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Evaluation of the Agronomic Characteristics of 16 Varieties of Sweet Potato (*Ipomea batatas*) Grown in the Agro-ecological Conditions of Southern Benin

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ABSTRACT The aim of this study was to analyse the yield and agronomic traits of 16 sweet potato varieties in Benin. The experiment was done in a randomized complete block design with three replicates where each variety is a treatment. Data were collected on both the qualitative and quantitative characters. Analysis of Variance and General Linear Model metrics was done to highlight the variability in the varieties. The analyses revealed an inter-cultivar variability in the shape and size of leaves, colour of skin and flesh of the tubers. Also, intra-cultivar variability in lengths of the internodes, the petiole of the leaf, stem and number of leaves was observed. China variety (440029) has highest performance with 24 t/ha above average Africa tuber yields (10 and 14 t/ha). The existence of such variability could be a starting point for genetic improvement of sweet potato in Benin.

INTRODUCTION

Self-sufficiency in food remains a concern due to natural (poor and uneven rainfall, soil poverty, etc.) and institutional constraints, as most agricultural research and extension institutions have focused on cereal crops with less attention for tubers, especially sweet potatoes (Nellemann 2009). While some countries have been able to achieve their food security and guarantee their economic growth by improving cereal yields (Schmidhuber and Tubiello 2007), other countries like Benin still remain in poverty and under-nourishment despite the efforts made (Bruinsma 2017).

Sweet potato (*Ipomea batatas*) is a tuberous rooting plant of great economic importance in tropical, subtropical and mild temperate regions. It is the seventh largest crop in the world after wheat, rice, corn, potato, barley and cassava (Martin and Sauerborn 2013). Its global production is estimated at more than 102 million tons in 2009, of which more than ninety-eight percent of production is grown in developing countries (Balat and Balat 2009). The tuberous roots contain large amounts of starch which can reach thirty percent of the fresh mass in some cultivars of sweet potato (Lebot 2009). Its agronomic characteristics (broad adaptability, high productivity, short cycle and high nutritional value) make it a particularly important crop for the food security of countries subject to strong anthropogenic pressures and vulnerable to climate change (Godfray and Garnett 2014). Despite these advantages, this crop is often not given importance in the agricultural policies of most tropical countries. Its production has been a strong regression for reasons intrinsic and extrinsic to the plant (Gichaga 2014). In Benin sweet potato production fell from 65,787 tons in 2013 to 58,144 tons in 2016 (http://www.fao.org/faostat). Also, the areas planted with sweet potatoes in Benin still are less productive.

Nutritionally, sweet potato is an important source of dietary fiber, it contains pectin content which sometimes reaches five percent of its fresh weight or twenty percent of the dry matter at the time of harvest; it can provide more calo-

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ries per unit area than cereals and most other crops, with the exception of sugarcane (Oke and Workneh 2013). However, sweet potato remains a marginalized crop in Benin's development programs. The average yield of sweet potato varies from 10.2 to 14 t/ha in Africa; these relatively low yields are mainly due to unavailability of the appropriate improved varieties. Compared to economically important plant like yam and cassava. *Ipomea batatas* is still too little studied and important scientific investments are needed for improvement and later one the use of its potentiality (Worku et al. 2013). Hence, the interest of the researchers' study to focus on: "Evaluation of the agronomic characteristics of seven varieties introduced and nine local varieties under the agro-ecological conditions of southern Benin" is justified by the fact that the collection and characterization of a species are the first fundamental steps for its genetic improvement of sweet potato.

MATERIAL AND METHODS

Protocol Experimental

The study was carried out at the International Institute of Tropical Agriculture (IITA), Benin station. The average total rainfall during the planting was about 782.1mm, relative humidity of 82.5 percent and temperature of 27.33°C (Fig. 1). Planting layout was done in a randomized complete block design with three replicates. The apical cuttings of the varieties from three different countries (Table 1) were planted in unit area of 9m² (3 ridges of 3m each) with 1m inter row spacing and 0.30m within row spacing. Fertilizers and phytosanitary treatment were not applied during the growth of plant. Data were taken on both quantitative and qualitative charac-

Table 1: List of the 16 sweet potato (*Ipomea batatas*) and their origin used in this research

Varieties	*Origin*
Carot-c	
Ejumula	
Ukerewe	East Africa
SPK 004/6	
SPK 004/6/6	
440029	China
400166	Bolivia
Bohombo	
Kolidokpon	
Gboadobodouaho	
Hanman	
Vobodouaho	Benin
Dokoui-vovo	
Lanwara	
Manouga	
Fornonwinka	

