. The area lies within the humid tropical rainforest zone of Nigeria. The rainfall is bimodal with an annual average of 2076.8mm. The soil of the experimental site is classified as sandy loam ultisol (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.

Each experiment occupied a land area of 48.5m x 11.0m and was laid out in a randomized complete block design with three replications. Fourteen plots represented the treatments in each replicate; each plot measured 3m x 3m and separated by 1m path. The experimental materials were thirteen open pollinated selection of newly developed sweet potato genotypes at the final stage of Uniform Yield Trial (UYT) and were obtained from the Clonal Observatory Nursery of the National Root Crops Research Institute, Umudike – Nigeria, namely: EA/11/031, EA/11/022, EA/11/014, EA/11/024, EA/11/026, EA/11/018, EA/11/030, EA/11/017, EA/11/003, EA/11/001, UM/II/002, EA/11/007, EA/11/005 and one standard check variety (TIS 87/0087) from the International Institute of Tropical Agriculture, Ibadan, Nigeria.
Sweet potato vines (apical portions) of each genotype (Mukhopadhyay *et al.*, 1990) were cut 30cm (Sanchez *et al*., 1985) with six nodes and sown 30cm along the crest of the ridges (Anyaegbunam *et al*., 2008). There were 30 plants per plot and a total of 1,260 sweet potato plants in the experimental farm. The sweet potato vines were planted on 2nd and 3rd July, 2012 and 2013, respectively. Fertilizer (NPK 15:15:15) was applied at 400kg/ha at four weeks after planting, immediately after the first weeding. Weeding was done two times, using the manual method. Selective removal of *Panicum maximum* and *Mucuna spp* by hand pulling was done at 8 WAP. The root tubers were harvested at 16 weeks after planting (Ezulike *et al*., 2001) .Two qualitative characters studied were skin colour and root flesh colour. Soil was brushed-off skin of randomly selected root tubers of each genotype and carefully washed in cool clean water and spread under shade for two hours for dryness. The skin colours were compared with the colour chart. Similarly, the skin was peeled to expose and observe the inner flesh colour and compared with the colour chart to establish the specific colour identity of each genotype (Bassey, 2012). Yield data were collected on total storage root tubers, number of root tubers per genotype, number of large root tubers, numbers of small root tubers, large root tuber yield (t/ha), small root tuber yield (t/ha), total root tuber yield (t/ha) and plant count at harvest (Levett, 1993).

Analysis of variance was conducted on all the metric characters and the means separated with the Duncan Multiple Range Test (DMRT) at 5% probability level (Wahua, 1999). Sweet potato genotypes were categorized into three classes: high yielding genotypes (18 – 30y/ha), moderate yielding genotypes (11 – 17t/ha) and poor yielding genotypes (less than 11t/ha), based on the National Agricultural Research Organisation (NARO) guideline.

Results and Discussion

Sweet potato genotypes were distinguished based on root skin and root flesh colours. The skin colour of the sweet potato genotypes in this study were white, light purple and purple, one genotype was white, seven light purple, while six were purple. Similarly, the root flesh colour also showed remarkable variations, four genotypes were white and ten creams. Nwankwo *et al*. (2012) reported that colour of the skin and flesh constitutes an important factor in the choice of sweet potato roots by consumers and could be used as genetic marker in determining yield and culinary attributes of sweet potato roots. Rees *et al*., (2001) reported that some farmers and consumers prefer white skin, yellow fleshed root tubers, white skin and orange fleshed while others prefer red skin and yellow flesh, red skin and white fleshed, white skin and white or cream fleshed. Kapinga *et al*. (1997) reported that consumers show greater preference for cream or white root flesh. Rees *et al*, (2001) established a correlation between flesh colour and β-carotene content in sweet potato. Lowe and Wilsonaka (2003) reported that the white fleshed genotypes produce good chips and high quality flour when compared with other root flesh colours. White fleshed genotypes are also associated with high starch and dry matter content whereas the orange fleshed types are associated with low starch and low dry matter contents. The cream and white fleshed types share similar characteristics and are much preferred for baking, biscuit and other confectioneries. Tewe *et al*. (2001), reported that sweet potato with white or pale yellow fleshed types are less sweet and moist than those with red, pink or orange fleshed type and are suitable candidates for flour and livestock feed (dry matter) production.

Table 1: Root Skin and Flesh Colours of sweet potato genotypes at Umudike, Nigeria

Sweet potato	Skin Colour	Flesh Colour
EA/11/031	White	White
EA/11/022	Light purple	Cream
EA/11/014	Purple	White
EA/11/024	Light purple	White
EA/11/026	Purple	Cream
EA/11/018	Purple	Cream
EA/11/030	Light purple	Cream
EA/11/017	Light purple	White
EA/11/003	Light purple	Cream
EA/11/001	Purple	Cream
UM/11/002	Purple	Cream
EA/11/007	Purple	Cream
EA/11/005	Light purple	Cream
TIS 87/0087	Light purple	Cream

Table 2 presents plant count at harvest, total root tuber number, large root tuber number, small root tuber number, number of root tubers per plant, total root tuber yield (t/ha), large root tuber (t/ha) and small root yield (t/ha) of the sweet potato genotypes. Significant differences were observed among the sweet potato genotypes in all the metric characters studied. Some genotypes out yielded even the national check variety (TIS 87/0087). Based on the results, EA/11/030 had the best performance in four yield related characters, namely total root tuber numbers, large root tuber number, number of root tubers per plant and small root tuber number. It was followed by EA/11/022 in two characters namely: total root tuber yield (t/ha) and large root tuber yield (t/ha). Similarly, EA/11/003 and EA/11/017 recorded good performances in three characters, namely total root tuber number, large root tuber number and number of root tubers per plant and where rated second and third best candidates, respectively.

Some genotypes performed better than the check, TIS 87/0087 in one or several characters. For example EA/11/031, EA/11/022, EA/11/030 and EA/11/024 had higher plant stands at harvest than the check. For large root number, EA/11/030, EA/11/003, EA/11/017 and EA/11/022 were better candidates compared with the check. Also, EA/11/030, EA/11/003 and EA/11/017 recorded higher number of root tubers per stand than the check. A similar observation was found for total root yield which 10 genotypes performed better than the check namely: EA/11/022, UM/11/002, EA/11/030, EA/11/018, EA/11/031, EA/11/026, EA/11/005, EA/11/001, EA/11/017 and EA/11/003. Nine genotypes demonstrated superiority over the check for large root tuber yield (t/ha), namely: EA/11/022, EA/11/030, EA/11/031, EA/11/003, EA/11/017, EA/11/001, EA/11/026, EA/11/005 and EA/11/018.

Ezulike *et al.* (2001) put the average sweet potato root tuber yield at 7t/ha for south eastern Nigeria In this study, the check variety (TIS 87/0087) yielded 7.6t/ha, and had lower tuber yield than some of the genotypes. The genotypes were grouped into three root tuber yield classes: high yielding (18-30t/ha), moderate yielding (11-17t/ha) and low yielding genotypes (<11t/ha) based on the NARO (National Agricultural Research Organization) yield classification criteria. None of the genotypes was in the top group (high yielding). However, four genotypes were in the moderate yielding group, namely EA/11/022, UM/11/002, EA/11/030 and EA/11/018. The remaining ten genotypes, including the standard check fell within the low yielding group, namely; EA/11/031, EA/11/026, EA/11/005, EA/11/017, EA/11/003, EA/11/001, TIS 87/0087 (check), EA/11/024, EA/11/014 and EA/11/007. The moderate yielding genotypes and those that yielded more than the check variety could be taken to the Advanced Yield Trial (AYT). Those genotypes which yielded lower than the check variety could be discarded from the trial list, namely: EA/11/007, EA/11/024 and EA/11/014.

Table 2: Plant counts at harvest, total root tuber number, large root tuber number, small root tuber number, number of root tubers per plant, total root tuber yield (t/ha), large root tuber yield (t/ha) and small root tuber yield (t/ha) of sweet potato genotypes at Umudike, Nigeria