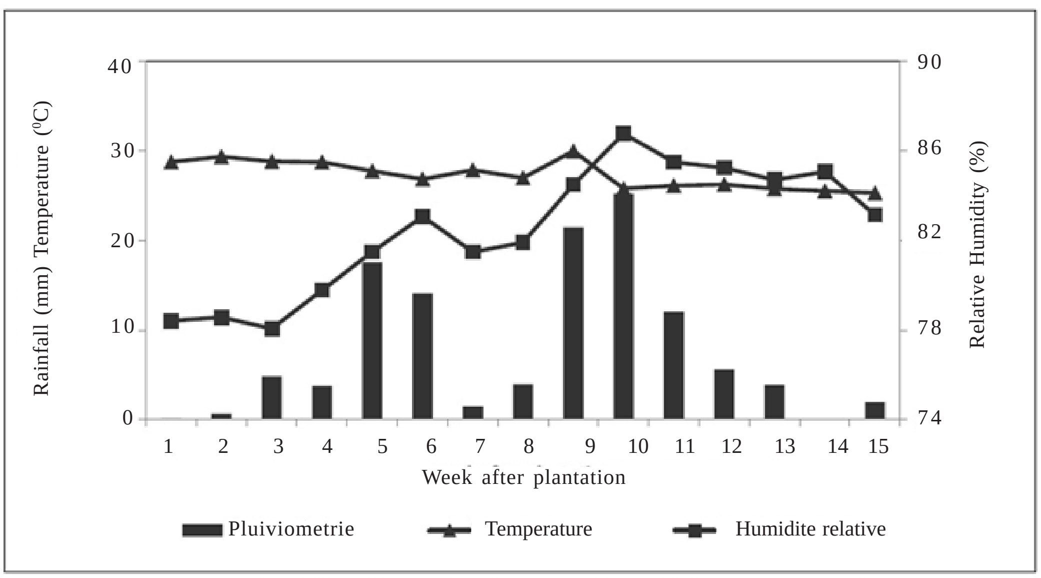

Fig. 1. Meteorological data showing the relative humidity, rainfall and temperature during experimentation
Source: IITA-BENIN station

teristics. It consisted of 5 randomly selected feet from the 10 plants on each observation line. The qualitative traits that were observed include; general leaf appearance (AGF), leaf lobe type (TLF), epidermal colour (EC) and tuber flesh (CCT) at 12 weeks and 16 weeks respectively after planting. While data on the following quantitative characters; time for the regeneration of planted cuttings (TRB), length of the petiole (LP), number of leaf (NF), length of internode (LEN) were randomly taken from 5 plants in each line comprising total of 10 plants. Similarly, at harvest information was obtained from the number of tubers (NT), fresh weight in aerial biomass and tuber per plant.

Data Analysis

Data were transformed to stabilize the variances and one-way analysis of variance (ANOVA) was performed using SPSS 16 software. Duncan multiple range tests were employed to discriminated means values at the five percent threshold. Correlations were established to study the relationships between the variables.

RESULTS AND DISCUSSION

Qualitative and Quantitative Characteristics

Inter-cultivar variability for most qualitative traits were observed (Table 2). Indeed, the leaves and tubers are of extremely variable in shape and size (Figs. 2 and 3). They can be whole or presented up to 7 lobes which corroborate those data obtained by several authors (Huamán and Zhang 1997; Yada et al. 2010).

Table 2: Regeneration time of different varieties of Ipomea batatas

Varities	*Time of regeneration*
SPK00/4/6	11.67 ± 0.66 ab
400166	11.33 ± 1.66 ab
440029	9.00 ± 1.00 a
Bohombo	13.67 ± 0.66 ab
Carrot-c	13.00 ± 2.00 ab
Dokoui-vovo	16.00 ± 0.57 b
Ejumula	9.67 ± 1.66 a
Fornonwinka	12.33 ± 0.66 ab
Gboadobodouaho	10.00 ± 1.52 a
Hanman	15.33 ± 1.45 b
Kolidokpon	15.67 ± 3.38 b
Lanwara	12.33 ± 0.66 ab
Manouga	9.33 ± 0.88 a
SPK004/6/6	9.67 ± 1.66 a
Ukerewe	10.33 ± 0.66 a
Vobodouaho	15.33 ± 0.33 b

P: 0,005 F: 2,92
Following DUNCAN's test, the average of one column followed by the same letter is not signifcantly different from each other at 5% threshold

Cultivar Performance

The researchers' observed that regeneration of planted cuttings varied between 9 and 16 days (Table 3), the length of internode range from 3.27cm to 5.53cm; 6.06cm to 19.00cm for petiole length; 7.33 cm to 13.40 cm for the LF trait which was confirmed by the research carried out Oggema et al. (2007) Variance analysis of the cultivars revealed that at the five percent threshold, there were highly significant differences between cultivars for internode length petiole and leaf (Table 4).