Sweet Potato Genotype	Plant Counts at Harvest		Total Roots Tubers/Genotype		Total Large Root Tubers/Genotype		Total Small Root Tubers/Genotype		Mean Number of Root Tubers per plant		Large Root Tuber Yield (t/ha)		Small Root Tuber Yield (t/ha)		Total Root Tuber Yield (t/ha)	
	Year of Cropping															
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
EA/11/031	25a	26a	35.0d	37.0d	24d	23d	11b	14b	1.40e	1.42e	9.6c	10.0b	0.8d	0.4gh	10.4bc	11.0c
EA/11/022	18b	9b	31.0e	33.0e	25d	25d	6d	8c	1.70e	1.73d	14.5a	14.8a	0.1f	0.2h	14.6a	15.0a
EA/11/014	16c	15d	31.0e	30.0e	17e	16e	14b	14b	1.93de	20.cd	3.8h	3.8f	0.5e	0.4gh	4.3d	4.2d
EA/11/024	17b	17c	7.0h	8.0h	4f	4g	3de	4d	0.41f	0.47g	20.1	2.2g	2.3c	2.4e	5.2d	5.6d
EA/11/026	14d	16c	6.0h	6.0h	4f	5g	2e	1d	0.42f	0.37g	8.1e	8.4cd	4.0b	3.0d	10.4bc	10.8c
EA/11/018	15c	16c	15.0g	16.0g	10ef	10f	5d	6c	1.0f	1.0f	7.5ef	7.1e	4.0b	4.3b	11.5b	11.4bc
EA/11/030	17b	18b	102.0a	104.0a	54a	53a	48a	51a	6.0a	5.77a	10.0b	10.0b	2.2c	3.6c	12.2b	13.6b
EA/11/017	13d	12e	40.0c	42.0c	30c	31c	10c	11bc	3.0c	3.50b	8.9d	9.0c	0.8d	1.0g	9.7bc	10.0c
EA/11/003	13	14d	48.0b	50.0b	35b	36b	13b	14b	3.69b	3.57b	9.0d	8.9c	0.5e	0.4gh	9.5bc	9.3c
EA/11/001	13d	14d	24.0f	26.0f	18e	19e	6d	7c	1.84de	1.85d	8.3e	8.0d	0.5e	0.4gh	8.8c	8.4cd
UM/11/002	13d	12e	30.0e	32.0e	18e	18e	12bc	14b	2.30d	2.66d	5.2g	5.0ef	7.4a	7.8a	12.6b	12.8b
EA/11/007	11e	12e	8.0h	9.0h	6f	6g	2e	3d	0.72f	0.75g	2.21	2.4g	0.4e	0.2h	2.6e	2.6e
EA/11/005	15c	16c	30.0e	31.0e	20e	20de	10c	11bc	2.0d	1.93d	7.9ef	8.0d	2.0c	2.0h	9.9bc	10.0c
TIS/87/0087	16c	16c	38.0cd	40.0cd	24d	25d	14b	15b	2.37d	2.50c	6.8f	6.8e	0.8d	0.7g	7.6c	7.5cd

Yield is an important factor which determines choice of sweet potato genotypes for cultivation (Njoku *et al*., 2009). It is an important agronomic index which shows adaptability of a genotype to its environment (Antiaobong and Bassey, 2008). The four sweet potato genotypes namely EA/11/022, UM/11/002, EA/11/030 and EA/11/018 with high root tuber yields of 14.6(t/ha), 12.6(t/ha), 12.2(t/ha) and 11.5t/ha are good candidates with high adaptation to Umudike environment. They may be said to possess high source potential and powerful sink (Tewe *et al*., 2001). It is imperative to sensitize the farmers and consumers of the high yielding non-sweet clones to enhance their acceptance as staple food. The data obtained for the study could be used to initiate production plans for the take-off of sweet potato business at Umudike, Nigeria and enhance further breeding of the crop.

Conclusion

Evaluation of sweet potato genotypes for yield at the last stage of Uniform Yield Trial (UYT) revealed some superior candidates for advancement to the next stage of yield trial. The candidates in this category were those that out yielded the check variety (TIS 87/0087) and include EA/11/031, EA/11/022, EA/11/026, EA/11/018, EA/11/030, EA/11/017, EA/11/003, EA/11/001, UM/11/002 and EA/11/005. The other candidates with yields lower than the check could be eliminated from the list for Advanced Yield Trial (AYT) namely: EA/11/014, EA/11/024 and EA/11/007. However, in a situation where only few superior candidates are required for further breeding, only the four moderately yielding types may qualify for enlistment, namely EA/11/022, EA/11/018, EA/11/030 and UM/11/002. Since all these superior candidates are cream types with low content of *B*-carotene, they could be crossed with *B* carotene rich varieties for consumers in the area.