Agronomic Traits Evaluation

The trend in the evolution of stem length is almost the same for all cultivars grouped by origin of acquisition despite the wide variability within cultivars of the potato (Fig. 4). On the other hand, the evolution of the number of leaves (Fig. 5) indicates that the leaves of the varieties coming from China and Bolivia increase very quickly despite the wide variability within each origin cultivar $\sigma = 33.44$).

Agronomic Performance

The analysis of Table 5 showed high, intermediate and low productivity. This is of particular interest in setting up a variety if these traits are related to the genome of the plant (Miflin 2000). For the 16 varieties tested, tuber yield ranged from 0.16 to 24.77 t/ha and from 6.22 to 41.22 t/ha for biomass yield. Indeed, variety 440029 from China has a strong productive performance in terms of tuber yield with more than 24 t/ha, followed by kolidokpon, vobodouaho and manouga varieties all from Benin which have 11.66 t/ha, 11.44 t/ha and 8.55 t/ha respectively. It should also be noted that the maximum yield and the minimum yield were recorded on improved varieties, which allows us to deduce that the local varieties that are: kolidokpon, vobodouaho, manouga have superior yield to the improved varieties: ejumula carrot-c, ukerewe SPK004/6/6 (Fischer and Edmeades 2010). The

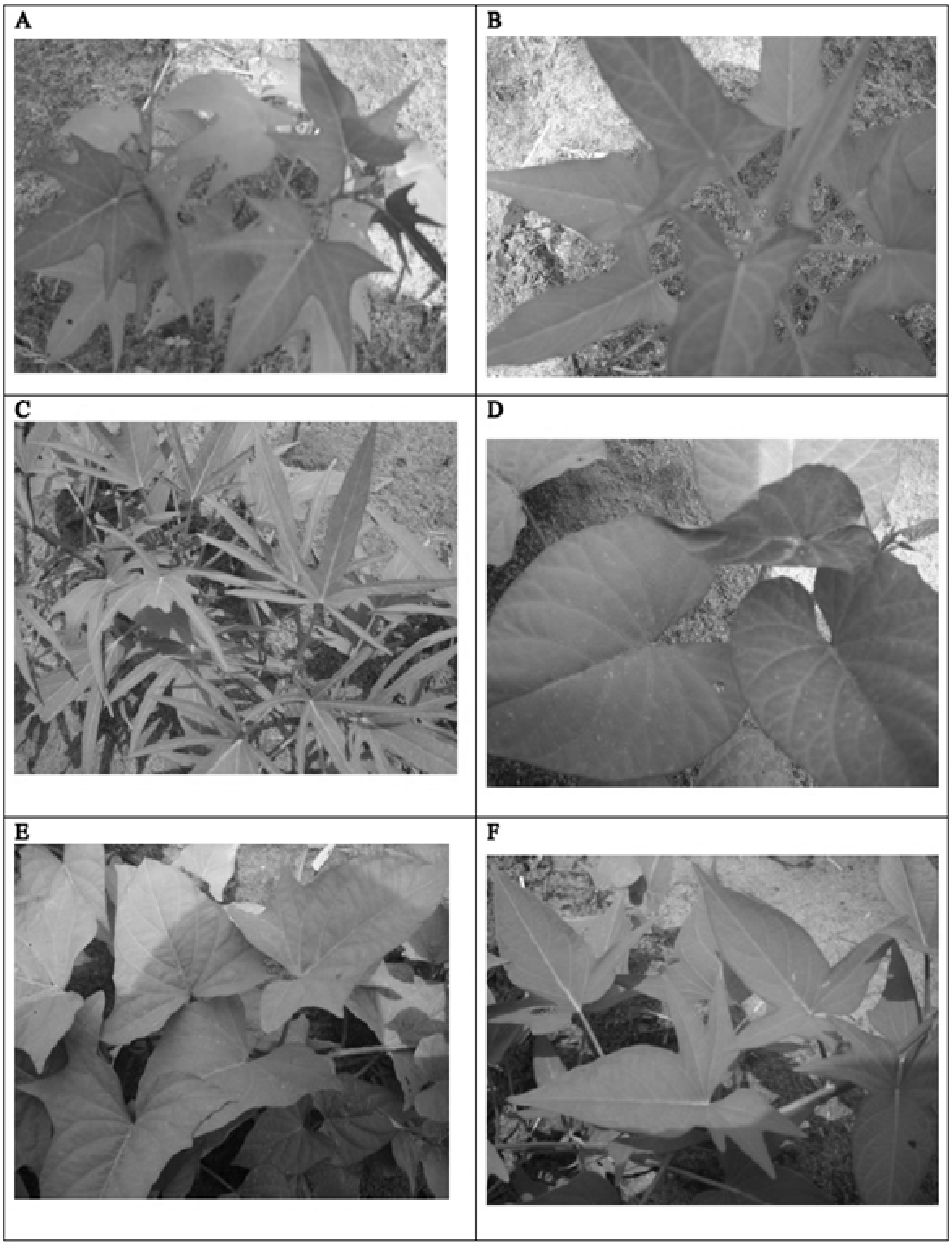

Fig. 2. Morphological variability of Sweet Potato leaves varieties tested A, B, C, D, E, F stand for the accession gbodobodouaho, Hanman, SPK004/6, Vobodouaho, Kolidopkon, Ejumula

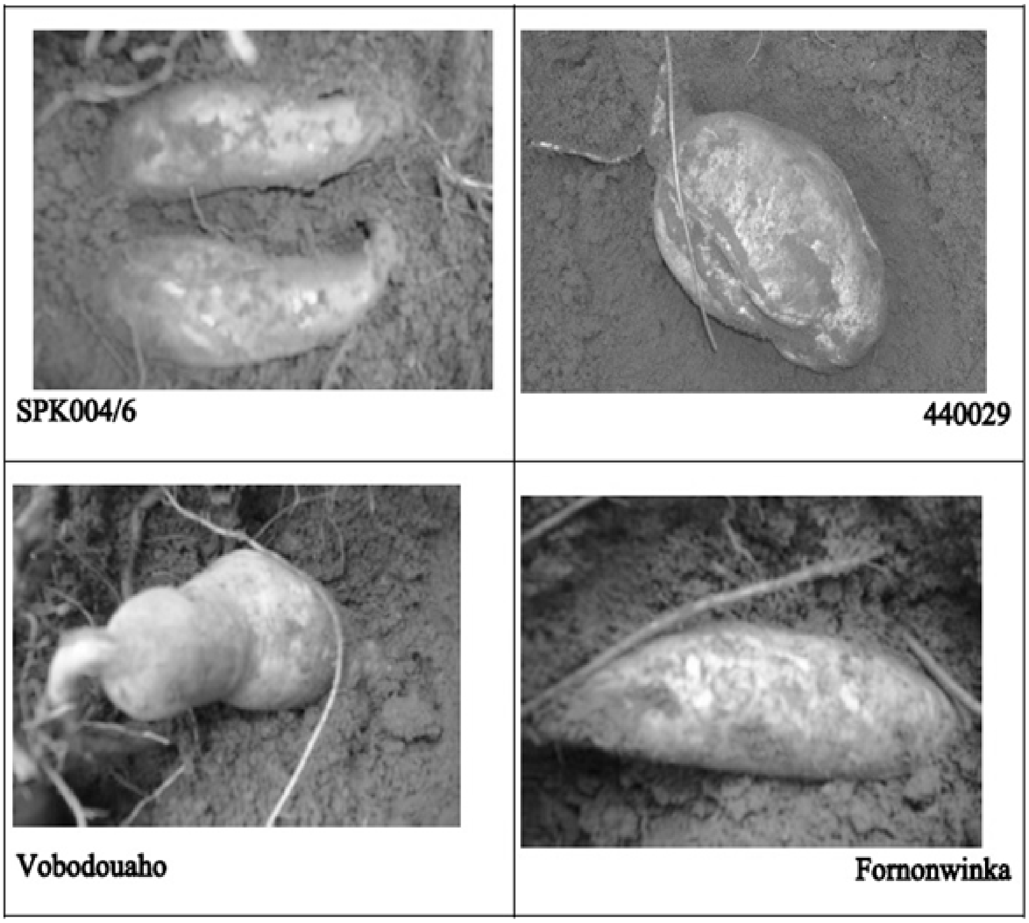

Fig. 3. Morphological variability of the sweet potato varieties tubers tested

Table 3: Qualitative characteristics and modalities observed

Varieties name	*Lobes appearance*	*Leaf approval*	*Epidermic color*	*Color of tubers*
SPK00/4/6	Presence of lobe	Very deep	Pink	Orange
400166	Presence of lobe	Deep	White	Pale yellow
440029	Triangular	Very slightly dentate	White	White
Bohombo	Triangular	Very slightly dentate	Pink	Pale yellow
Carrot-c	Presence of lobe	Moderately	Blanc	Pale yellow
Dokoui-vovo	Sweetheart	Absence of lobe	Pink	White
Ejumula	Presence of lobe	Slightly dentate	White	Orange
Fornonwinka	Triangular	Very slightly dentate	Orange	Pale yellow
Gboadobodouaho	Presence of lobe	Deep	Pink	White
Hanman	Hastate	Moderately	White	Pale yellow
Kolidokpon	Triangular	Very slightly dentate	Pink	White
Lanwara	Sweetheart	Very slightly dentate	Orange	Orange
Manouga	Sweetheart	Slightly dentate	Orange	Orange
SPK00/4/6/6	Presence of lobe	Very deep	Pink	Orange
Ukerewe	Presence of lobe	Deep	Pink	Pale yellow
Vobodouaho	Sweetheart	Absence of lobe	Pink	White

Table 4: Quantitative characteristics observed (lenght of internodes, petiole and nomber of leaves)

Varieties	*Internodes (cm)*	*Petiole (cm)*	*Leaves*
SPK00/4/6	3.27 ± 0.46 d	12.00 ± 3.12 b c d	10.93 ± 0.89 b c
400166	4.40 ± 0.64 a b c d	16.86 ± 4.05 a b	13.40 ± 0.64 a
440029	5.53 ± 0.41 a	19.00 ± 0.98 b a	10.00 ± 0.41 b c d
Bohombo	3.93 ± 0.24 b c d	13.26 ± 1.37 a b c	8.73 ± 0.24 d e f