References

Antiaobong, E.E and Bassey E.E. (2008). Constraints and prospects of sweet potato (*Ipomoea batatas*(L)Lam) production in humid environment of southeastern Nigeria. Proceedings of the Second African Regional Conference on Sustainable Agriculture, held at the Governor's office Annex, Uyo, Nigeria, 2(3): 68-72.

Antiaobong, E.E and Bassey E.E. (2009). Characterization and evaluation of six sweet potato varieties (*Ipomoea batatas* (L)Lam) for quantitative and qualitative characters and tolerance to *Cylas puncticollis,* Boh in high humid environment of southeastern Nigeria. *Journal of Agricultural Research and policies*, 4(1): 17-21.

Antiaobong, E.E. (2007). Life cycle, economic threshold and control of sweet potato weevils, *Cylas puncticollis* Boh (*Coleoptera*: *Curculionidae*) in Akwa Ibom State, Nigeria. Ph.D Thesis submitted to Michael Okpara University of Agriculture, Umudike - Nigeria, pp. 3 – 5.

Anyaegbunam, H. N., Asumugha, G. N., Mbanasor, E. O., Ezulike, T. O. and Nwosu, K. I. (2008). Guide to Improved Sweet Potato Production in Nigeria. National Root Crops Research Institute, Umudike, Extension Guide 24, pp.1-9.

Anyaegbunam, H.N., Nwosu, A.C and Mbanasor, J.A. (2011). Spatial price analysis of sweet potato marketing in southeast agro ecological zone, Nigeria. *The Nigerian Agricultural Journal*, 42: 130-137.

Bassey, E.E. (2012). Response of improved varieties of sweet potato (*Ipomoea batatas* (L) Lam) to early and late cropping seasons in southeastern Nigeria. Proceedings of the 36th Annual Conference of Genetic Society of Nigeria held at the University of Calabar, Nigeria, 15-18th October, 2012, pp. 170-177.

Bouwkamp, J. C. (1985). Production requirements for sweet potato production, In: J.C. Bouwkamp, J.C (ed.). Natural Resources for the tropics. CRC Press, Boca Raton, Florida, pp.9-33.

Chinaka, C.C., (1983). Sweet Potato Production. Extension Bulletin No. 7, AERLS, National Root Crops Research Institute (NRCRI), Umudike, Nigeria, pp. 7-8.

Chukwu, G.O. (2001). Seasonality and climate period effects on crop evapotranspiration of sweet potato, In: Akoroda, M.O and Ngeve, J.M (compilers). Root Crops in the 21st Century. Proceedings of the 7th Triennial Symposium of the International Society for Tropical Root Crops-African Branch, held at Centre International des Conference, Cotonou, Benin, 11-17 October, 1998, pp.280-284.

Ezeocha, V.C., Oti, E., Ezigbo, V.U and Ekeledo, N.E. (2010). Effect of storage conditions and duration of storage on the chemical composition of two varieties of orange fleshed sweet potato. The Nigerian Agricultural Journal, 41(2): 75-79.

Ezulike, T.O., Anioke, S.C and Odurukwe, S.O. (2001). Integrated control of sweet potato weevil (*Cylas puncticollis*, Boh) in South Eastern Nigeria, In: Akoroda, M.O and Ngeve. J.M., (Compilers). Root crops in the 21st century. Proceedings of the 7th Triennial Symposium of the International Society for Tropical Root Crops, African Branch, held at the Centre International des Conference, Cotonou, Benin, 11-17 October, 1998, pp.645-648.

FAO (Food and Agriculture Organization) (2004) FAOSTAT-Database Result 228. Records of sweet potato production 2002-2004, FAO, Rome.

Horton, D. (1988). Underground Crops. Winrock International Institute for Agricultural Development, Morrilton, USA., pp 22-23.

ICAR (Indian Council of Agricultural Research) (2007). Handbook of Agriculture. Directorate of Information and Publication, India Council of Agricultural Research, New Delhi, pp. 512-516.