Carrot-c	4.60 ± 0.80 a b c	13.46 ± 2.90 a b c	9.40 ± 0.80 c d e
Dokoui vovo	4.11 ± 0.43 b c d	6.06 ± 0.53 d	7.33 ± 0.43 f
Ejumula	4.47 ± 0.40 a b c d	15.33 ± 1.50 b c d	9.86 ± 0.40 b c d
Fornonwinka	4.72 ± 0.41 a b c	10.93 ± 0.59 b c d	9.00 ± 0.41 d e f
Gboadobodouaho	3.47 ± 0.37 c d	10.73 ± 1.13 b c d	10.26 ± 0.37 b c d
Hanman	4.28 ± 0.92 a b c d	9.64 ± 0.71 c d	10.17 ± 0.92 b c d
Kolidokpon	5.20 ± 0.64 a b	9.53 ± 1.37 c d	7.8 ± 0.64 e f
Lanwara	4.07 ± 0.46 b c d	9.58 ± 0.74 c d	8.78 ± 0.46 d e f
Manouga	5.53 ± 0.17 a	16.26 ± 1.59 a b	10,13 ± 0.17 b c d
SPK00/4/6/6	4.13 ± 0.30 b c d	12.26 ± 2.26 b c d	11.60 ± 0.30 b
Ukerewe	3.62 ± 0.59 c d	12.86 ± 1.57 a b c	10.46 ± 0.59 b c d
Vobodouaho	4.47 ± 0.48 a b c d	13.20 ± 1.90 a b c	9.66 ± 0.48 c d
P =	0.006	0.006	0
F =	2.885	2.889	6.77

Following DUNCAN's test, the average of one column followed by the same letter is not signifcantly different from each other at 5% threshold.

Table 5: Yields (t/ha) of biomass and tuber of different varieties of sweet potato

Varieties	*Tuber yield*	*Biomass yield*
SPK004/6	3.77b-e	19.66a-c
SPK004/6/6	0.88ef	34.38ab
Ukerewe	1.11ef	18.80a-d
Carrot-c	0.16f	32.83ab
Ejumula	2.00d-f	40.72a
400166	2.77c-f	14.30b-e
440029	24.77a	21.83a-c
Vobodouaho	11.44ab	20.36a-c
Dokoui-vovo	2.77d-f	6.22e
Fornonwinka	1.00ef	16.33a-d
Gboadobodouaho	3.66b-e	19.25a-d
Hanman	1.66d-f	10.50c-e
Kolidokpon	11.66a-c	22.00a-c
Lanwara	1.33ef	6.83de
Manouga	8.55b-d	20.36a-c
Bohombo	2.93d-f	41.22a
P =	0	0.001
F =	8.91	3.89