Kapinga, R. E., Ewell, P.T. and Jeremiah, S.C. (1997). Sweet potato in Tanzania farming and food systems: Implication for research, Ministry of Agriculture and Livestock Development, Tanzania/International Potato Centre (CIP), Nairobi, Kenya, p.47.

Korieocha, D.S., Ogbonna, M.C., Nwokocha, C.C., Echendu T.N.C and Okorocha, E.O.A. (2009). Effects of time of herbicide application and sweet potato morpho-types on the effectiveness of herbicide on weeds. Proceedings of the 43rd Annual Conference of Agricultural Society of Nigeria, held at the National Universities Commission, Abuja, Nigeria, Tuesday 20th-Friday 23rd October, pp.12-16.

Leveth, M.P. (1993). The effect of methods of planting cuttings of sweet potato (*Ipomoea batatas* (L)Lam) on yield. *Tropical Agriculture* (Trinidad), 70(2): 110-115.

Lowe, S.A. and Wilsonaka, S.F. (2003). Variability and possible sources of variation in sweet potato roots. *Experimental Agriculture*, 11:45-78.

Mukhopadhyay, S.K., Sen, H and Hana, P.K. (1990). Effect of planting materials on growth and yield of sweet potato. *Journal of Root Crops*, 16(2): 119-122.

Nedunchezhiyan, M., Byji, G. and Jata, S. K. (2012). Sweet Potato Agronomy; Journal of Agricultural University Puerto Rico, 60(2): 163-171.

Njoku, J.C., Muoneke, C.O., Okocha, P.I. and Ekeleme, F. (2009). Effect of propagule size and intra-row spacing on the growth and yield of sweet potato in a humid agro-ecological zone. *Nigerian Agricultural Journal*, 40(1): 115-124.

Nwankwo, I.I.M, Bassey, E.E., Afuape, S.O., Njoku, J., Korieocha D.S., Nwaigwe, G. and Echendu,T.N.C (2012). Morpho-Agronomic characterization and evaluation of in-country sweet potato accessions in southeastern Nigeria. *Journal of Agricultural Science*, 4(11): 281-288.

Okonkwo, J.C. (2002). Effect of time of introducing soybean into potato on the performance of potato/soybean intercrop in Jos Plateau, Nigeria. *Journal of Sustainable Agriculture and the Environment*, 4(2): 185-191.

Ray, R.C and Ravi, V. (2005). Post harvest spoilage of sweet potato and its control measures. *Critical Review of Food Science and Nutrition*, 35: 623-644.

Rees, D., Kapinga, R., Jeremiah, S and Rwiza, E. (2001). Preferences and Selection Criteria of sweet potato varieties in rural and urban areas of Tanzania, In: Akoroda, M.O and Ngeve, J.M. (Compilers). Root Crops in the 21st century. Proceedings of the 7th Triennial Symposium of the International Society for Tropical Root Crops – African Branch, held at the Centre International des Conference, Cotonou, Benin, 11-17 October, 1998, pp. 417-423.

Sanchez, V.E.E., Morales, T.A and Lopez, Z.Y.M. (1985). The influence of stem cutting length on root yield of sweet potato clone, CEMSACENSA, 74-228, *Ciencia y Teenica en la Agricultural Variables Tropicales*, 5(1): 49-68.

Srinivas, T. (2009). Economics of sweet potato production and marketing, In: Loebenstein, G and Thottapilly, G (eds.). The sweet potato, Spring Science Business Media, BV 2009, 436-447.

Tewe, O.O., Abu, O.A., Ojeniyi, E.F and Nwokocha, N.H. (2001). Status of sweet potato production, utilization and marketing in Nigeria. Root crops in the 21st century. Proceedings of the 7th Triennial Symposium of the International Society for Tropical Root Crops, African Branch, held at the Centre International des Conference, Cotonou, Benin, 11-17 October, 1998, pp.65-74.

Tortoe, C. (2010). Microbial deterioration of white variety sweet potato (*Ipomoea batatas*) under different storage structures. *International Journal of plant Biology*, 1(1): 10-15.

Wahua, T.A.T. (1999). Applied Statistics for Scientific Studies. Afrika Links Books, Owerri, Nigeria. p. 171.

Woolfe, J.A. (1992). Sweet Potato: An untapped food resources. International Potato Centre (CIP), Peru/Cambridge University Press, Cambridge, pp. 16-19.