Following DUNCAN's test, the average of one column followed by the same letter is not signifcantly different from each other at 5%

yields obtained in particular for the kolidokpon and vobodouaho varieties are similar to the yields obtained by Paraiso et al. (2012), which are: 13.12 t/ha and 9.34 t/ha respectively for these same varieties. For most varieties from East Africa including the variety: 400166 of Bolivia, dokuvovo, fornonwinka, hanman, lanwara, bohombo and gboadobodouaho of Benin, all have a low yield. This could be explained by the choice of the agro-ecological zone, which was the main focus of the present study, because the cultivars have not undergone any water stress with respect to the researchers' experimental conditions. The test took place not only during the long rainy season but the researchers' watered them also. The amount of water dropped is 782 mm; Belehu (2003) indicates that sweet potato produces best in areas with 750-1000 mm of rainfall per year with about 500 mm during the growing season. According to this researcher, the amount of rainfall and the distribution of moisture in the field greatly influence yield. The characters tuber number, tuber yield and aerial biomass had low standard deviations. These low values indicate some aggregation of individuals around averages for these traits. This is explained by the high values noted for the coefficient of variation reaching 37.75 percent; 31.56 percent and 21.63 percent respectively. The variance analysis results applied to the yield parameter show that there is a highly significant difference between the 16 varieties compared to tuber yields and biomass (Table 6).

Importance of Relationships between Characters

Positive and highly significant correlations exist between stem length and number of leaves,

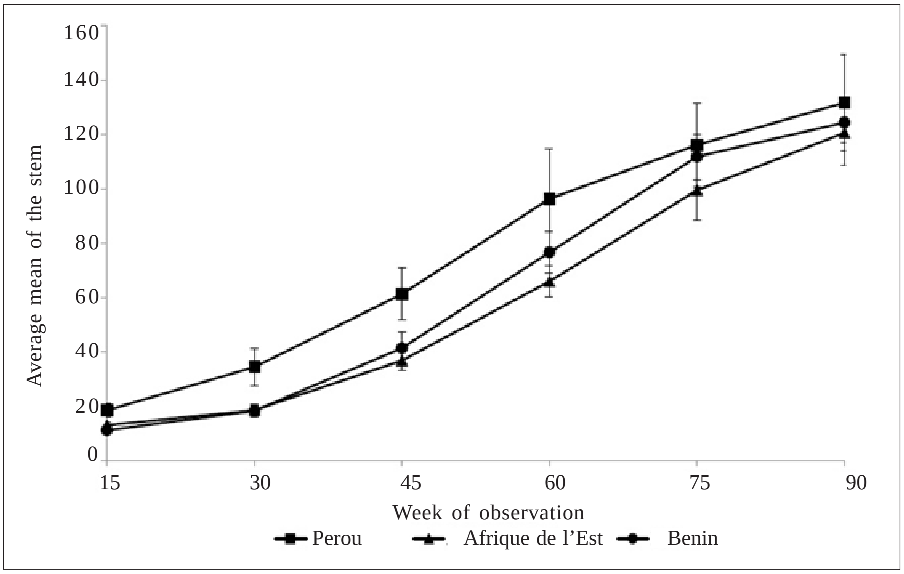

Fig. 4. Evolution of stem elongation of sweet potato varieties by origin

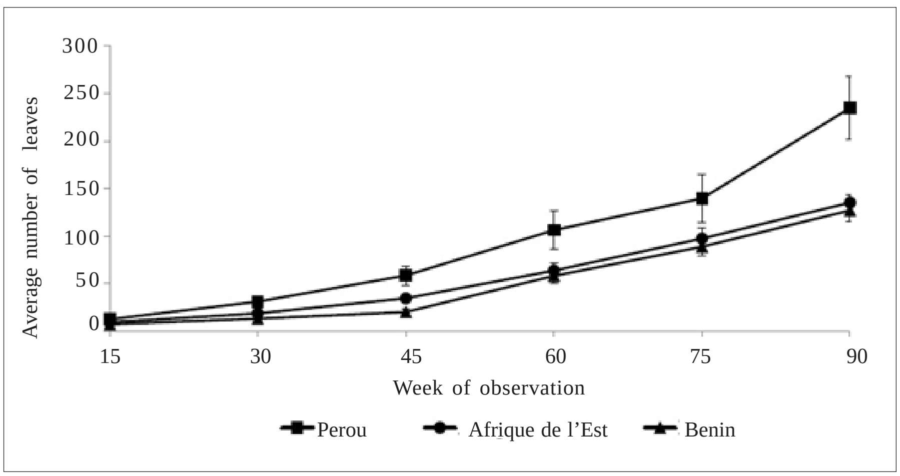

Fig. 5. Evolution of the number of leaves of sweet potato varieties by origin

Table 6: Agronomic performance and results of the analysis of variance of the 16 varieties of Ipomea batatas

Characters	*Minimum Value*	*Maximum value*	*Mean Value*	*Standard deviation*	*Coefficient (%)*	*Probability*	*Signification du F observed*
LT (cm)	82.86	17866	101.38	15.52	15.3	0.001	**
NF	55.85	289.87	143.01	20.59	14.4	0	**
NT	0.06	2.53	0.98	0.37	37.75	0.007	**
RT(t/ha)	0.16	24.77	5.1	1.61	31.56	0	**
RBA (t/ha)	6.22	41.22	21.6	4.67	21.63	0.001	**

** highly significant difference, LT: stem length, NF: number of leaves, NT: number of tubers, RT: tuber yield, RBA: yield of above ground biomass

Table 7: Correlation between vegetative and agronomic traits

	TRB	*LT*	*NF*	*NT*	*RBA*	*RT*
TRB	1					
LT	-0.147	1				
NF	-0.091	0.729**	1			
NT	-0.108	0.317*	0.316*	1		
RBA	-0.279	0.424**	0.424**	0.256	1	
RT	-0.64	0.341*	0.354*	0.877**	0.154	1

* P = 0.05 ** P = 0.01
TRB: cuttings recovery time, LT: stem length NF number of leaves, NT: number of tubers, RBA: aboveground biomass yield, RT: tuber yield

stem length and aboveground biomass yield, leaf number and biomass yield followed by tuber number and tuber yield (George et al. 2002). There are also positive and significant correlations between stem length and number of tubers, number of leaves and number of tubers, stem length and tuber yield, number of leaves, and tuber yield (Zelalem et al. 2009) (Table 7). There are direct relationships between the leaves and tubers of the plant. These relationships are indicated by strong positive correlations between the number of tubers and the number of leaves (Lahlou and Ledent 2005; OLIVEIRA 2000). Research conducted on yams highlighted the physiology and morphogenesis relationship and confirmed the researchers' result (Baah 2009; Maliki et al. 2012; Mitchell and Ahmad 1999). These results are explained by the fact that more leaves do have a great capacity to produce carbonaceous products, hence the more photosynthetic assimilas will be stored in the tubers. On the other hand, when the number of newly formed tubers is reduced, the photosynthetic activity and transpiration are lowered. Hence, the interdependence between newly formed tubers and the leaves and, it is this interdependence that makes it possible to increase the yield of the plant (Saidur et al. 2011).

CONCLUSION

Inter and intra-cultivar variabilities were present in 16 varieties. The inter-cultivar variability was found to be essentially based on the general appearance of the leaves, the type of leaf, the colour of the tubers. The researchers' observed variability based primarily on vegetative size and yield potential. Clearly, the sample the researchers' studied contains a wide range of variability. However, the variability highlighted is only a partial reflection of what are the characteristics of each cultivar, this study being one of the first in Benin, it would be desirable to continue the research in order to have more information for a more rational production of sweet potatoes in Benin. However, the researchers' still cannot judge the performance of the tested varieties.

RECOMMENDATIONS

Improving food crops production is a key component of food security. Research works that generate technologies to refine strategies to increase crops yield and storage are determinant to ensure food availability and affordability and thereby food security. Identifying sound strategies to manage farm and stores remains the biggest challenge in food and agriculture sector.

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REFERENCES

Baah FD 2009. *Characterization of Water Yam (Dioscorea Alata) for Existing and Potential Food Products*. A Thesis Submitted in Partial Fulfilment of the Requirements for the Degree of Doctor Of Philosophy. Pretoria: Department of Plant Production and Soil Science in the Faculty of Natural and Agricultural Science. University of Pretoria.
Balat M, Balat H 2009. Recent trends in global production and utilization of bio-ethanol fuel. *Applied Energy*, 86(11): 2273-2282.
Belehu T 2003. Agronomical and physiologycal factor affecting growth, development and yield of sweet

potato in Ethiopia. A Thesis Submitted in Partial Fulfilment of the Requirements for the Degree of Doctor of Philosophy. Ghana: Department of Food Science and Technology, Kwame Nkrumah University of Science and Technology.

Bruinsma J 2017. *World Agriculture: Towards 2015/ 2030: An FAO Study*. London: Routledge.

FAOSTAT. Food and Agriculture Organization of the United State. <http://wwwfao.org/faostat>.

Fischer R, Edmeades GO 2010. Breeding and cereal yield progress. *Crop Science*, 50(Suppl 1): S85-S98.

George MS, Lu G, Zhou W 2002. Genotypic variation for potassium uptake and utilization efficiency in sweet potato (*Ipomoea batatas* L.). *Field Crops Research,* 77(1): 7-15.

Gichaga L 2014. *Network Frames and Their Link to Commitment in Drought Early Warning Information Systems: Evidence from the FEWS NET-KF-SSG Anti-Famine Campaign*. USA: Regent University/UMI Dissertation Publishers.

Godfray HCJ, Garnett T 2014. Food security and sustainable intensification. *Phil Trans R Soc B*, 369 (1639): 20120273.

Huamán Z, Zhang D 1997. Sweetpotato. In: D Fuccillo, L Sears, P Stapleton (Eds): *Biodiversity in Trust. Conservation and Use of Plant Genetic Resources in CGIAR Centres.* Cambridge, UK: Cambridge University Press, pp. 29-38.

Lahlou O, Ledent JF 2005. Root mass and depth, stolons and roots formed on stolons in four cultivars of potato under water stress. *European Journal of Agronomy,* 22(2): 159-173.

Lebot V 2009. *Tropical Root and Tuber Crops: Cassava, Sweet Potato, Yams and Aroids.* Wallingford: CABI, P. 432.

Maliki R, Sinsin B, Floquet A 2012. Evaluating yam-based cropping systems using herbaceous leguminous plants in the savannah transitional agroecological zone of Benin. *Journal of Sustainable Agriculture*, 36(4): 440-460.

Martin K, Sauerborn J 2013. *Agroecology.* Netherlands: Springer.

Miflin B 2000. Crop improvement in the 21st century. *Journal of Experimental Botany,* 51(342): 1-8.

Mitchell SA, Ahmad M 1999. Morphological changes of dioscorea trifida cv. short neck yampie and D. cayenensis cv. round leaf yellow yam linked to the number and size of harvested tubers. *The Journal of Horticultural Science and Biotechnology,* 74(4): 531-539.

Nellemann C 2009. *The Environmental Food Crisis: The Environment's Role in Averting Future Food Crises: A UNEP Rapid Response Assessment*. UNEP/Earthprint, Nairobi, Kenya.

Oke M, Workneh T 2013. A review on sweet potato postharvest processing and preservation technology. *African Journal of Agricultural Research,* 8(40): 4990-5003.

OLIVEIRA CADS 2000. Potato crop growth as affected by nitrogen and plant density. *Pesquisa Agropecuária Brasileira,* 35(5): 940-950.

Paraiso AA 2012. Analysis of Sweet Potato *(Ipomea batatas* L.*)* production in the commune of Gogounou, Benin. *International Journal of Science and Advanced Technology,* 11(2): 46-53.

Saidur R, Abdelaziz E, Demirbas A, Hossain M, Mekhilef S 2011. A review on biomass as a fuel for boilers. *Renewable and Sustainable Energy Reviews,* 15(5): 2262-2289.

Schmidhuber J, Tubiello FN 2007. Global food security under climate change. *Proceedings of the National Academy of Sciences,* 104(50): 19703-19708.

Worku A, Tsegaw T, Mengistu F 2013. Yield and Yield Components of Potato Cultivars as Influenced by Period of Seed Tuber Storage at Adet. *Proceedings of the National Workshop on Seed Potato Tuber Production and Dissemination*, 12-14 March 2012, Bahir Dar, Ethiopia, pp. 136-151.

Yada B, Tukamuhabwa P, Alajo A, Mwanga R 2010. Morphological characterization of Ugandan sweet-potato germplasm. *Crop Science*, 50(6): 2364-2371.

Zelalem A, Tekalign T, Nigussie D 2009. Response of potato (*Solanum tuberosum* L.) to different rates of nitrogen and phosphorus fertilization on vertisols at Debre Berhan, in the central highlands of Ethiopia. *African Journal of Plant Science,* 3(2): 16-24.

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